LECTURE PRESENTATIONS

For CAMPBELL BIOLOGY, NINTH EDITION

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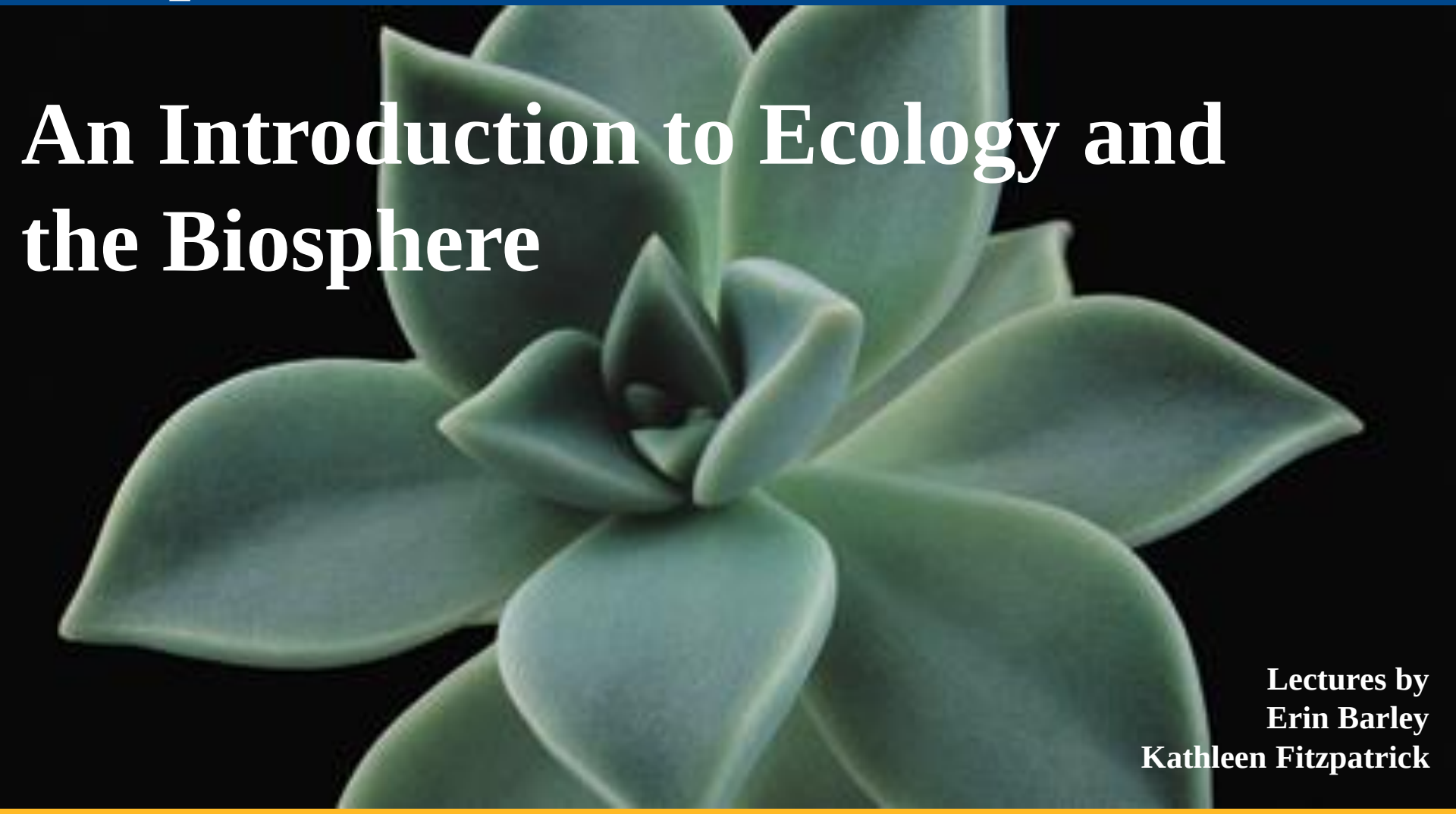
Chapter 52

An Introduction to Ecology and the Biosphere



Lectures by
Erin Barley
Kathleen Fitzpatrick

Overview: Discovering Ecology

- **Ecology** is the scientific study of the interactions between organisms and the environment
- These interactions determine the distribution of organisms and their abundance
- Modern ecology includes observation and experimentation

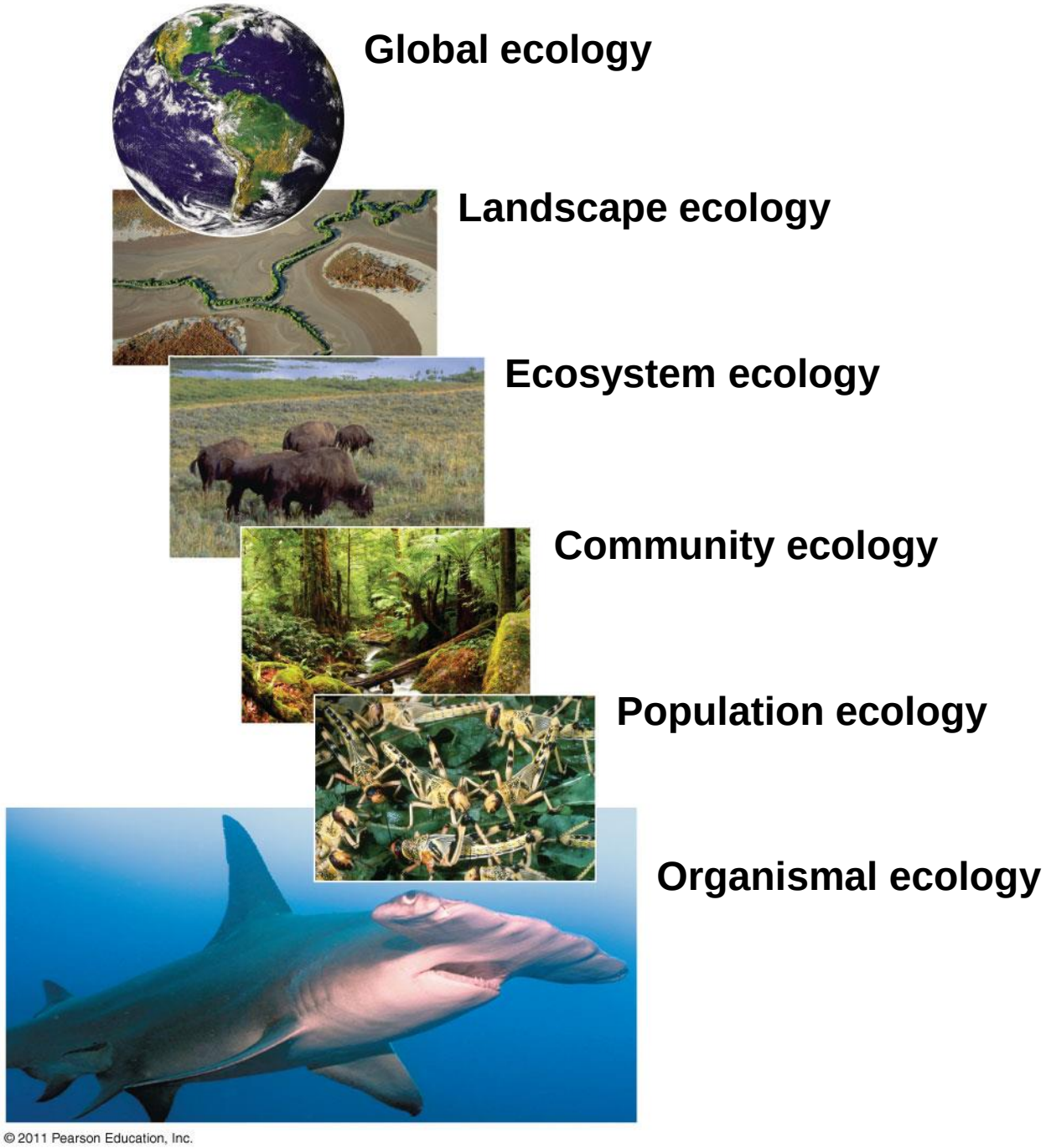
- The rediscovery of the nearly extinct harlequin toad in Costa Rica raises many ecological questions
  - What environmental factors limit their geographic distribution?
  - What factors (food, pathogens) affect population size?

Figure 52.1

The Scope of Ecological Research

- Ecologists work at levels ranging from individual organisms to the planet

Figure 52.2



Global Ecology

- The **biosphere** is the global ecosystem, the sum of all the planet's ecosystems
- **Global ecology** examines the influence of energy and materials on organisms across the biosphere

Figure 52.2a

Global ecology

Landscape Ecology

- A **landscape** or **seascape** is a mosaic of connected ecosystems
- **Landscape ecology** focuses on the exchanges of energy, materials, and organisms across multiple ecosystems

Figure 52.2b

Landscape ecology

Ecosystem Ecology

- An **ecosystem** is the community of organisms in an area and the physical factors with which they interact
- **Ecosystem ecology** emphasizes energy flow and chemical cycling among the various biotic and abiotic components

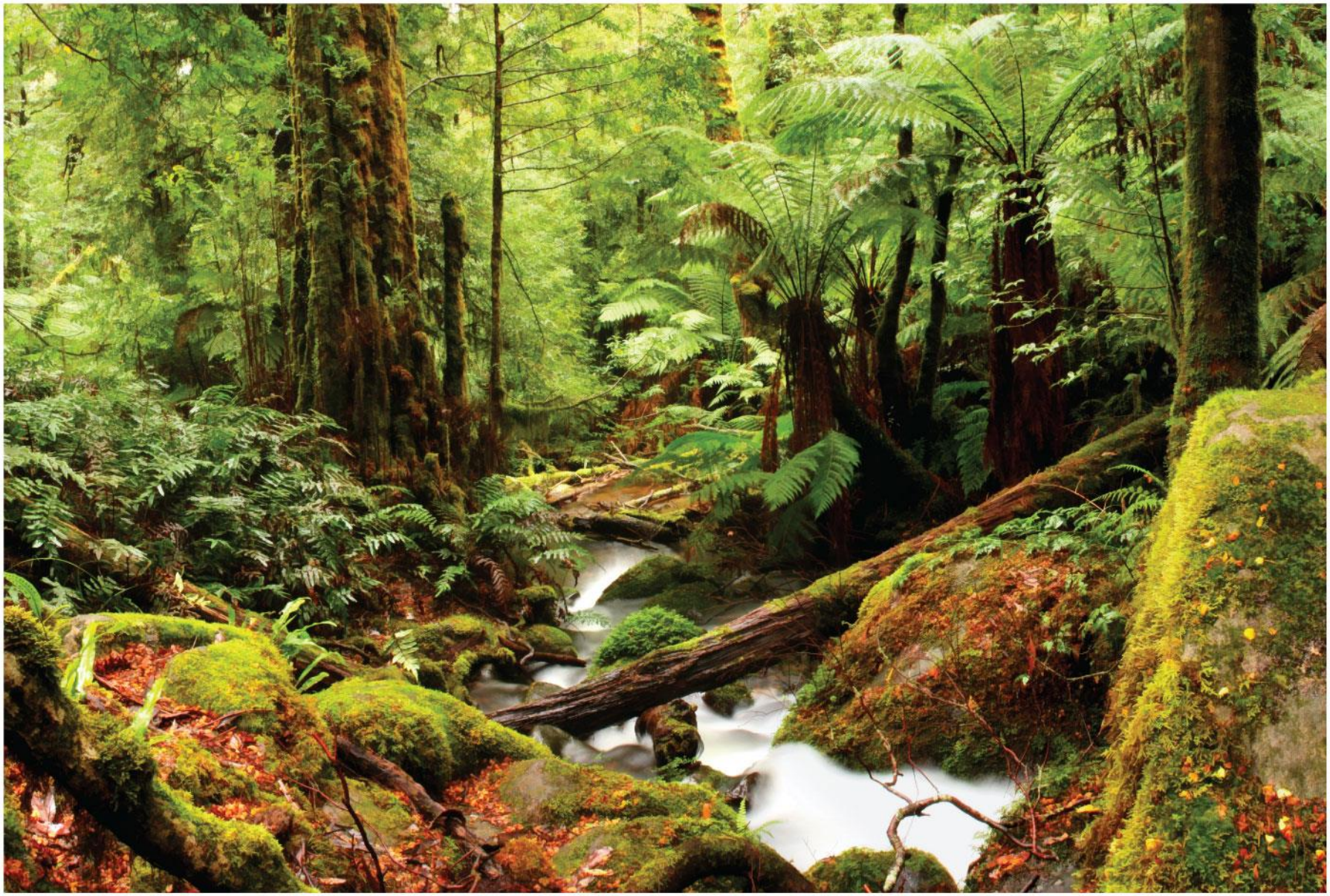
Figure 52.2c

Ecosystem ecology

Community Ecology

- A **community** is a group of populations of different species in an area
- **Community ecology** deals with the whole array of interacting species in a community

Figure 52.2d



Community ecology

Population Ecology

- A **population** is a group of individuals of the same species living in an area
- **Population ecology** focuses on factors affecting population size over time

Figure 52.2e

Population ecology

Organismal Ecology

- **Organismal ecology** studies how an organism's structure, physiology, and (for animals) behavior meet environmental challenges
- Organismal ecology includes physiological, evolutionary, and behavioral ecology

Figure 52.2f

Organismal ecology

Concept 52.1: Earth's climate varies by latitude and season and is changing rapidly

- The long-term prevailing weather conditions in an area constitute its **climate**
- Four major abiotic components of climate are temperature, precipitation, sunlight, and wind
- **Macroclimate** consists of patterns on the global, regional, and landscape level
- **Microclimate** consists of very fine patterns, such as those encountered by the community of organisms underneath a fallen log

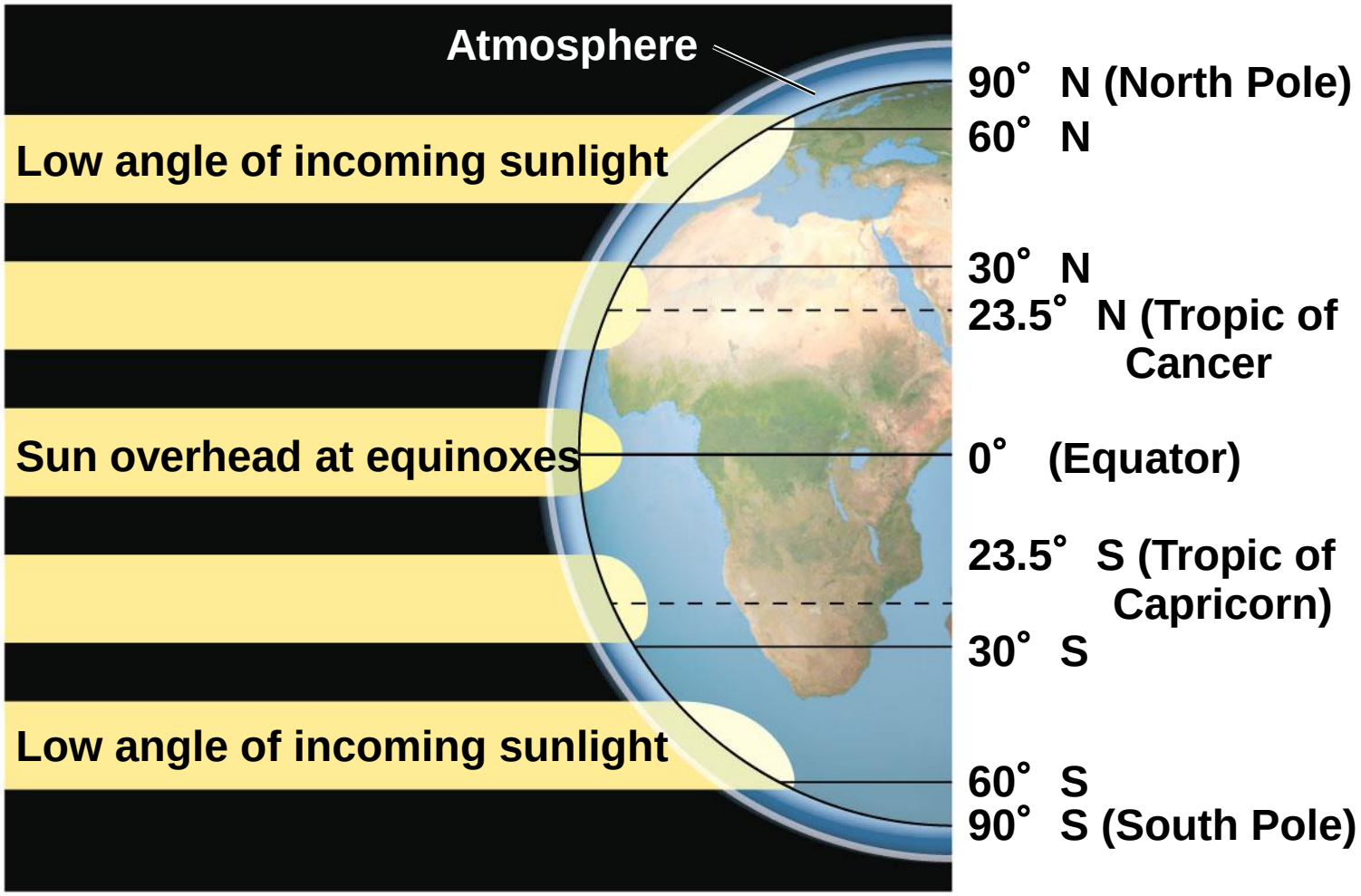
Global Climate Patterns

- Global climate patterns are determined largely by solar energy and the planet's movement in space
- The warming effect of the sun causes temperature variations, which drive evaporation and the circulation of air and water
- This causes latitudinal variations in climate

Latitudinal Variation in Sunlight Intensity

- The angle at which sunlight hits Earth affects its intensity, the amount of heat and light per unit of surface area
- The intensity of sunlight is strongest in the tropics (between 23.5° north latitude and 23.5° south latitude)

Figure 52.3a



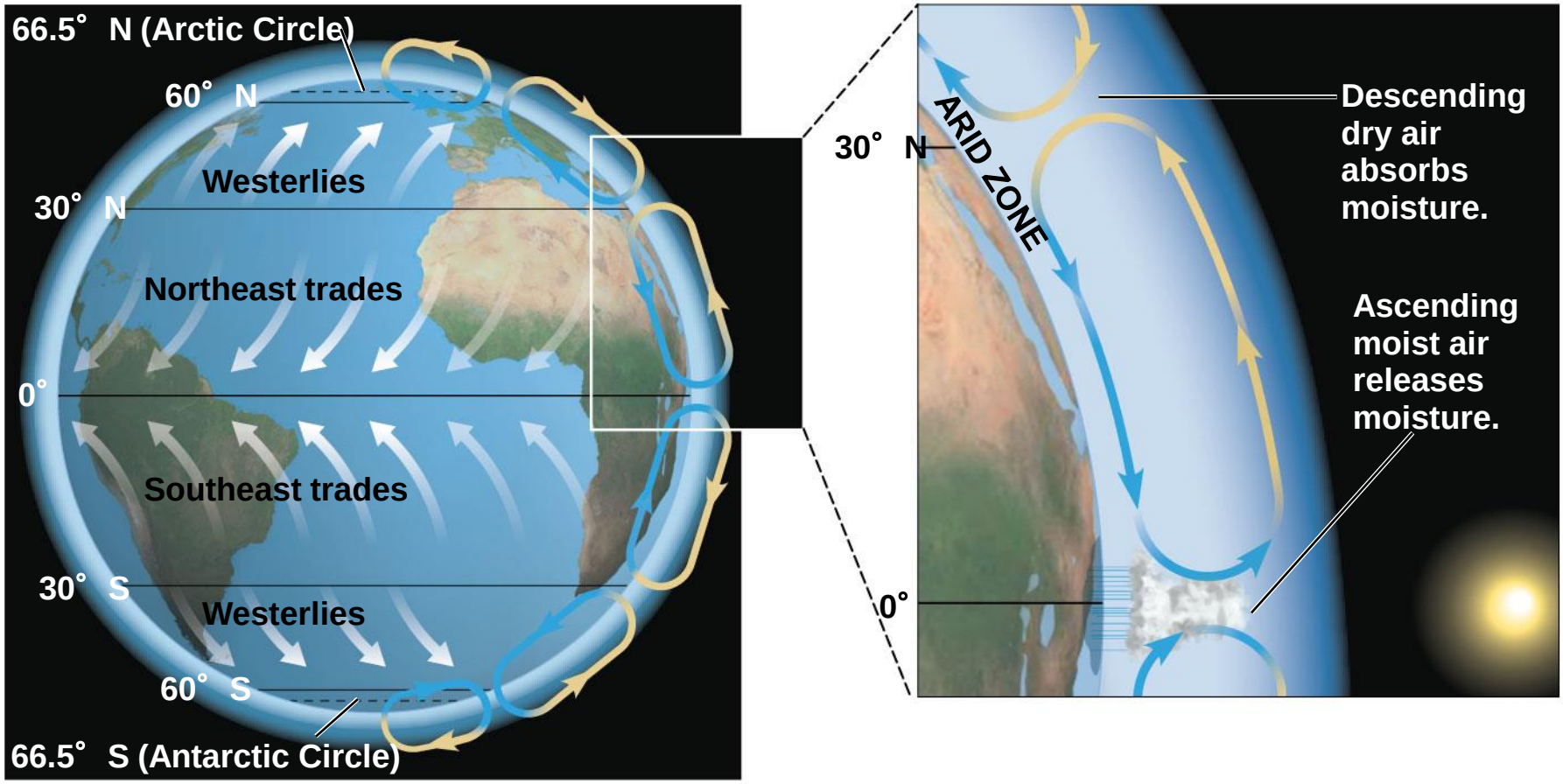
Latitudinal variation in sunlight intensity

Global Air Circulation and Precipitation Patterns

- Global air circulation and precipitation patterns play major roles in determining climate patterns
- Water evaporates in the tropics, and warm, wet air masses flow from the tropics toward the poles

- Rising air masses release water and cause high precipitation, especially in the tropics
- Dry, descending air masses create arid climates, especially near 30° north and south
- Air flowing close to Earth's surface creates predictable global wind patterns
- Cooling trade winds blow from east to west in the tropics; prevailing westerlies blow from west to east in the temperate zones

Figure 52.3b



Global air circulation and precipitation patterns

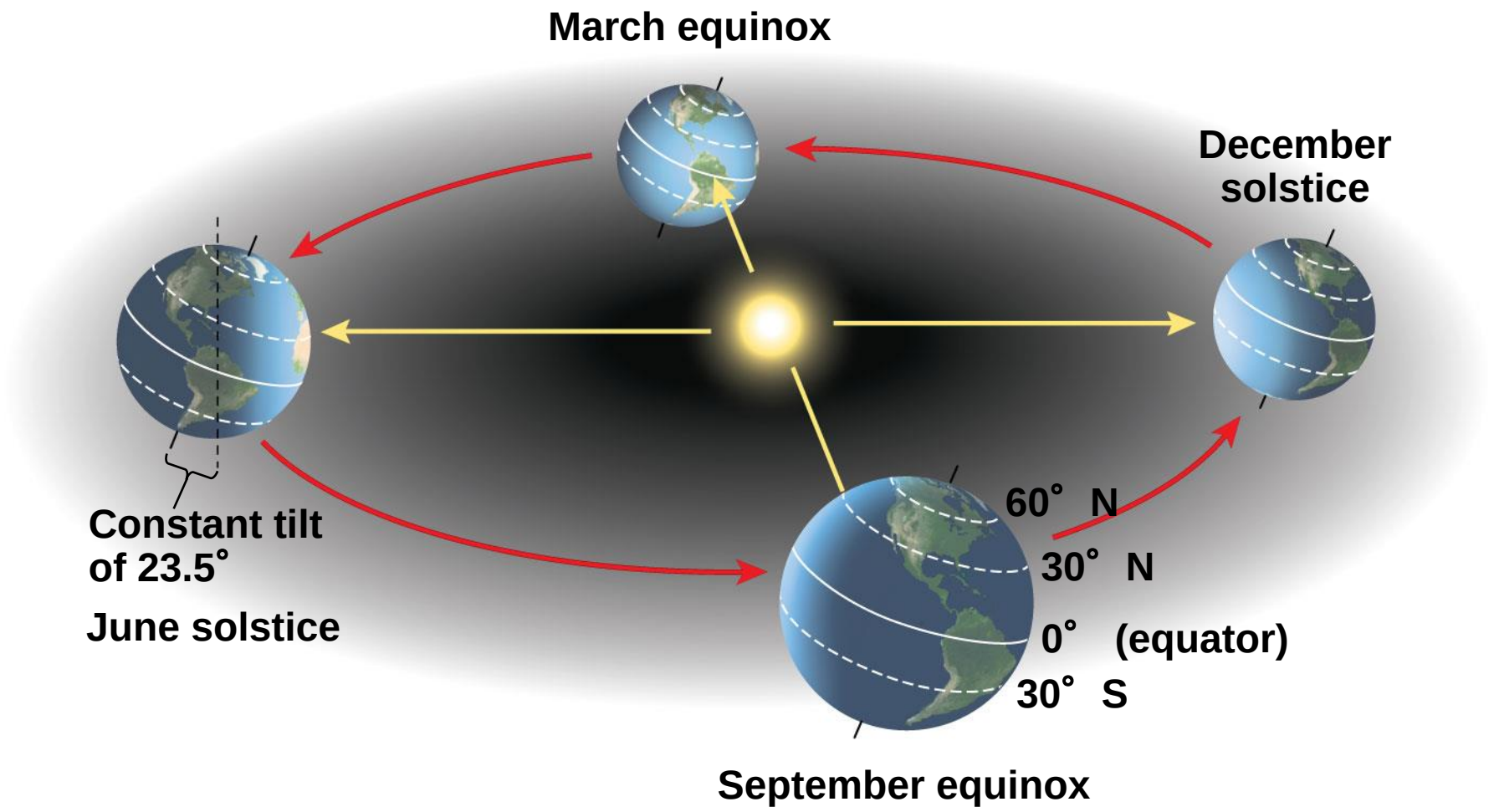
Regional and Local Effects on Climate

- Climate is affected by seasonality, large bodies of water, and mountains

Seasonality

- Seasonal variations of light and temperature increase steadily toward the poles
- Seasonality at high latitudes is caused by the tilt of Earth's axis of rotation and its annual passage around the sun
- Belts of wet and dry air straddling the equator shift throughout the year with the changing angle of the sun
- Changing wind patterns affect ocean currents

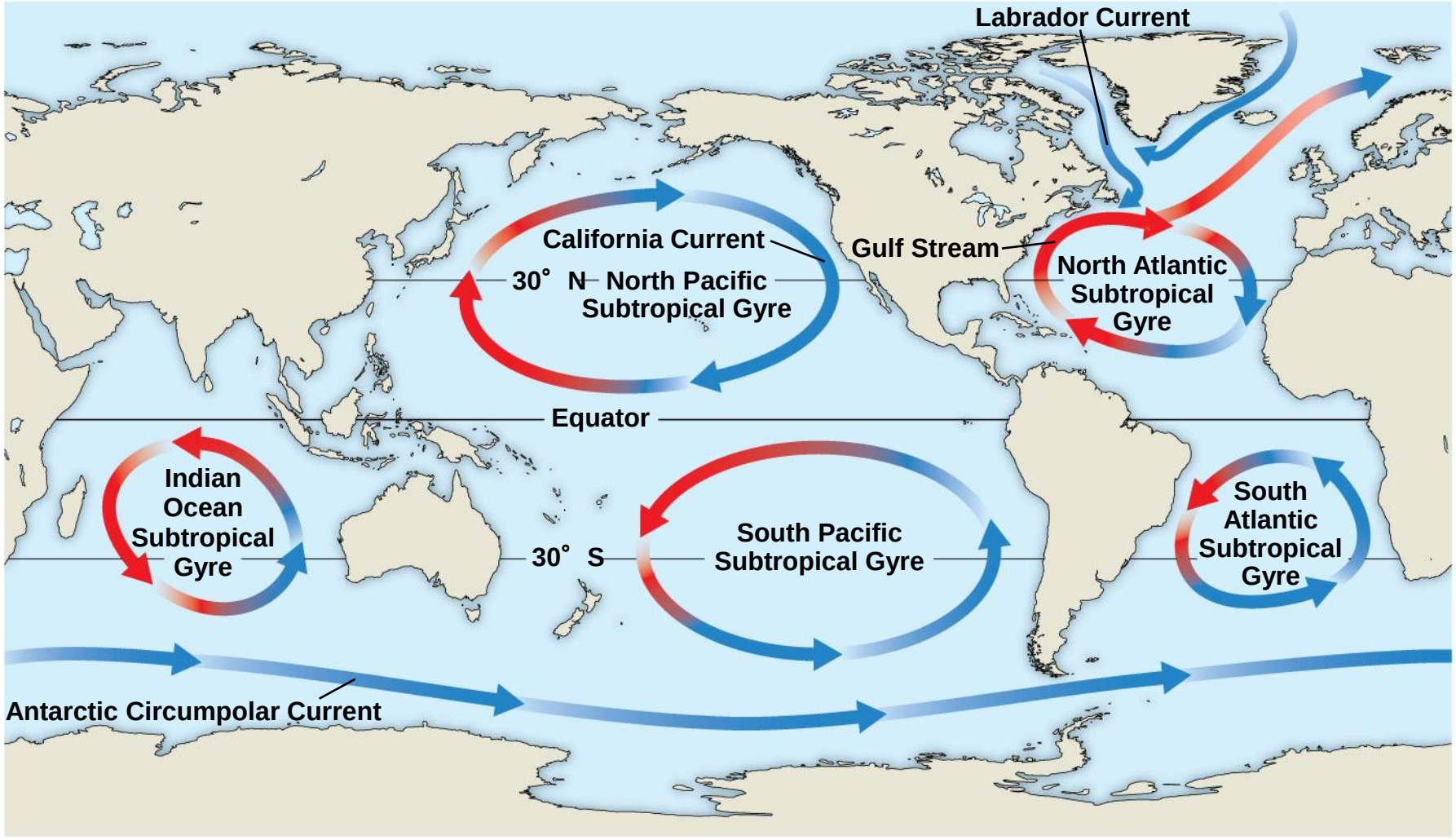
Figure 52.4



Bodies of Water

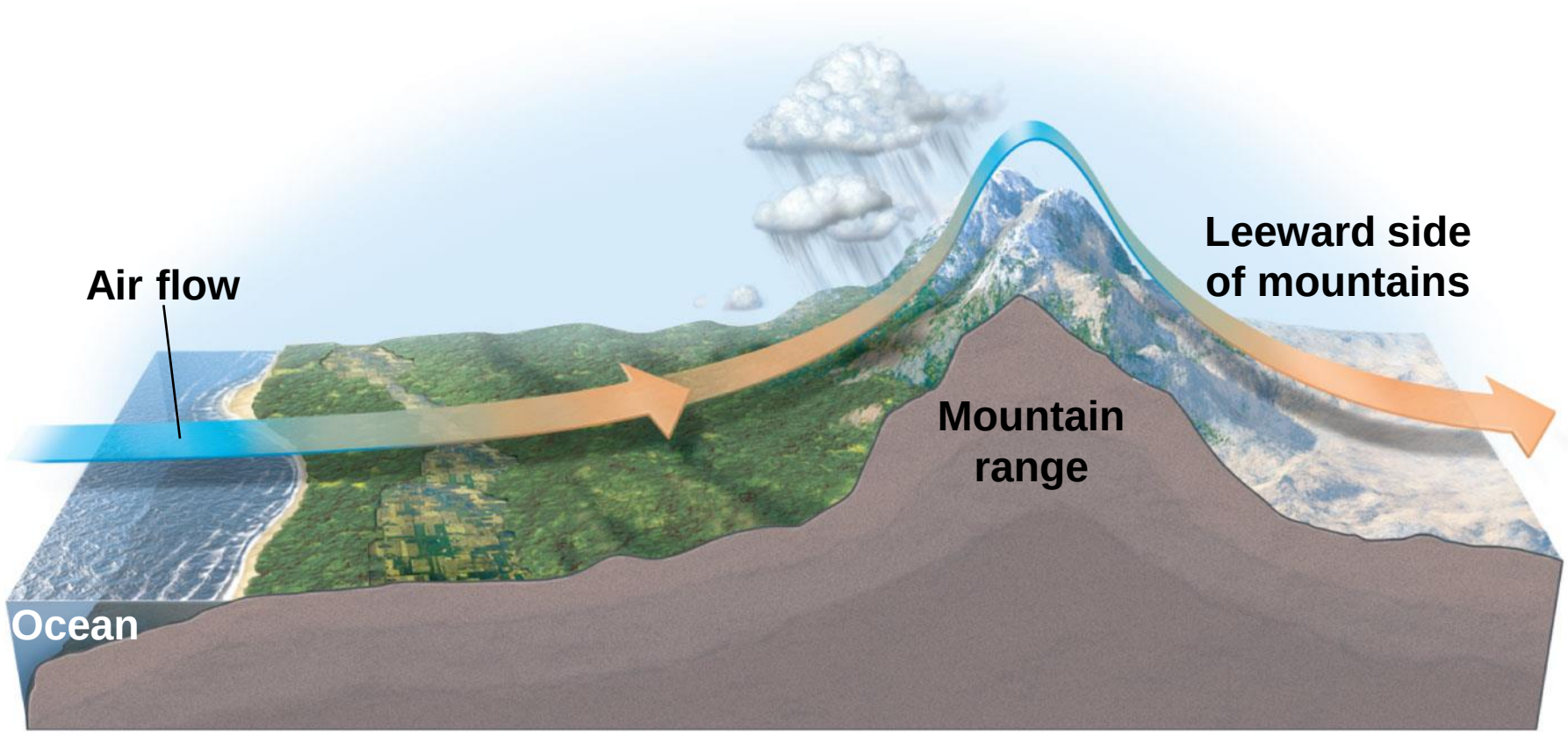
- Oceans, their currents, and large lakes moderate the climate of nearby terrestrial environments
- The Gulf Stream carries warm water from the equator to the North Atlantic

Figure 52.5



- During the day, air rises over warm land and draws a cool breeze from the water across the land
- As the land cools at night, air rises over the warmer water and draws cooler air from land back over the water, which is replaced by warm air from offshore

Figure 52.6



Mountains

- Rising air releases moisture on the windward side of a peak and creates a “rain shadow” as it absorbs moisture on the leeward side
- Mountains affect the amount of sunlight reaching an area
- In the Northern Hemisphere, south-facing slopes receive more sunlight than north-facing slopes
- Every 1,000 m increase in elevation produces a temperature drop of approximately 6°C

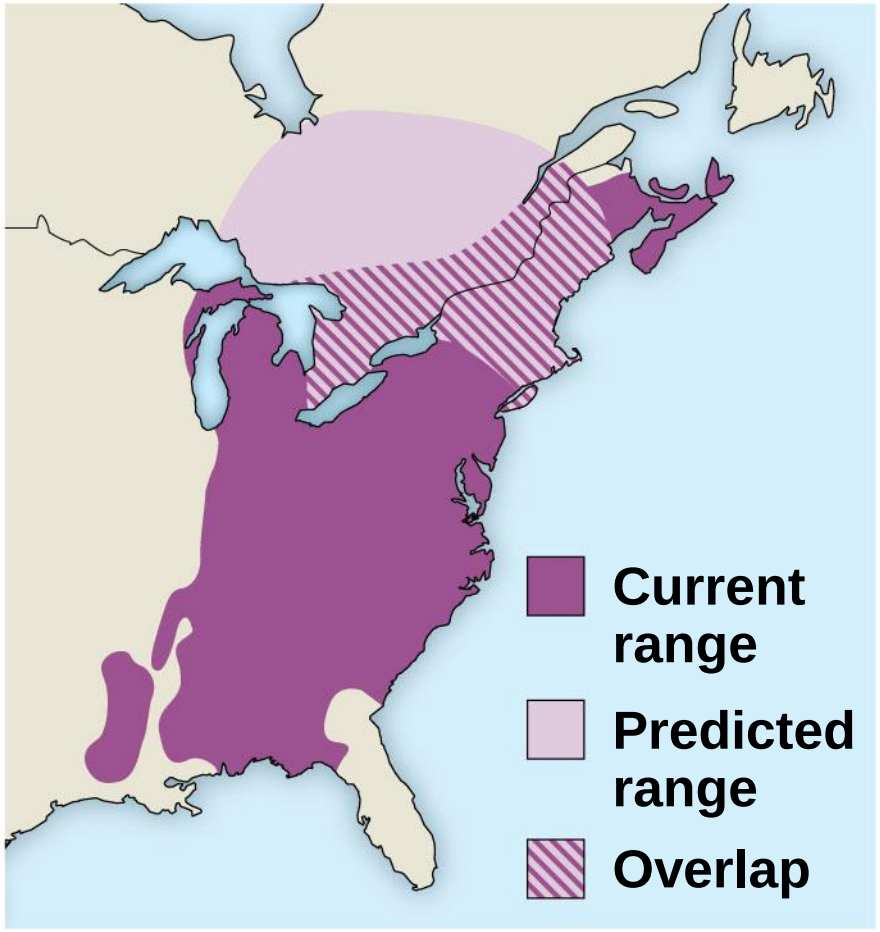
Microclimate

- Microclimate is determined by fine-scale differences in the environment that affect light and wind patterns
- Every environment is characterized by differences in
  - **Abiotic** factors, including nonliving attributes such as temperature, light, water, and nutrients
  - **Biotic** factors, including other organisms that are part of an individual's environment

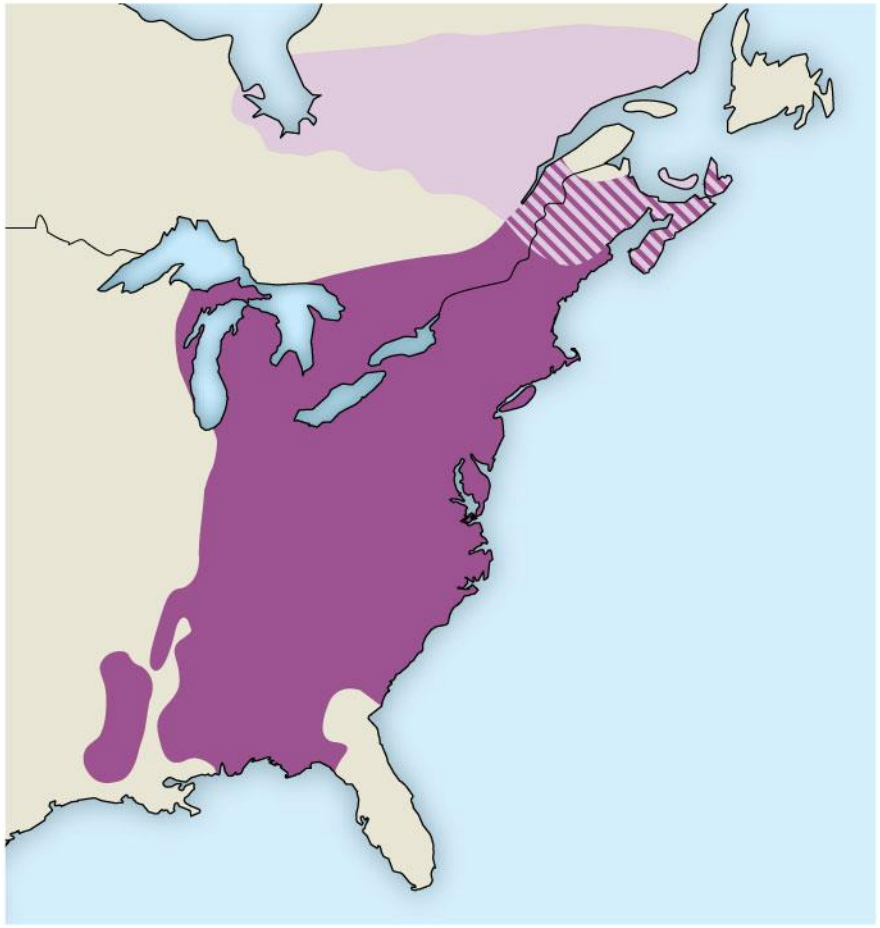
Global Climate Change

- Changes in Earth's climate can profoundly affect the biosphere
- One way to predict the effects of future global climate change is to study previous changes
- As glaciers retreated 16,000 years ago, tree distribution patterns changed
- As climate changes, species that have difficulty dispersing may have smaller ranges or could become extinct

Figure 52.7

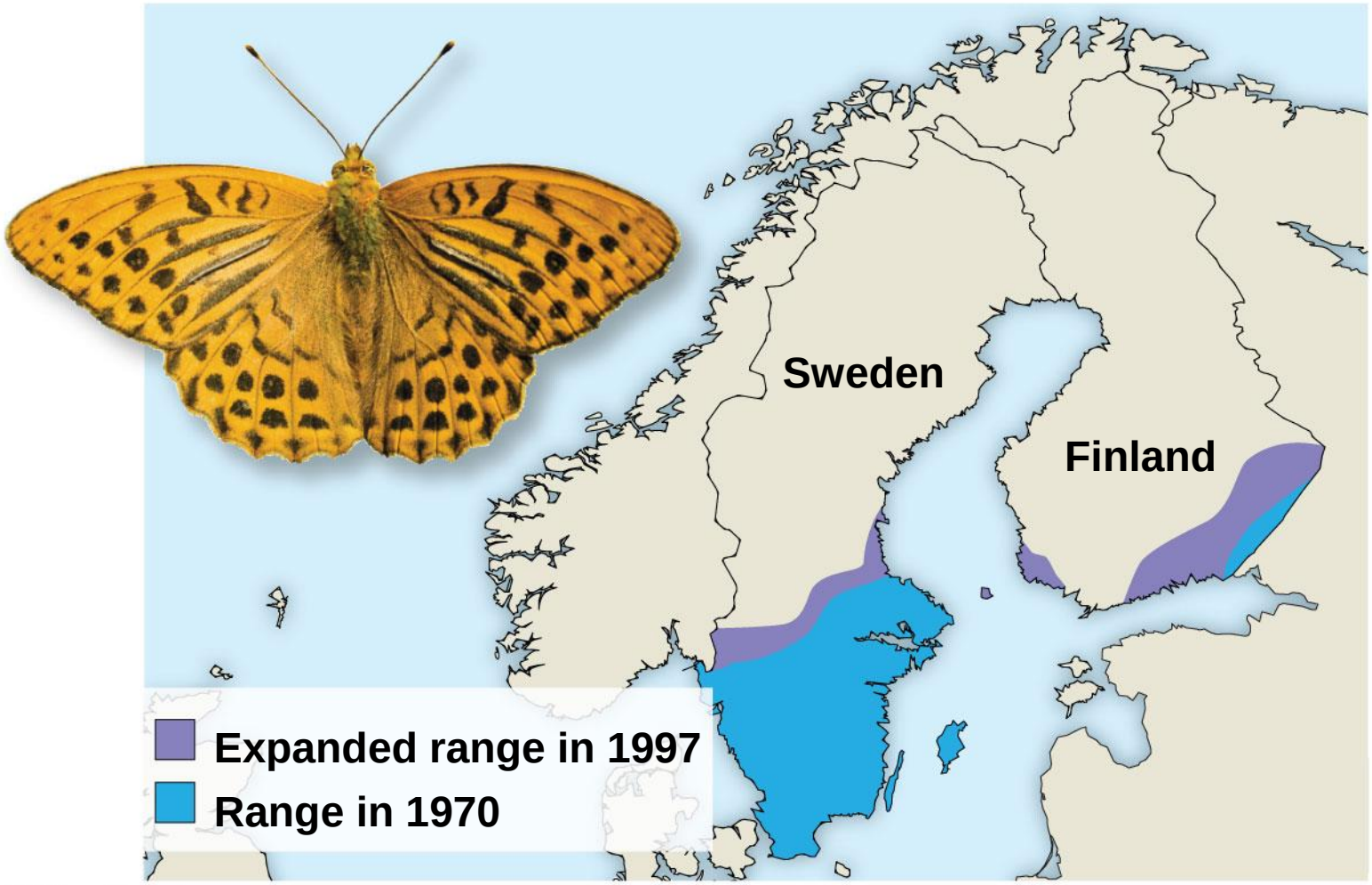


(a) 4.5° C warming over next century



(b) 6.5° C warming over next century

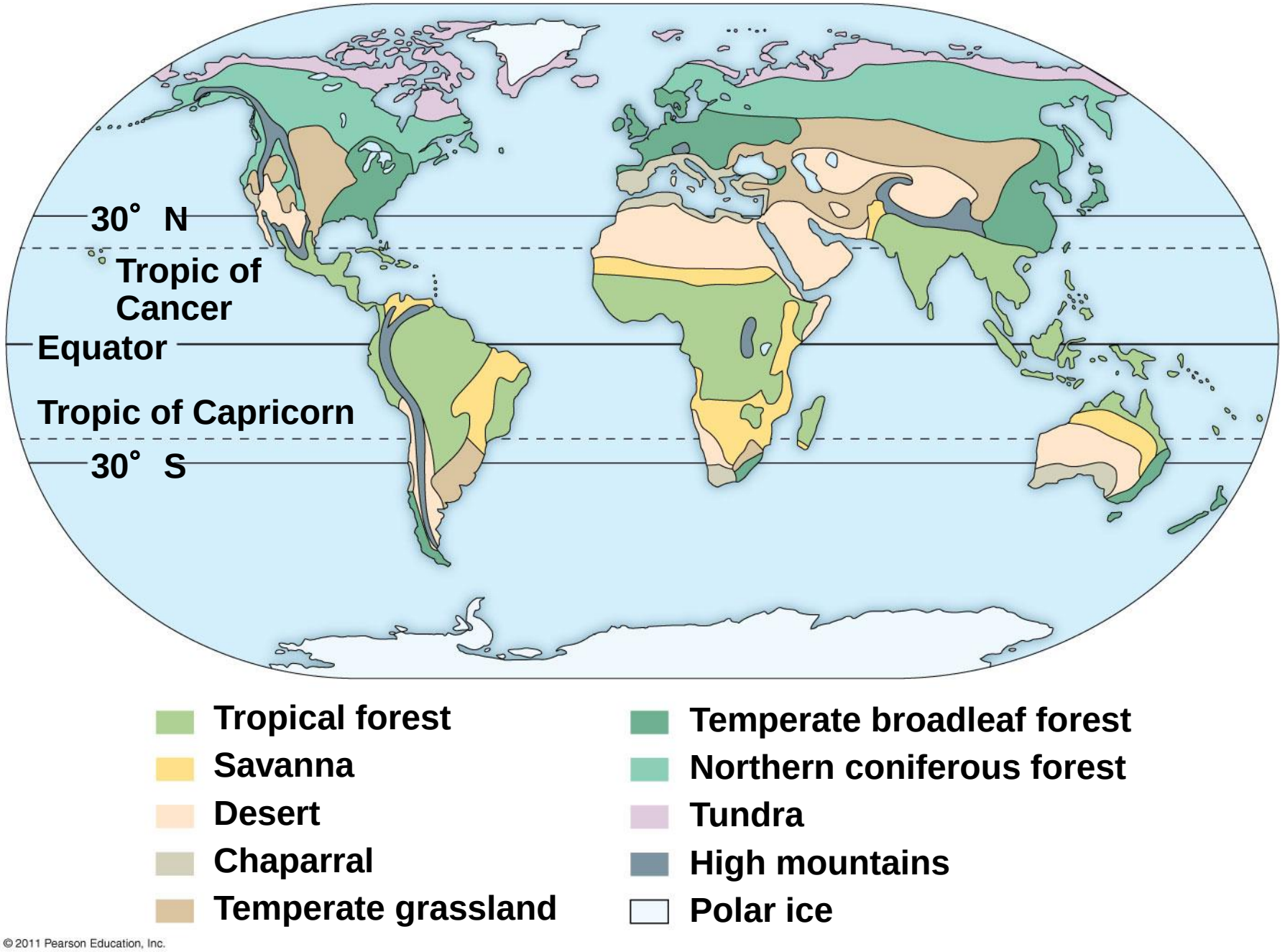
Figure 52.8



Concept 52.2: The structure and distribution of terrestrial biomes are controlled by climate and disturbance

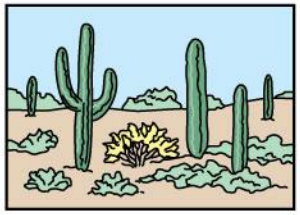
- **Biomes** are major life zones characterized by vegetation type (terrestrial biomes) or physical environment (aquatic biomes)
- Climate is very important in determining why terrestrial biomes are found in certain areas

Figure 52.9



- A **climograph** plots the temperature and precipitation in a region
- Biomes are affected not just by average temperature and precipitation, but also by the pattern of temperature and precipitation through the year

Figure 52.10



Desert

Temperate grassland

Tropical forest

Annual mean temperature (° C)

30

15

0

–15

0

100

200

300

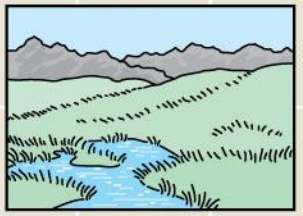
400

Annual mean precipitation (cm)

Temperate broadleaf forest

Northern coniferous forest

Arctic and alpine tundra



General Features of Terrestrial Biomes

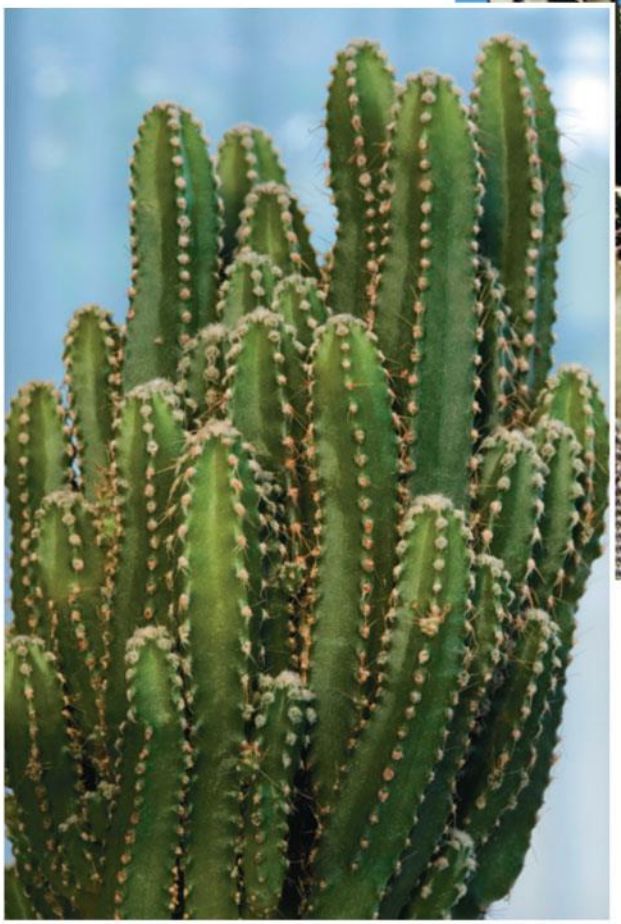
- Terrestrial biomes are often named for major physical or climatic factors and for vegetation
- Terrestrial biomes usually grade into each other, without sharp boundaries
- The area of intergradation, called an **ecotone**, may be wide or narrow

- Vertical layering is an important feature of terrestrial biomes, and in a forest it might consist of an upper **canopy**, low-tree layer, shrub understory, ground layer of herbaceous plants, forest floor, and root layer
- Layering of vegetation in all biomes provides diverse habitats for animals
- Biomes are dynamic and usually exhibit extensive patchiness

- Similar characteristics can arise in distant biomes through convergent evolution
  - For example, cacti in North America and euphorbs in African deserts appear similar but are from different evolutionary lineages

Figure 52.11

▲ ***Euphorbia canariensis***



◀ ***Cereus peruvianus***

Disturbance and Terrestrial Biomes

- **Disturbance** is an event such as a storm, fire, or human activity that changes a community
  - For example, frequent fires can kill woody plants and maintain the characteristic vegetation of a savanna
  - For example, fires and outbreaks of pests create gaps in forests that allow different species to grow
- Fire suppression has changed the vegetation of the Great Plains

Terrestrial Biomes

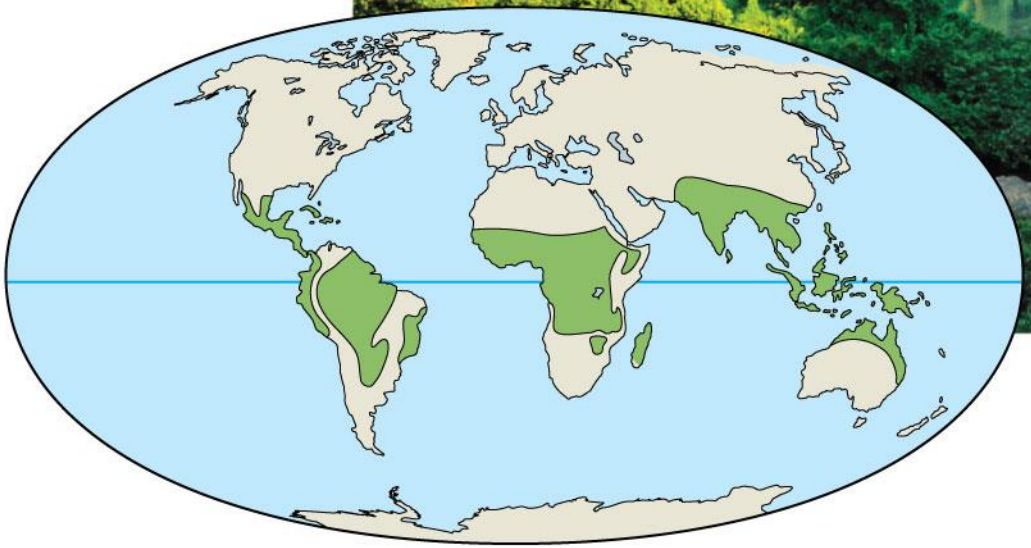
- Terrestrial biomes can be characterized by distribution, precipitation, temperature, plants, and animals

Tropical Forest

- Distribution is in equatorial and subequatorial regions
- In **tropical rain forests**, rainfall is relatively constant, while in **tropical dry forests** precipitation is highly seasonal
- Temperature is high year-round (25–29°C) with little seasonal variation

- Tropical forests are vertically layered, and competition for light is intense
- Tropical forests are home to millions of animal species, including an estimated 5–30 million still undescribed species of insects, spiders, and other arthropods
- Rapid human population growth is now destroying many tropical forests

Figure 52.12a



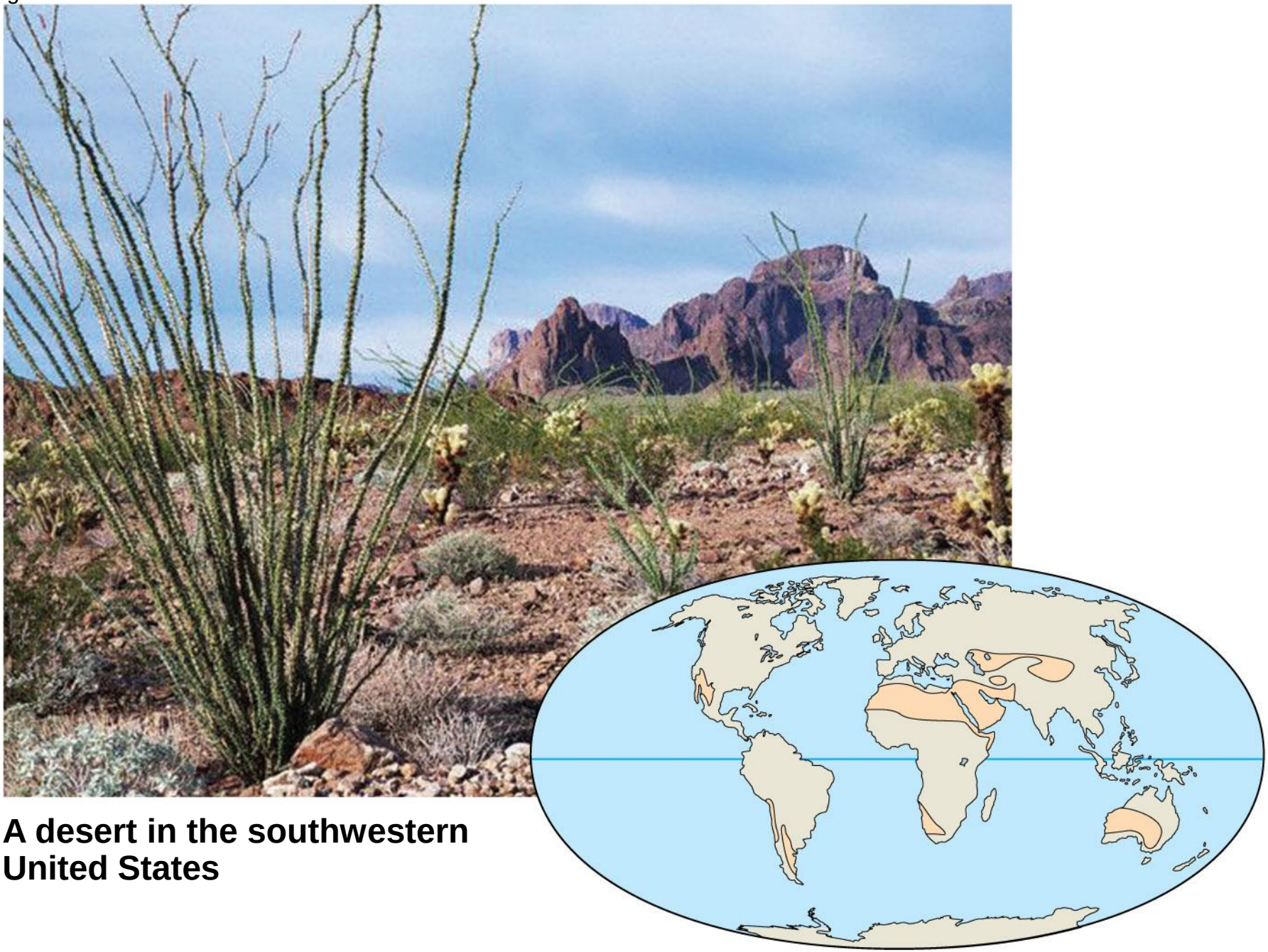
A tropical rain forest in Borneo

Desert

- **Deserts** occur in bands near 30° north and south of the equator, and in the interior of continents
- Precipitation is low and highly variable, generally less than 30 cm per year
- Deserts may be hot or cold

- Desert plants are adapted for heat and desiccation tolerance, water storage, and reduced leaf surface area
- Common desert animals include many kinds of snakes and lizards, scorpions, ants, beetles, migratory and resident birds, and seed-eating rodents; many are nocturnal
- Urbanization and conversion to irrigated agriculture have reduced the natural biodiversity of some deserts

Figure 52.12b



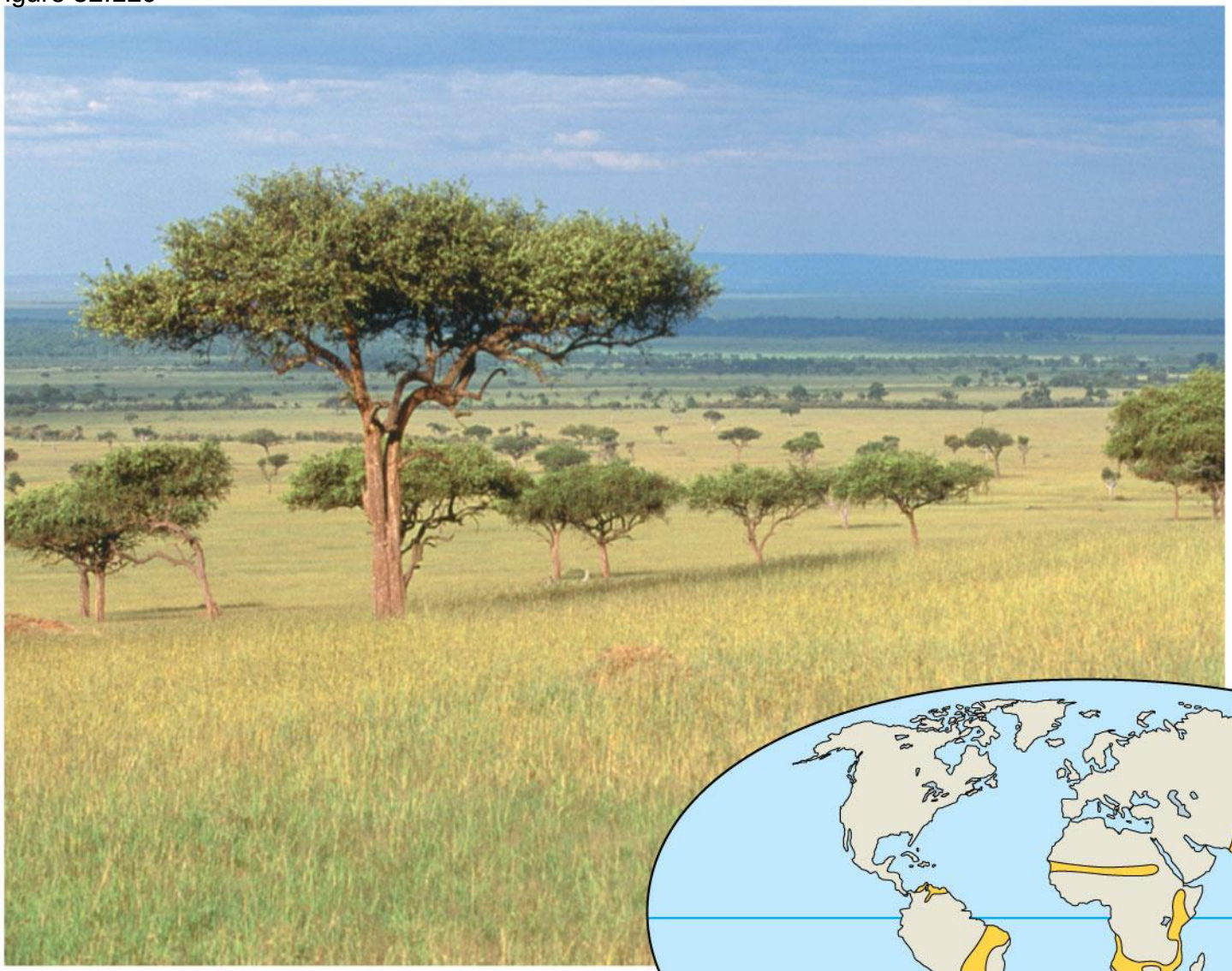
A desert in the southwestern United States

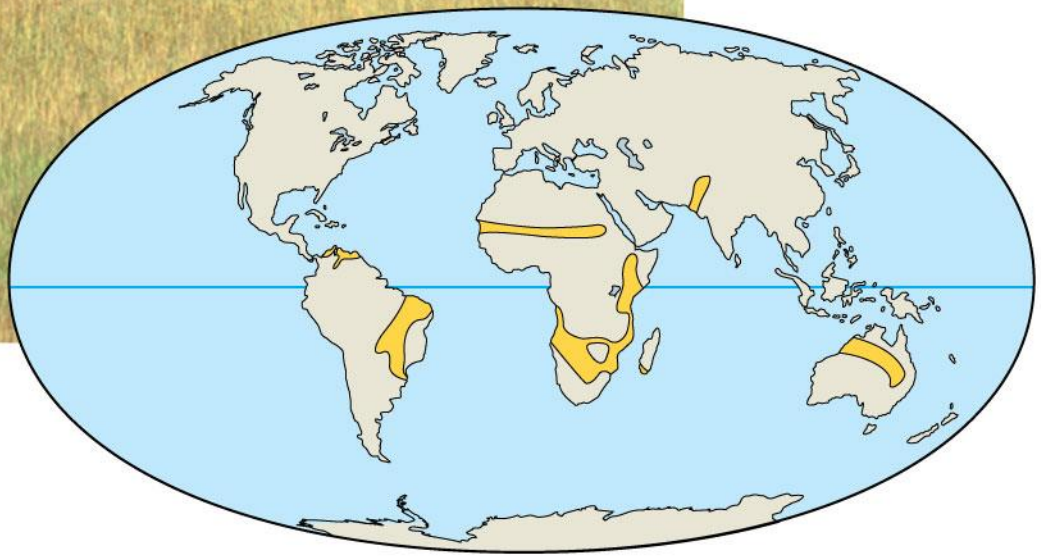
Savanna

- Equatorial and subequatorial regions
- **Savanna** precipitation is seasonal
- Temperature averages (24–29°C) but is more seasonally variable than in the tropics

- Grasses and forbs make up most of the ground cover
- The dominant plant species are fire-adapted and tolerant of seasonal drought
- Common inhabitants include insects and mammals such as wildebeests, zebras, lions, and hyenas
- Fires set by humans may help maintain this biome

Figure 52.12c





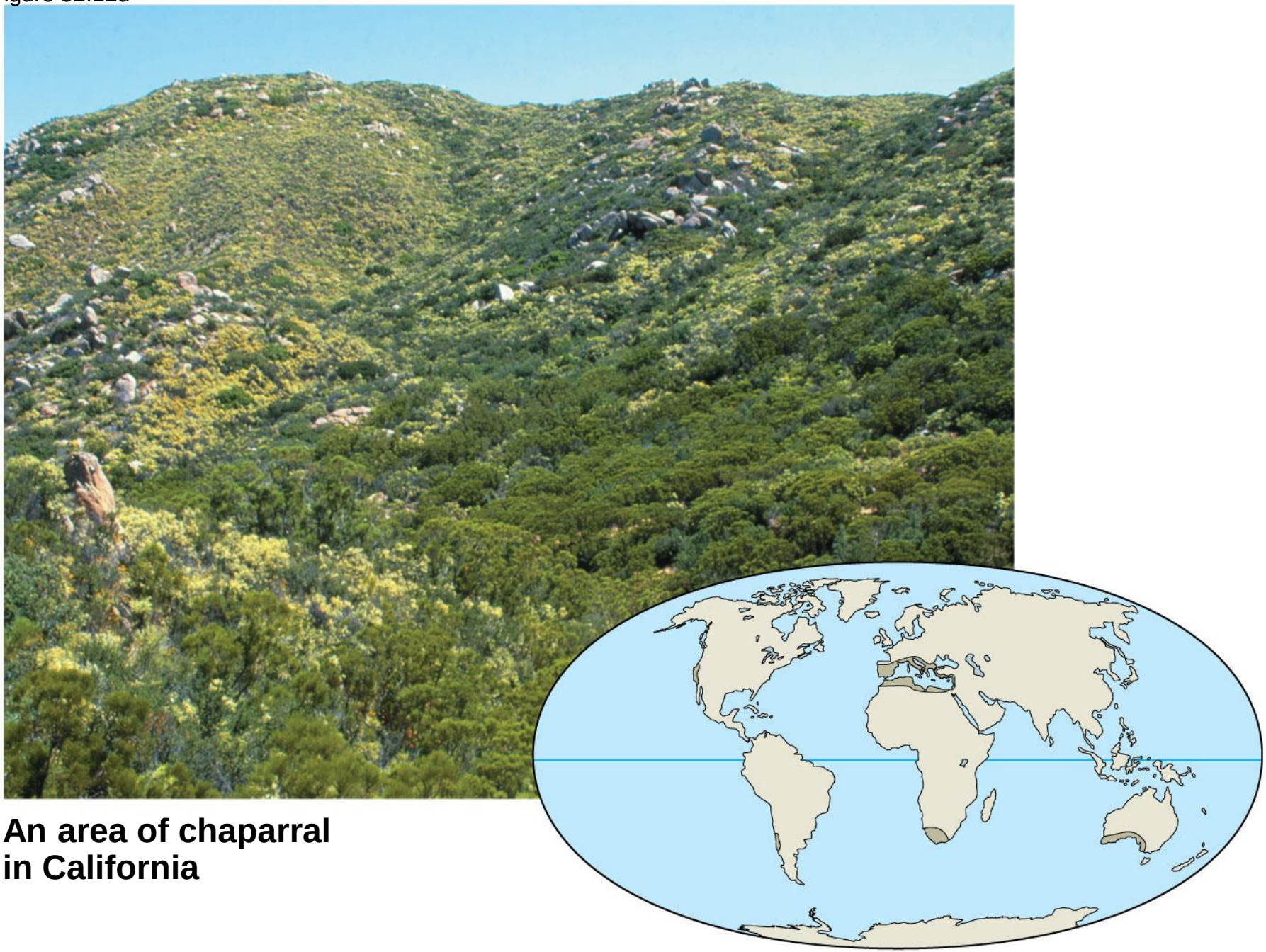
A savanna in Kenya

Chaparral

- **Chaparral** occurs in midlatitude coastal regions on several continents
- Precipitation is highly seasonal with rainy winters and dry summers
- Summer is hot (30°C+); fall, winter, and spring are cool (10–12°C)

- The chaparral is dominated by shrubs, small trees, grasses, and herbs; many plants are adapted to fire and drought
- Animals include amphibians, birds and other reptiles, insects, small mammals, and browsing mammals
- Humans have reduced chaparral areas through agriculture and urbanization

Figure 52.12d



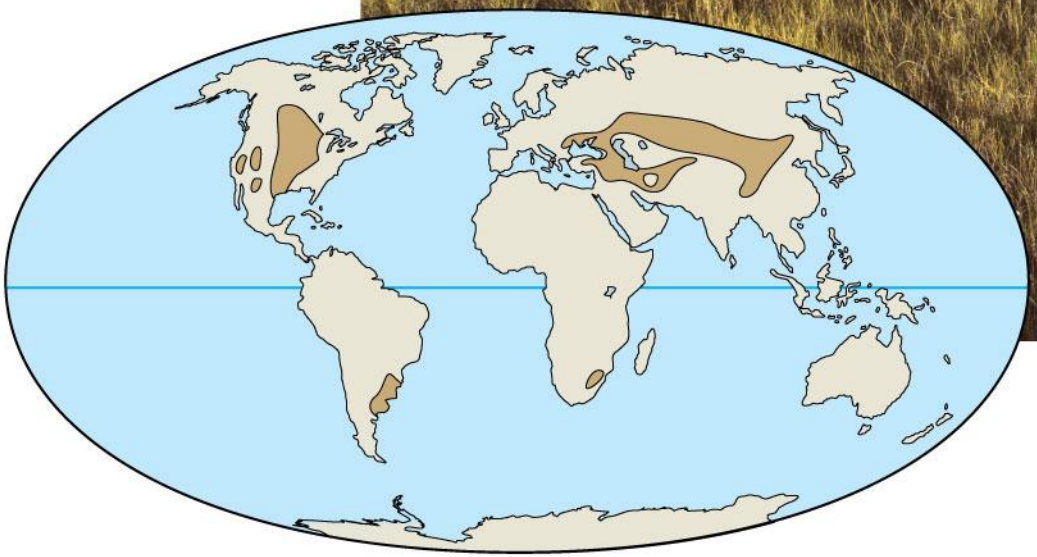
An area of chaparral in California

Temperate Grassland

- **Temperate grasslands** are found on many continents
- Precipitation is highly seasonal
- Winters are cold (often below –10°C) and dry; summers are hot (often near 30°C) and wet

- The dominant plants, grasses and forbs, are adapted to droughts and fire
- Native mammals include large grazers such as bison and wild horses and small burrowers such as prairie dogs
- Most grasslands have been converted to farmland

Figure 52.12e



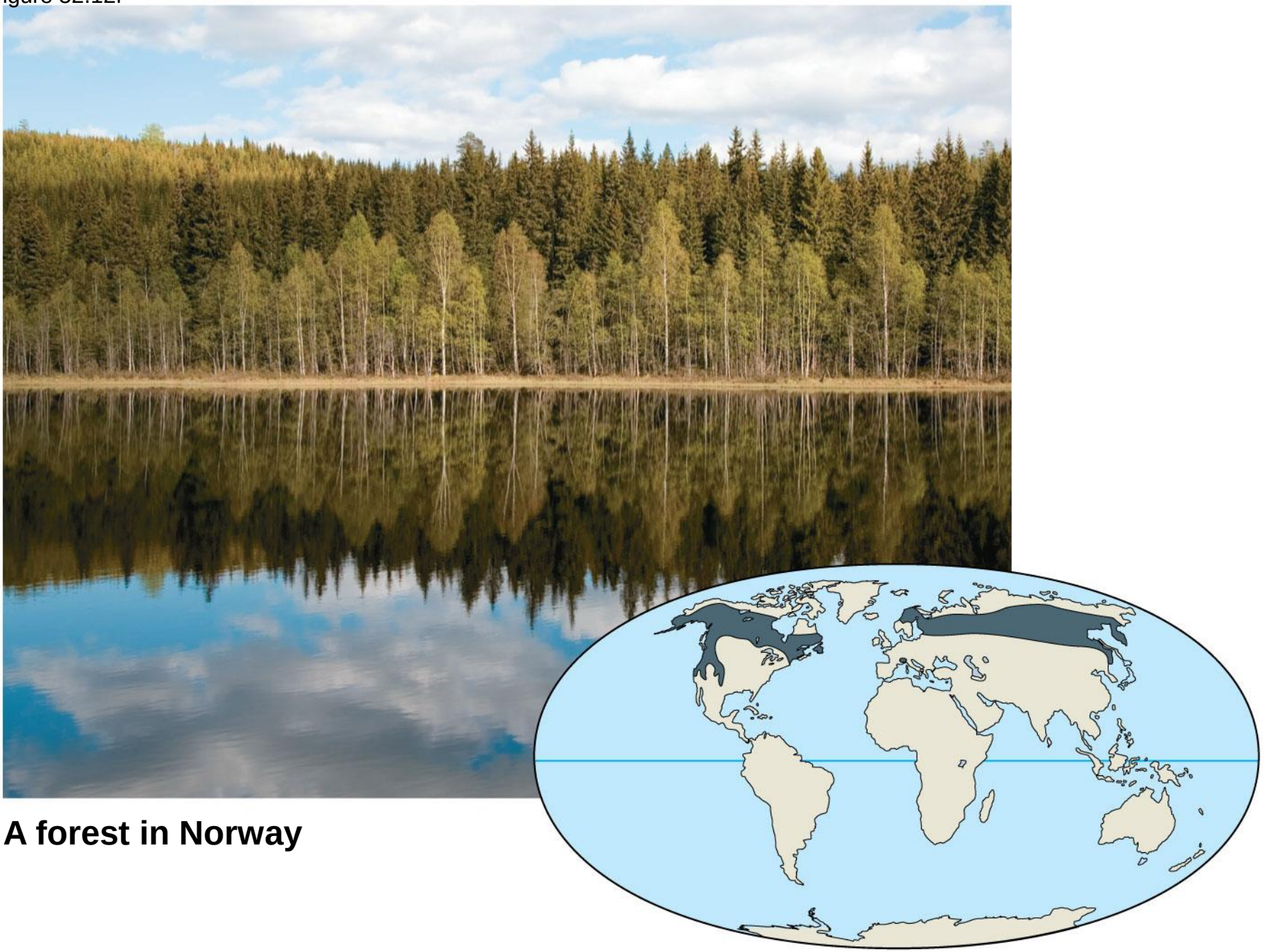
Grasslands National Park, Saskatchewan

Northern Coniferous Forest

- The **northern coniferous forest**, or taiga, spans northern North America and Eurasia and is the largest terrestrial biome on Earth
- Precipitation varies; some have periodic droughts and others, especially near coasts, are wet
- Winters are cold; summers may be hot (e.g., Siberia ranges from –50°C to 20°C)

- Conifers such as pine, spruce, fir, and hemlock dominate
- The conical shape of conifers prevents too much snow from accumulating and breaking their branches
- Animals include migratory and resident birds and large mammals such as moose, brown bears, and Siberian tigers
- Some forests are being logged at an alarming rate

Figure 52.12f



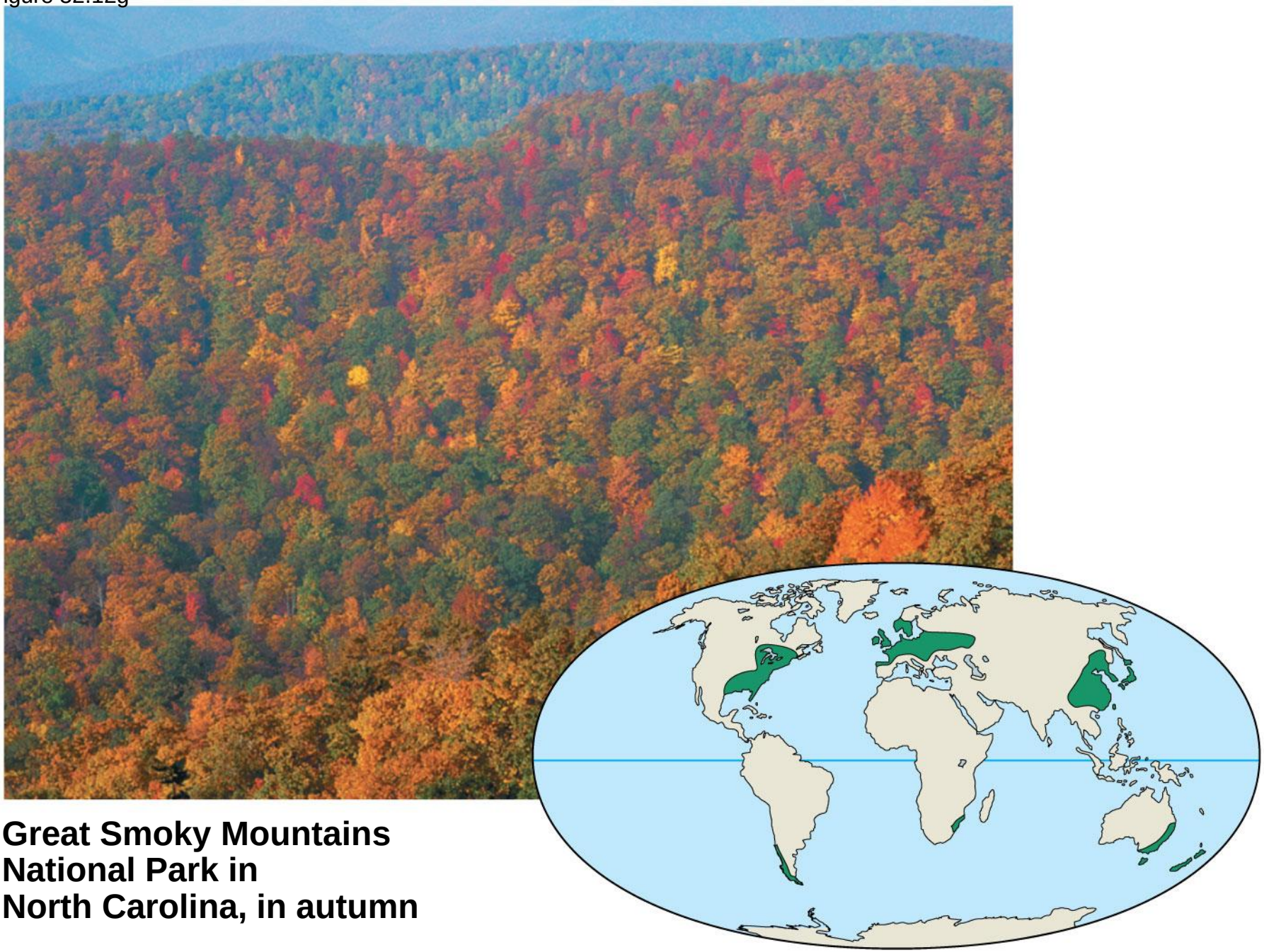
A forest in Norway

Temperate Broadleaf Forest

- **Temperate broadleaf forest** is found at midlatitudes in the Northern Hemisphere, with smaller areas in Chile, South Africa, Australia, and New Zealand
- Significant amounts of precipitation fall during all seasons as rain or snow
- Winters average 0°C; summers are hot and humid (near 35°C)

- Vertical layers are dominated by deciduous trees in the Northern Hemisphere and evergreen eucalyptus in Australia
- Mammals, birds, and insects make use of all vertical layers in the forest
- In the Northern Hemisphere, many mammals hibernate in the winter
- These forests have been heavily settled on all continents but are recovering in places

Figure 52.12g



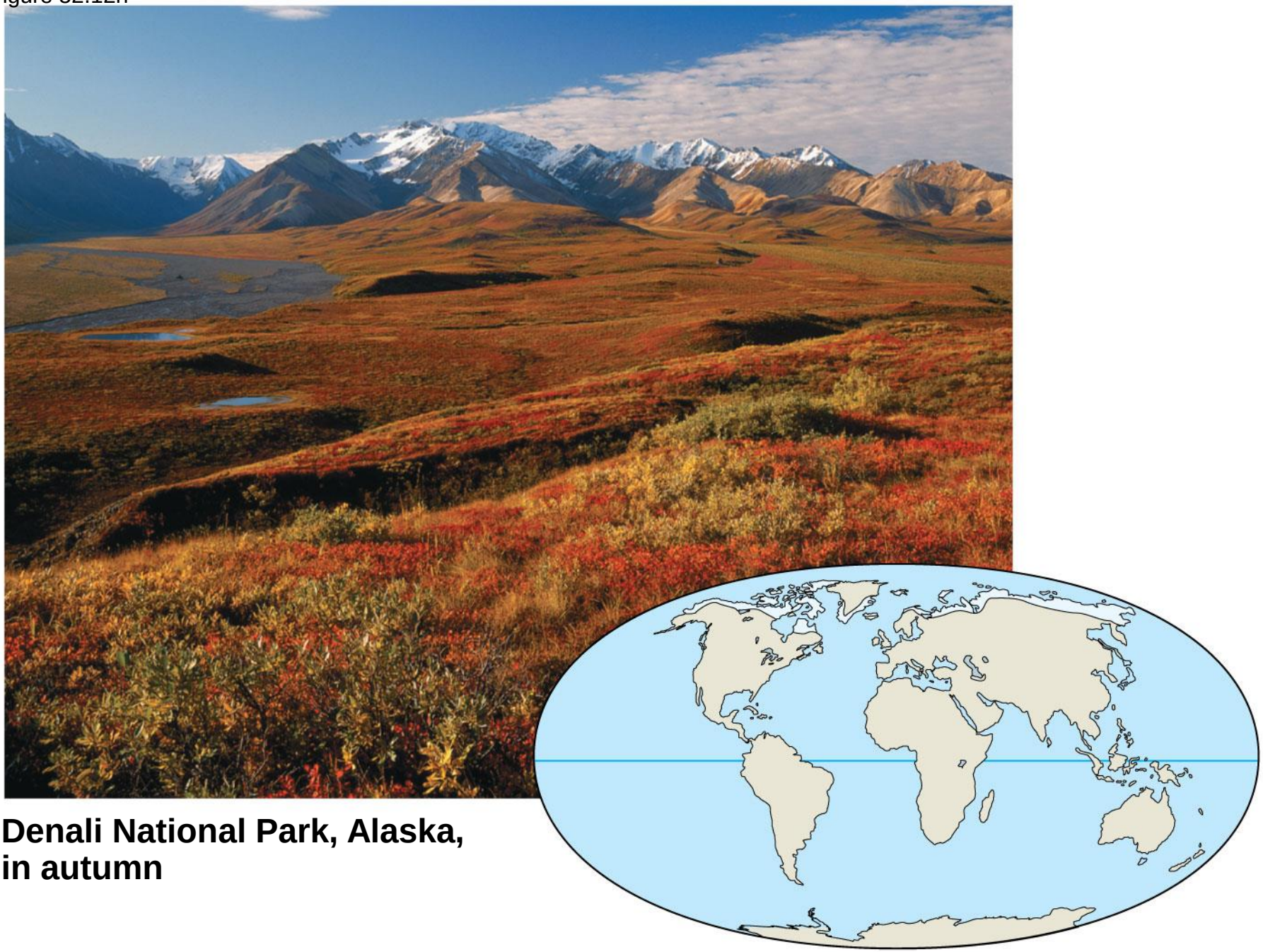
Great Smoky Mountains National Park in North Carolina, in autumn

Tundra

- **Tundra** covers expansive areas of the Arctic; alpine tundra exists on high mountaintops at all latitudes
- Precipitation is low in arctic tundra and higher in alpine tundra
- Winters are cold (below –30°C); summers are relatively cool (less than 10°C)

- **Permafrost**, a permanently frozen layer of soil, prevents water infiltration
- Vegetation is herbaceous (mosses, grasses, forbs, dwarf shrubs and trees, and lichen) and supports birds, grazers, and their predators
- Mammals include musk oxen, caribou, reindeer, bears, wolves, and foxes; many migratory bird species nest in the summer
- Settlement is sparse, but tundra has become the focus of oil and mineral extraction

Figure 52.12h



Denali National Park, Alaska, in autumn

Concept 52.3: Aquatic biomes are diverse and dynamic systems that cover most of Earth

- Aquatic biomes account for the largest part of the biosphere in terms of area
- They show less latitudinal variation than terrestrial biomes
- Marine biomes have salt concentrations of about 3%
- The largest marine biome is made of oceans, which cover about 75% of Earth's surface and have an enormous impact on the biosphere

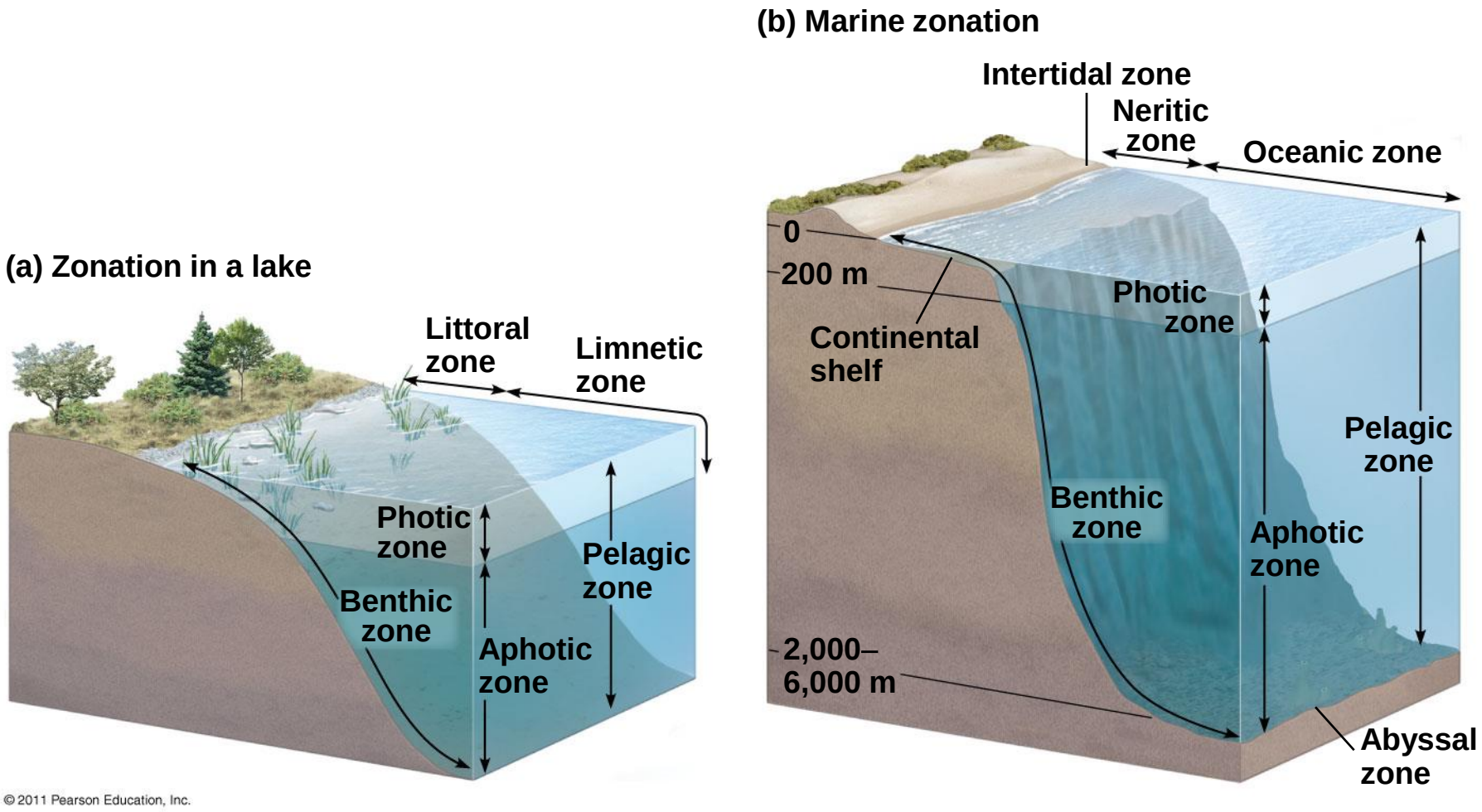
- Freshwater biomes have salt concentrations of less than 0.1%
- Freshwater biomes are closely linked to soils and the biotic components of the surrounding terrestrial biome

Zonation in Aquatic Biomes

- Many aquatic biomes are stratified into zones or layers defined by light penetration, temperature, and depth
- The upper **photic zone** has sufficient light for photosynthesis, while the lower **aphotic zone** receives little light
- The photic and aphotic zones make up the **pelagic zone**
- Deep in the aphotic zone lies the **abyssal zone** with a depth of 2,000 to 6,000 m

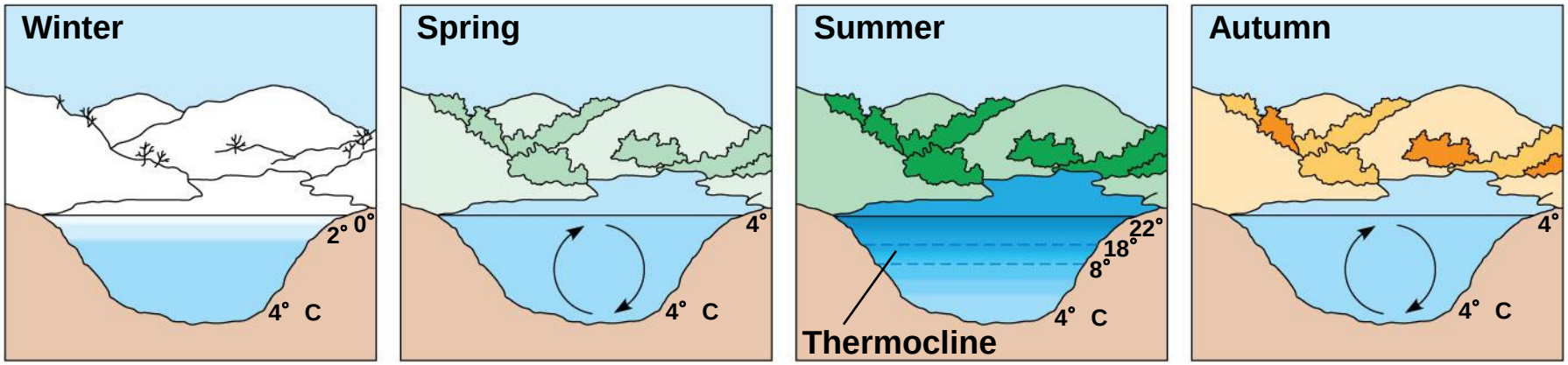
- The organic and inorganic sediment at the bottom of all aquatic zones is called the **benthic zone**
- The communities of organisms in the benthic zone are collectively called the **benthos**
- **Detritus**, dead organic matter, falls from the productive surface water and is an important source of food

Figure 52.13



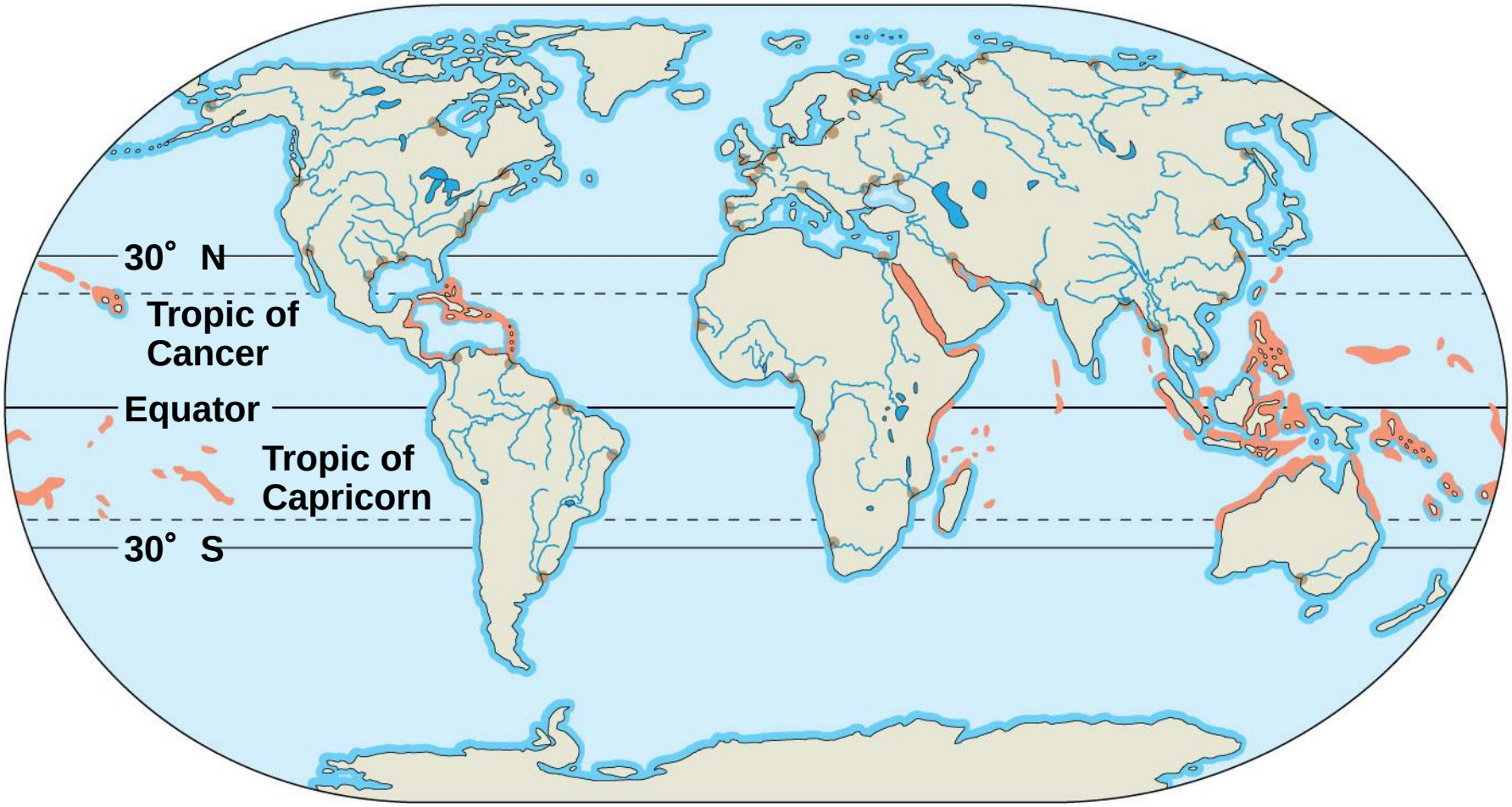
- In oceans and most lakes, a temperature boundary called the **thermocline** separates the warm upper layer from the cold deeper water
- Many lakes undergo a semiannual mixing of their waters called **turnover**
- Turnover mixes oxygenated water from the surface with nutrient-rich water from the bottom

Figure 52.14



- Communities in aquatic biomes vary with depth, light penetration, distance from shore, and position in the pelagic or benthic zone
- Most organisms occur in the relatively shallow photic zone
- The aphotic zone in oceans is extensive but harbors little life

Figure 52.15



Aquatic Biomes

- Major aquatic biomes can be characterized by their physical environment, chemical environment, geological features, photosynthetic organisms, and heterotrophs

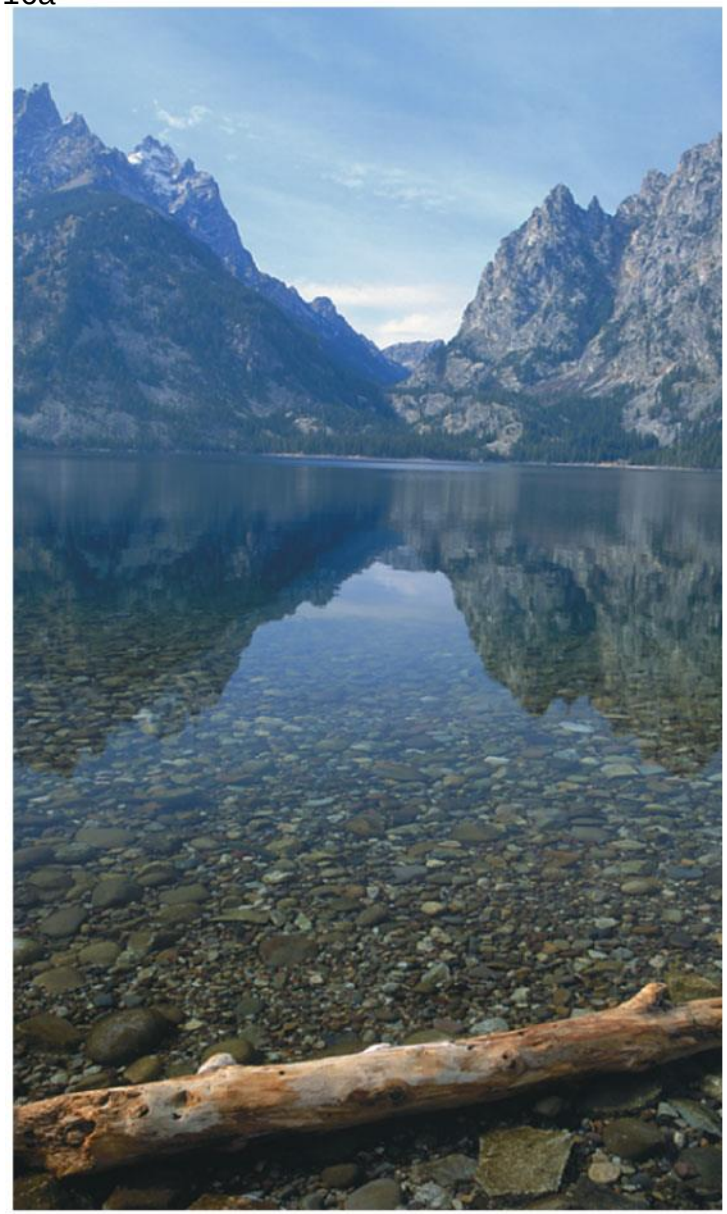
Lakes

- Size varies from small ponds to very large lakes
- Temperate lakes may have a seasonal thermocline; tropical lowland lakes have a year-round thermocline
- **Oligotrophic lakes** are nutrient-poor and generally oxygen-rich
- **Eutrophic lakes** are nutrient-rich and often depleted of oxygen if ice covered in winter

- Eutrophic lakes have more surface area relative to depth than oligotrophic lakes
- Rooted and floating aquatic plants live in the shallow and well-lighted **littoral zone** close to shore
- Water is too deep in the **limnetic zone** to support rooted aquatic plants; small drifting animals called zooplankton graze on the phytoplankton

- Zooplankton are drifting heterotrophs that graze on the phytoplankton
- Invertebrates live in the benthic zone
- Fishes live in all zones with sufficient oxygen
- Human-induced nutrient enrichment can lead to algal blooms, oxygen depletion, and fish kills

Figure 52.16a



An oligotrophic lake in Grand Teton National Park, Wyoming

A eutrophic lake in the Okavango Delta, Botswana

Wetlands

- A **wetland** is a habitat that is inundated by water at least some of the time and that supports plants adapted to water-saturated soil
- Wetlands have high organic production and decomposition and have low dissolved oxygen
- Wetlands can develop in shallow basins, along flooded river banks, or on the coasts of large lakes and seas

- Wetlands are among the most productive biomes on Earth
- Plants include lilies, cattails, sedges, tamarack, and black spruce
- Wetlands are home to diverse invertebrates and birds, as well as otters, frogs, and alligators
- Humans have destroyed up to 90% of wetlands; wetlands purify water and reduce flooding

Figure 52.16b

A basin wetland in the United Kingdom

Streams and Rivers

- The most prominent physical characteristic of streams and rivers is current
- Headwaters are generally cold, clear, turbulent, swift, and oxygen-rich; they are often narrow and rocky
- Downstream waters form rivers and are generally warmer, more turbid, and more oxygenated; they are often wide and meandering and have silty bottoms

- They may contain phytoplankton or rooted aquatic plants
- A diversity of fishes and invertebrates inhabit unpolluted rivers and streams
- Pollution degrades water quality and kills aquatic organisms
- Damming and flood control impair natural functioning of stream and river ecosystems

Figure 52.16c

A headwater stream in the Great Smoky Mountains

The Loire river (in France) far from its headwaters

Estuaries

- An **estuary** is a transition area between river and sea
- Salinity varies with the rise and fall of the tides
- Estuaries are nutrient-rich and highly productive
- Estuaries include a complex network of tidal channels, islands, natural levees, and mudflats

- Saltmarsh grasses and algae are the major producers
- An abundant supply of food attracts marine invertebrates, fish, waterfowl, and marine mammals
- Humans consume oysters, crabs, and fish
- Human interference upstream has disrupted estuaries worldwide

Figure 52.16d

An estuary in the southeastern United States

Intertidal Zones

- An **intertidal zone** is periodically submerged and exposed by the tides
- Intertidal organisms are challenged by variations in temperature and salinity and by the mechanical forces of wave action
- Oxygen and nutrient levels are high
- Substrate varies from rocky to sandy

- Sandy zones support sea grass and algae; rocky zones support attached marine algae
- In rocky zones, many animals have structural adaptations for attaching to the hard substrate
- In sandy zones, worms, clams, and crustaceans bury themselves in sand
- Other animals include sponges, sea anemones, echinoderms, and small fishes
- Oil pollution has disrupted many intertidal areas

Figure 52.16e

Rocky intertidal zone on the Oregon coast

Oceanic Pelagic Zone

- The **oceanic pelagic zone** is constantly mixed by wind-driven oceanic currents
- Oxygen levels are high
- Turnover in temperate oceans renews nutrients in the photic zones; year-round stratification in tropical oceans leads to lower nutrient concentrations
- This biome covers approximately 70% of Earth's surface

- Phytoplankton and zooplankton are the dominant organisms in this biome; also found are free-swimming animals
- Zooplankton includes protists, worms, copepods, krill, jellies, and invertebrate larvae
- Other animals include squids, fishes, sea turtles, and marine mammals
- Overfishing has depleted fish stocks
- Humans have polluted oceans with dumping of waste

Figure 52.16f

Open ocean off the island of Hawaii

Coral Reefs

- **Coral reefs** are formed from the calcium carbonate skeletons of corals (cnidarians)
- Shallow reef-building corals live in the photic zone in warm (about 20–30°C), clear water; deep–sea corals live at depths of 200–1,500 m
- Corals require high oxygen concentrations and a solid substrate for attachment
- A coral reef progresses from a fringing reef to a barrier reef to a coral atoll

Figure 52.16g

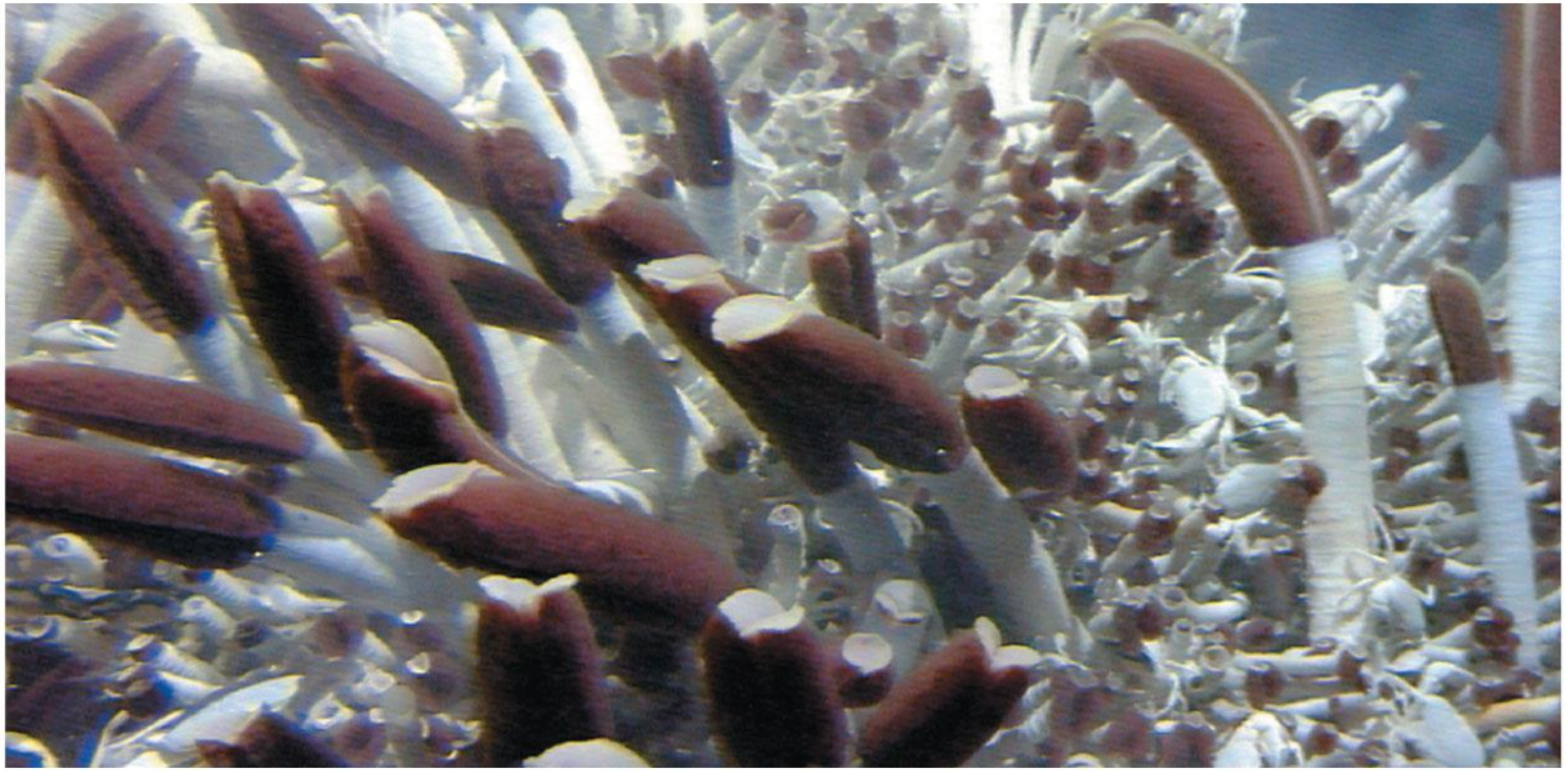
A coral reef in the Red Sea

Marine Benthic Zone

- The **marine benthic zone** consists of the seafloor below the surface waters of the coastal, or **neritic,** zone and the offshore pelagic zone
- Organisms in the very deep benthic (abyssal) zone are adapted to continuous cold and extremely high water pressure
- Substrate is mainly soft sediments; some areas are rocky

- Shallow areas contain seaweeds and filamentous algae
- Deep-sea hydrothermal vents of volcanic origin on mid-oceanic ridges are surrounded by unique chemoautotrophic prokaryotes, as well as echinoderms and arthropods
- Neritic benthic communities include invertebrates and fishes
- Overfishing and dumping of waste have depleted fish populations

Figure 52.16h



A deep-sea hydrothermal vent community

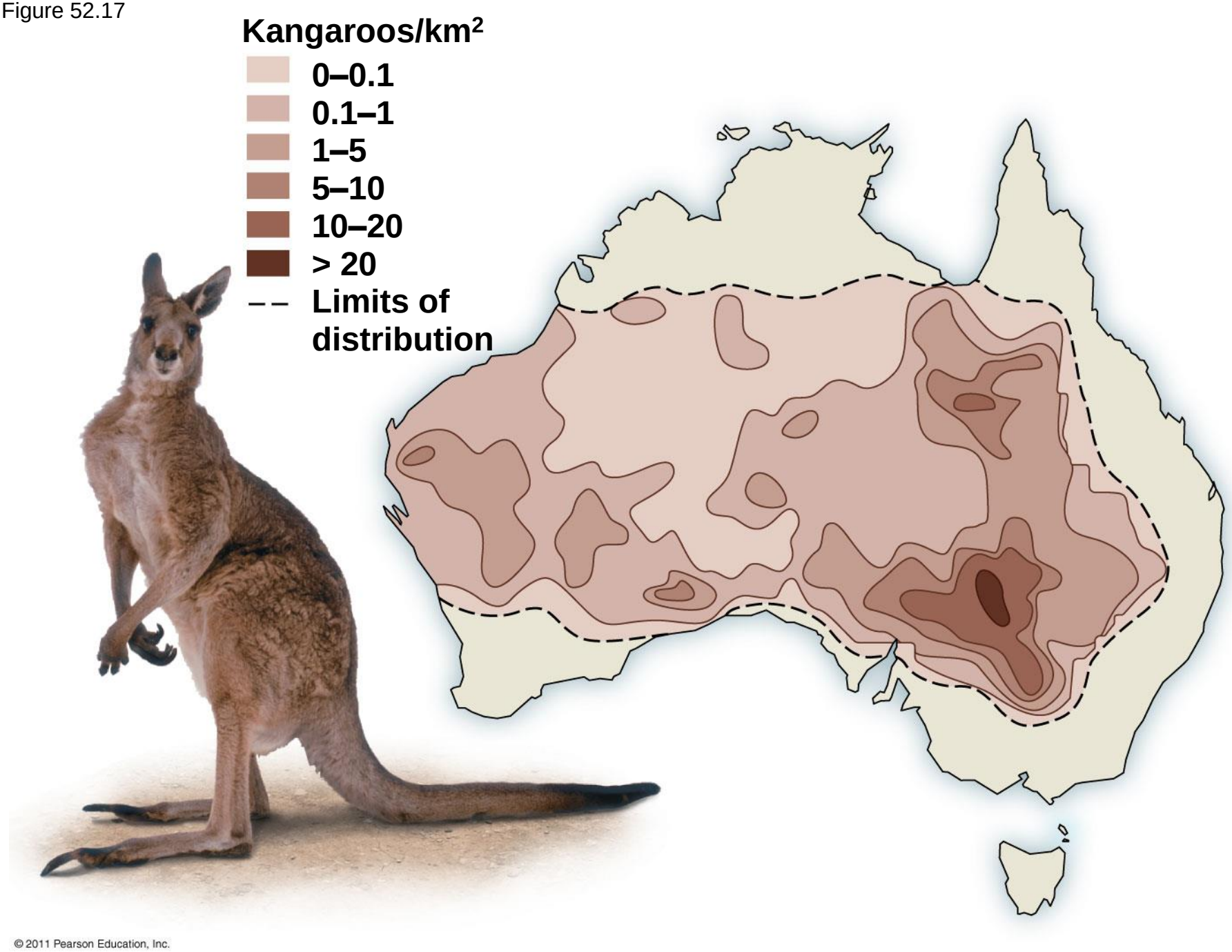
Concept 52.4: Interactions between organisms and the environment limit the distribution of species

- Species distributions are the result of ecological and evolutionary interactions through time
- Ecological time is the minute-to-minute time frame of interactions between organisms and the environment
- Evolutionary time spans many generations and captures adaptation through natural selection

- Events in ecological time can lead to evolution
- For example, Galápagos finches with larger breaks were more likely to survive a drought as they could eat the available larger seeds
- As a result, the average beak size was larger in the next generation
- This resulted in an evolutionary change

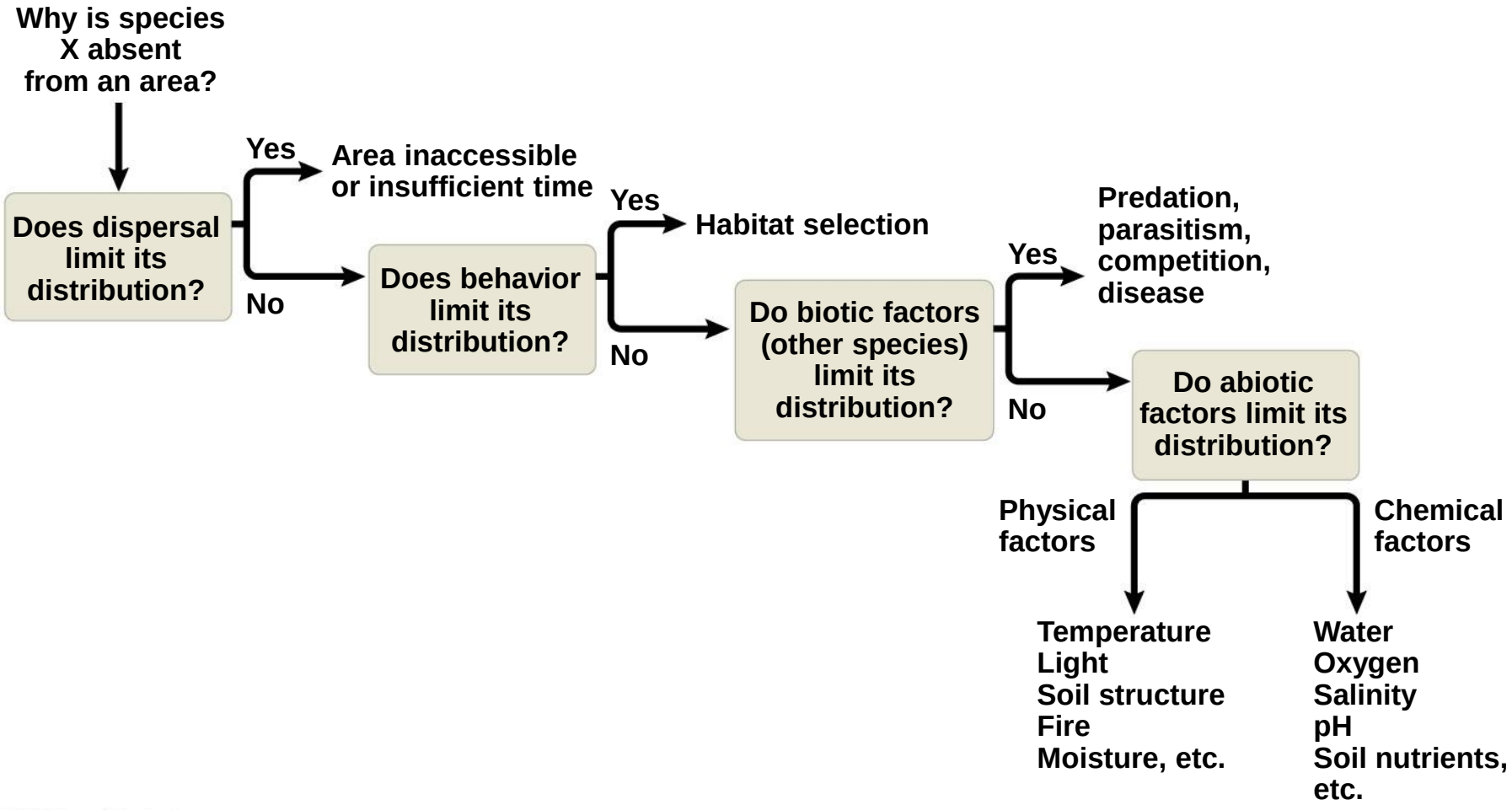
- Both biotic and abiotic factors influence species distribution
  - For example, climate, interspecific interactions, and other factors affect the distribution of the red kangaroo

Figure 52.17



- Ecologists ask questions about where species occur and why species occur where they do

Figure 52.18



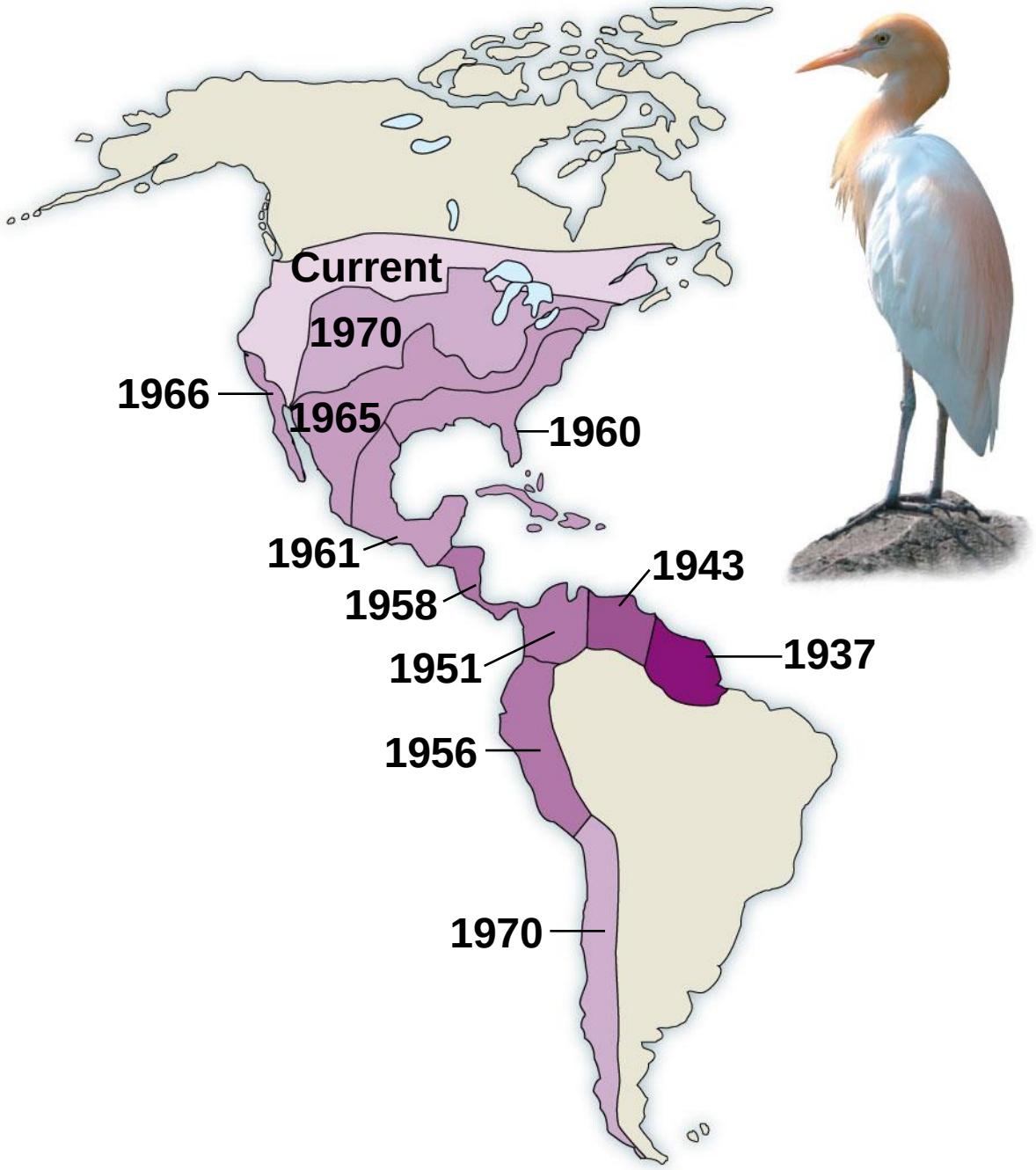
Dispersal and Distribution

- **Dispersal** is the movement of individuals away from centers of high population density or from their area of origin
- Dispersal contributes to the global distribution of organisms

Natural Range Expansions and Adaptive Radiation

- Natural range expansions show the influence of dispersal on distribution
  - For example, cattle egrets arrived in the Americas in the late 1800s and have expanded their distribution
- In rare cases, long-distance dispersal can lead to adaptive radiation
  - For example, Hawaiian silverswords are a diverse group descended from an ancestral North American tarweed

Figure 52.19



Species Transplants

- Species transplants include organisms that are intentionally or accidentally relocated from their original distribution
- If a transplant is successful, it indicates that its potential range is larger than its actual range
- Species transplants can disrupt the communities or ecosystems to which they have been introduced

Behavior and Habitat Selection

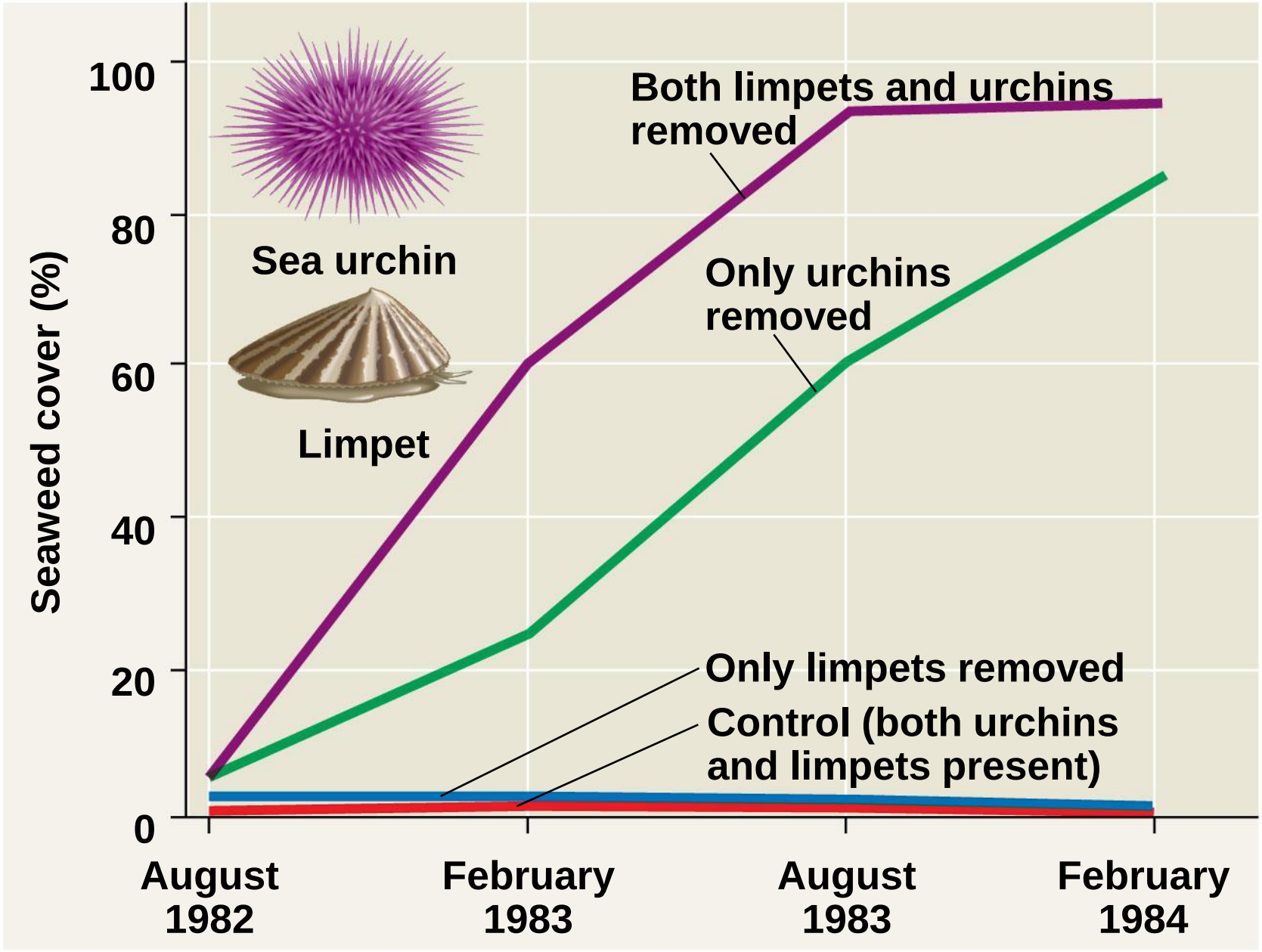
- Some organisms do not occupy all of their potential range
- Species distribution may be limited by habitat selection behavior

Biotic Factors

- Biotic factors that affect the distribution of organisms may include
  - Predation
  - Herbivory
    - For example, sea urchins can limit the distribution of seaweeds
  - Competition

Figure 52.20

RESULTS



Abiotic Factors

- Abiotic factors affecting the distribution of organisms include
  - Temperature
  - Water
  - Sunlight
  - Wind
  - Rocks and soil
- Most abiotic factors vary in space and time

Temperature

- Environmental temperature is an important factor in the distribution of organisms because of its effects on biological processes
- Cells may freeze and rupture below 0°C, while most proteins denature above 45°C
- Mammals and birds expend energy to regulate their internal temperature

Water and Oxygen

- Water availability in habitats is another important factor in species distribution
- Desert organisms exhibit adaptations for water conservation
- Water affects oxygen availability as oxygen diffuses slowly in water
- Oxygen concentrations can be low in deep oceans and deep lakes

Salinity

- Salt concentration affects the water balance of organisms through osmosis
- Most aquatic organisms are restricted to either freshwater or saltwater habitats
- Few terrestrial organisms are adapted to high-salinity habitats

Sunlight

- Light intensity and quality (wavelength) affect photosynthesis
- Water absorbs light; as a result, in aquatic environments most photosynthesis occurs near the surface
- In deserts, high light levels increase temperature and can stress plants and animals

Rocks and Soil

- Many characteristics of soil limit the distribution of plants and thus the animals that feed on them
  - Physical structure
  - pH
  - Mineral composition

Figure 52.UN01