Chapter 52

An Introduction to Ecology and the Biosphere

PowerPoint® Lecture Presentations for

Biology

Eighth Edition

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Overview: The Scope of Ecology

- **Ecology** is the scientific study of the interactions between organisms and the environment
- These interactions determine distribution of organisms and their abundance
- Ecology reveals the richness of the biosphere

The Scope of Ecological Research

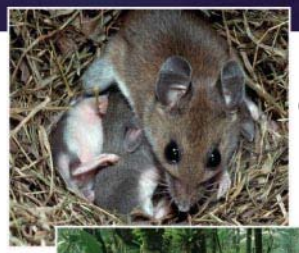
- Ecologists work at levels ranging from individual organisms to the planet

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

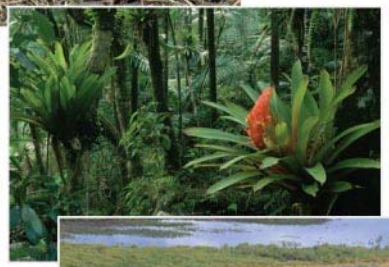
Fig. 52-1

Fig. 52-2

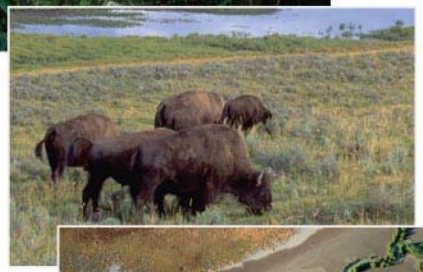
Organismal ecology



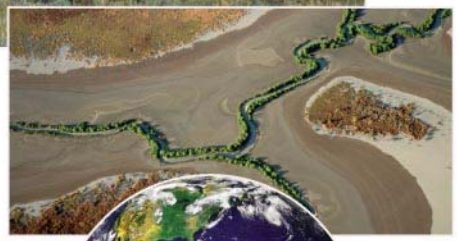
Population ecology



Community ecology



Ecosystem ecology



Landscape ecology

Global ecology

Fig. 52-2a

- A **population** is a group of individuals of the same species living in an area
- **Population ecology** focuses on factors affecting how many individuals of a species live in an area

Fig. 52-2b

- 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

Fig. 52-2c

- 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

Fig. 52-2d

- A **landscape** is a mosaic of connected ecosystems
- **Landscape ecology** deals with arrays of ecosystems and how they are arranged in a geographic region

Fig. 52-2e

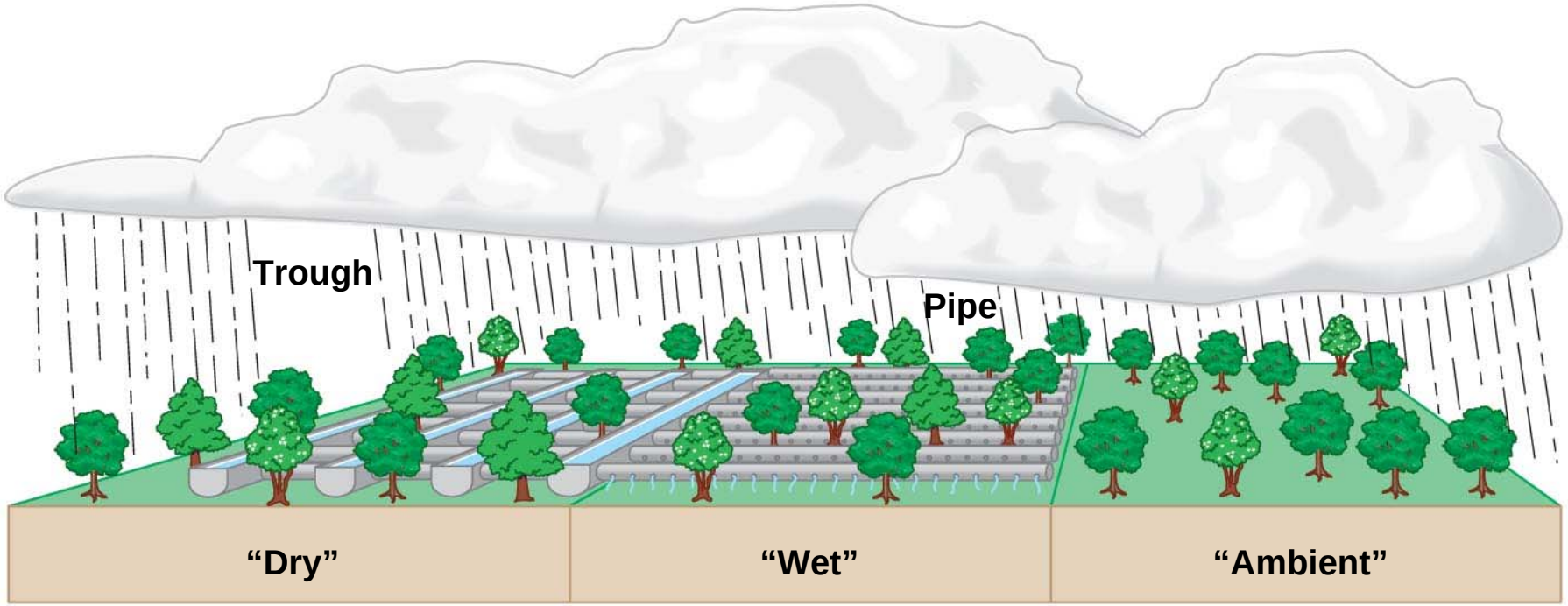
- The **biosphere** is the global ecosystem, the sum of all the planet's ecosystems
- **Global ecology** examines the influence of energy and materials on organisms across the biosphere

Fig. 52-2f

Concept 52.1: Ecology integrates all areas of biological research and informs environmental decision making

- Ecology has a long history as a descriptive science
- It is also a rigorous experimental science

Fig. 52-3



Linking Ecology and Evolutionary Biology

- Events that occur in ecological time affect life on the scale of evolutionary time

Ecology and Environmental Issues

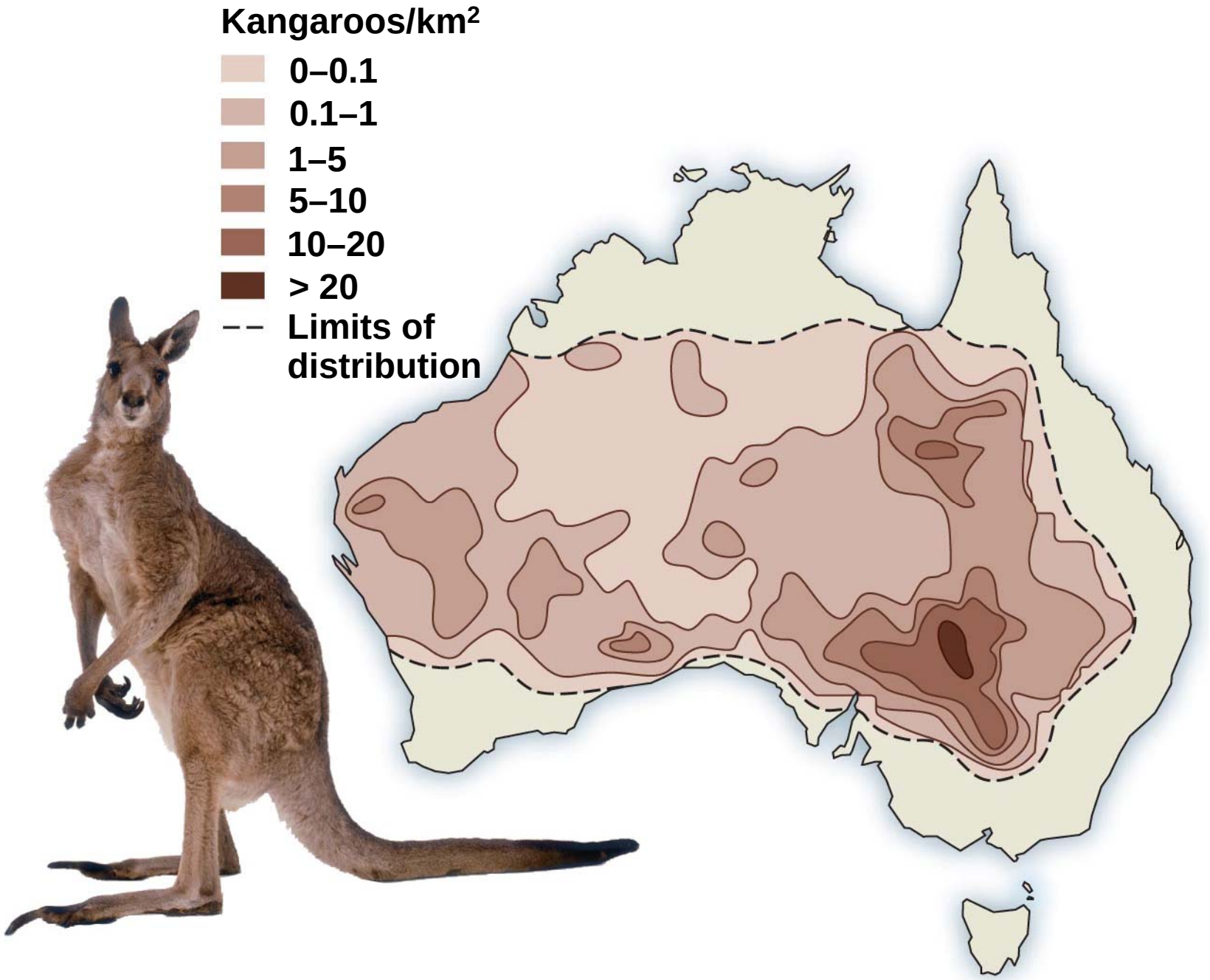
- Ecology provides the scientific understanding that underlies environmental issues
- Ecologists make a distinction between science and advocacy
- Rachel Carson is credited with starting the modern environmental movement with the publication of *Silent Spring* in 1962

Fig. 52-4

Concept 52.2: Interactions between organisms and the environment limit the distribution of species

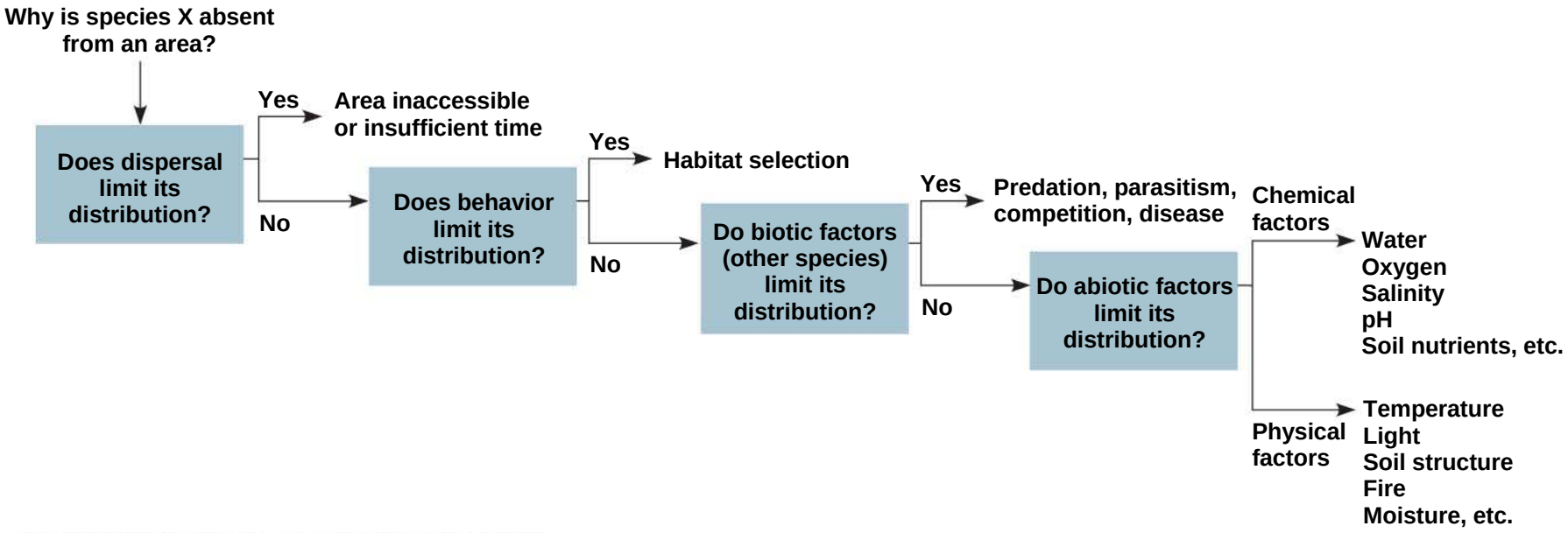
- Ecologists have long recognized global and regional patterns of distribution of organisms within the biosphere
- Biogeography is a good starting point for understanding what limits geographic distribution of species
- Ecologists recognize two kinds of factors that determine distribution: **biotic**, or living factors, and **abiotic**, or nonliving factors

Fig. 52-5



- Ecologists consider multiple factors when attempting to explain the distribution of species

Fig. 52-6



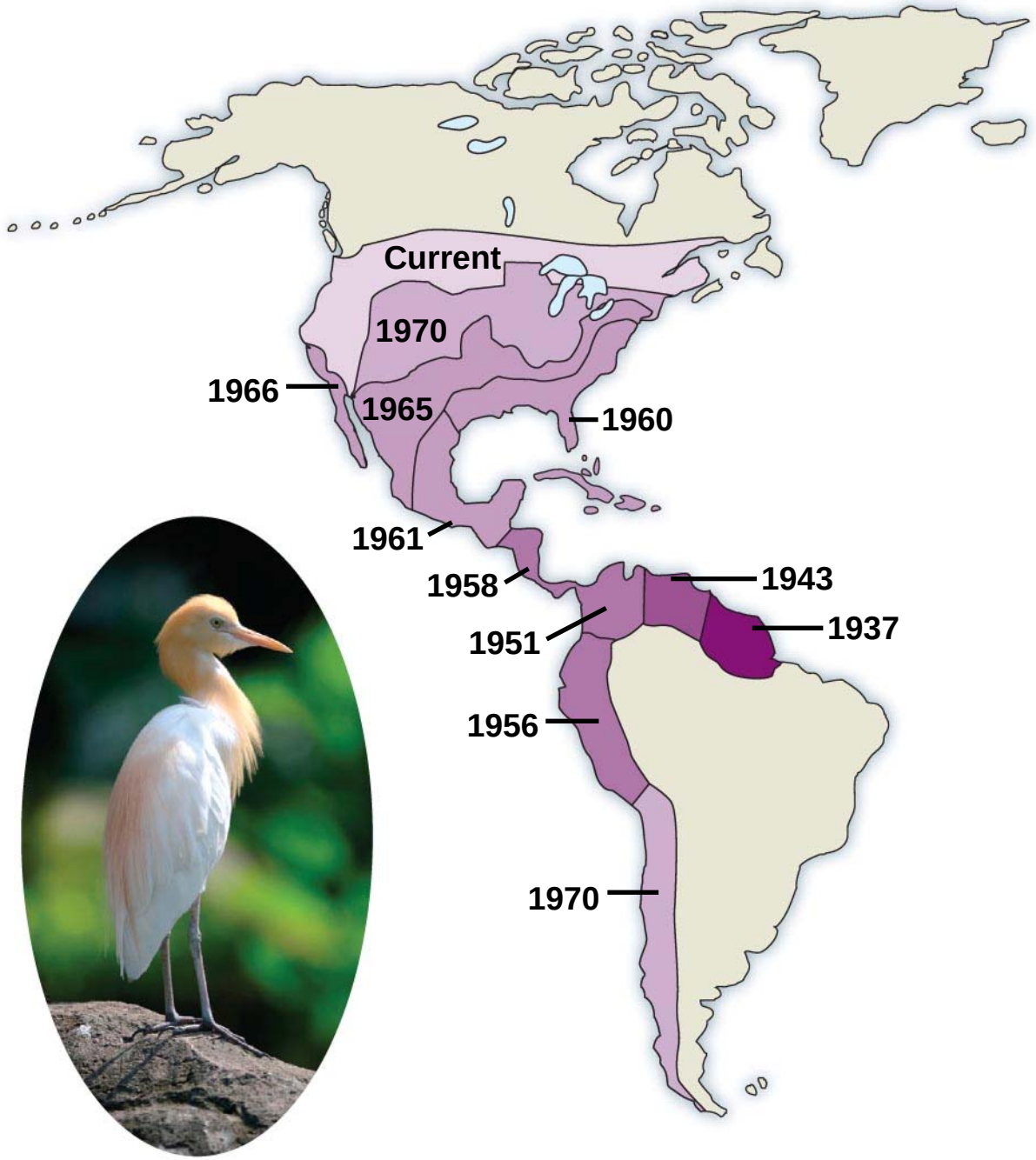
Dispersal and Distribution

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

Natural Range Expansions

- Natural range expansions show the influence of dispersal on distribution

Fig. 52-7



Species Transplants

- Species transplants include organisms that are intentionally or accidentally relocated from their original distribution
- Species transplants can disrupt the communities or ecosystems to which they have been introduced

Behavior and Habitat Selection

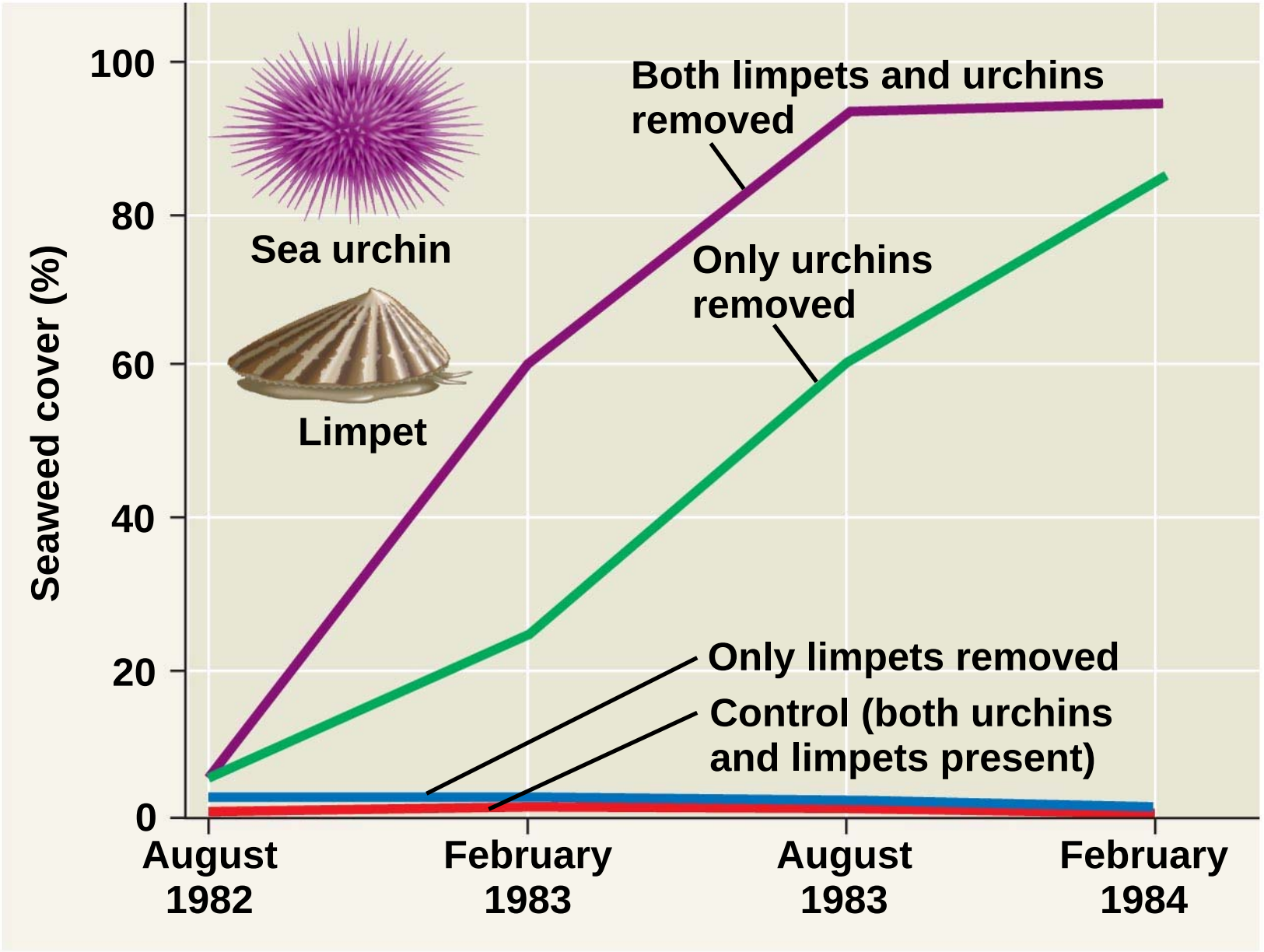
- Some organisms do not occupy all of their potential range
- Species distribution may be limited by habitat selection behavior

Biotic Factors

- Biotic factors that affect the distribution of organisms may include:
  - Interactions with other species
  - Predation
  - Competition

Fig. 52-8

RESULTS



Abiotic Factors

- Abiotic factors affecting 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 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

- Water availability in habitats is another important factor in species distribution
- Desert organisms exhibit adaptations for water conservation

Salinity

- Salt concentration affects water balance of organisms through osmosis
- Few terrestrial organisms are adapted to high-salinity habitats

Sunlight

- Light intensity and quality affect photosynthesis
- Water absorbs light, thus in aquatic environments most photosynthesis occurs near the surface
- In deserts, high light levels increase temperature and can stress plants and animals

Fig. 52-9

Rocks and Soil

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

Climate

- Four major abiotic components of **climate** are temperature, water, sunlight, and wind
- The long-term prevailing weather conditions in an area constitute its climate
- **Macroclimate** consists of patterns on the global, regional, and local 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
- Sunlight intensity plays a major part in determining the Earth's climate patterns
- More heat and light per unit of surface area reach the **tropics** than the high latitudes

Fig. 52-10a

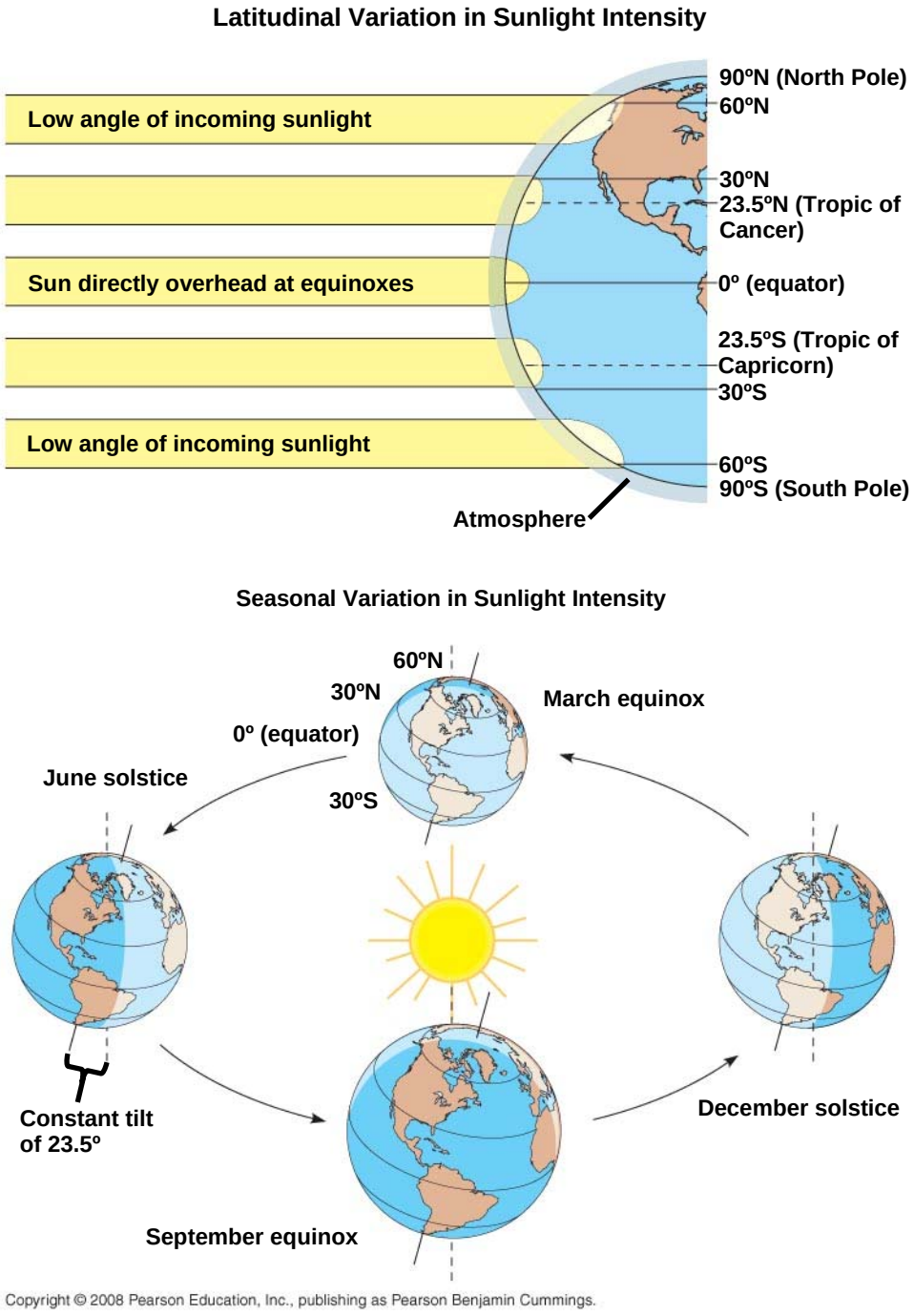
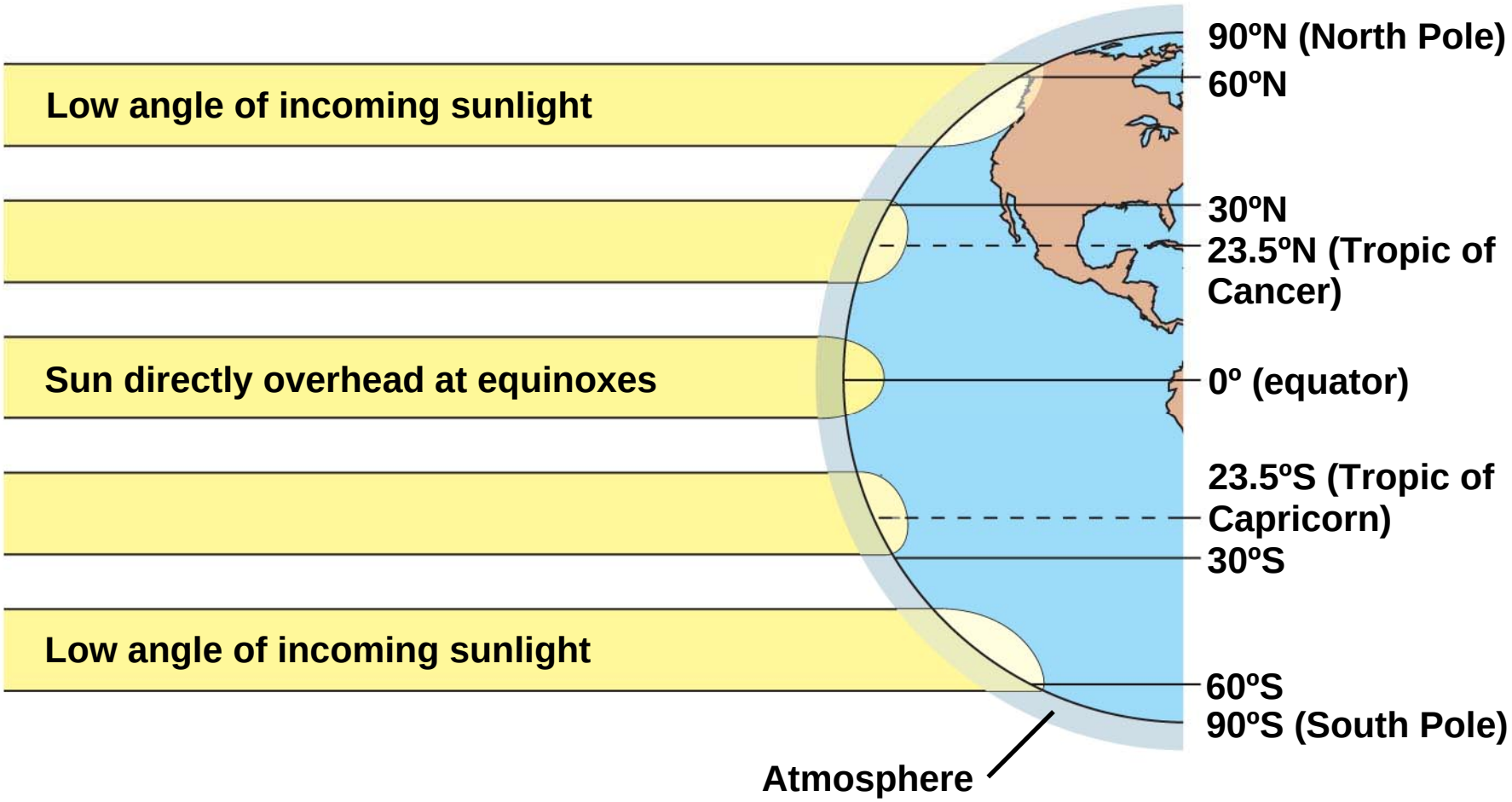
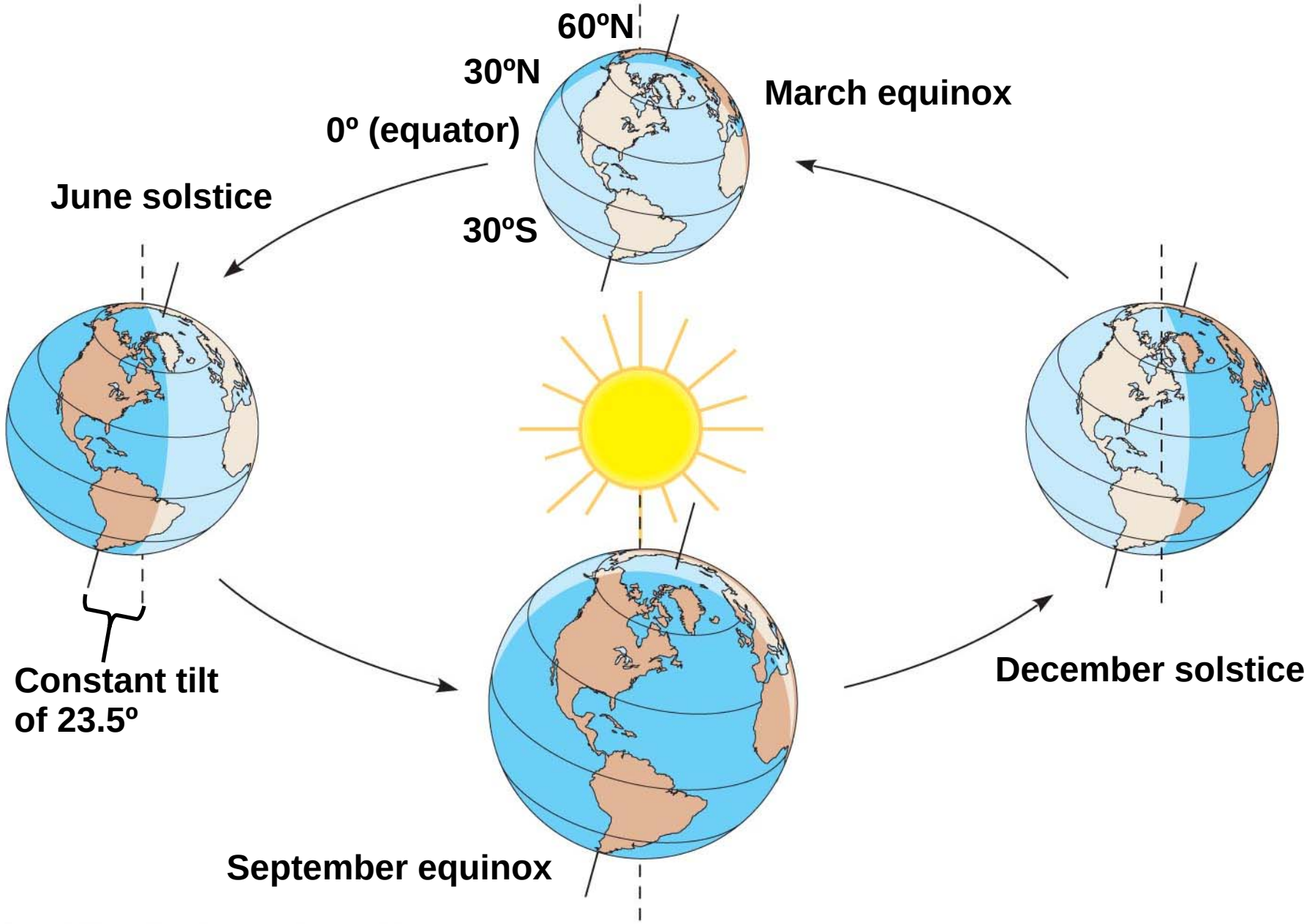


Fig. 52-10b



- Seasonal variations of light and temperature increase steadily toward the poles

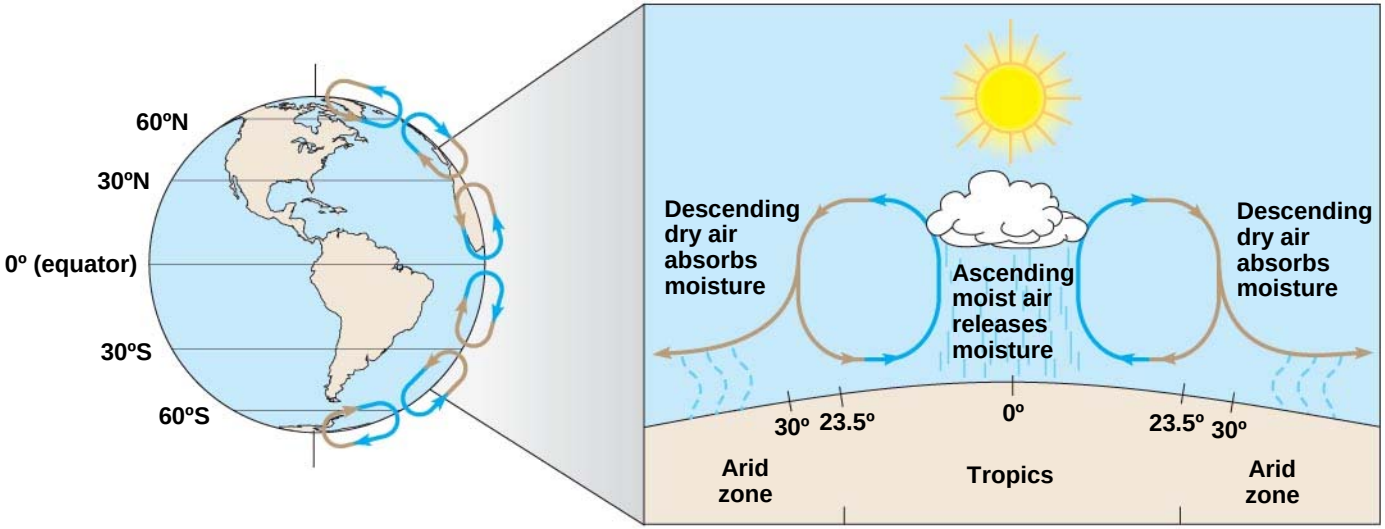
Fig. 52-10c



- Global air circulation and precipitation patterns play major roles in determining climate patterns
- Warm wet air flows from the tropics toward the poles

Fig. 52-10d

Global Air Circulation and Precipitation Patterns



Global Wind Patterns

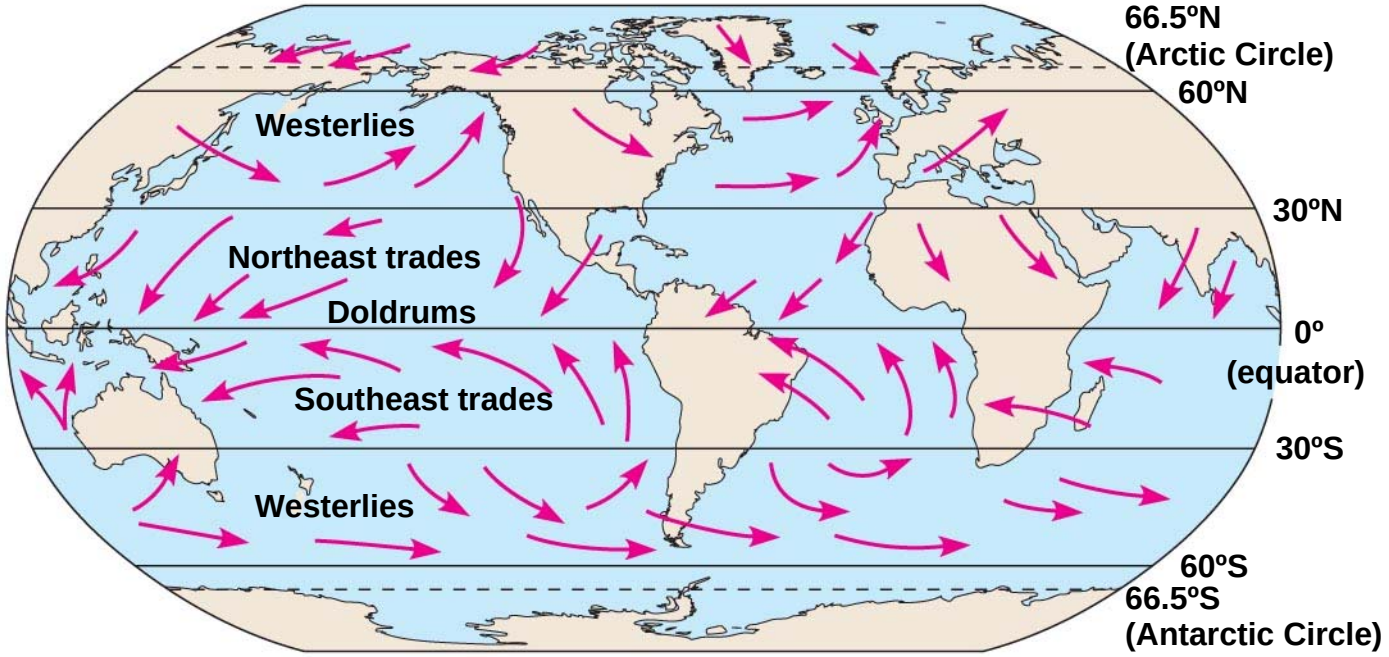
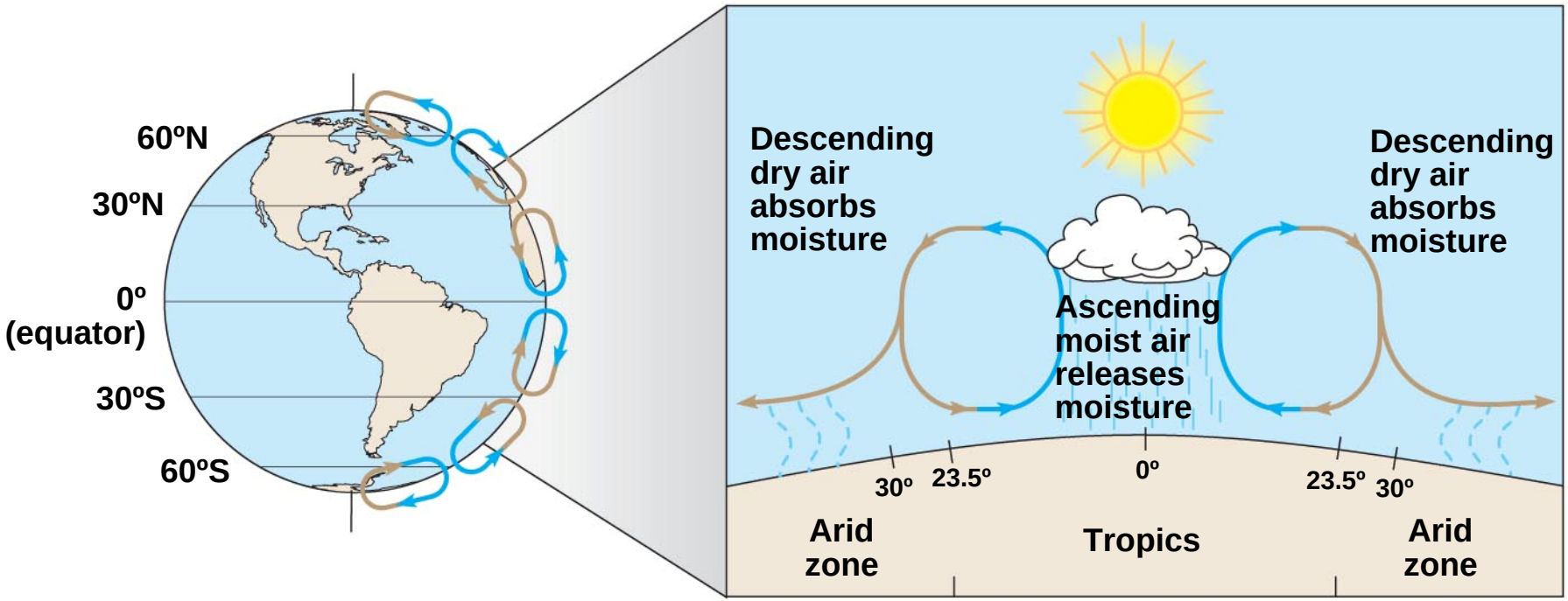
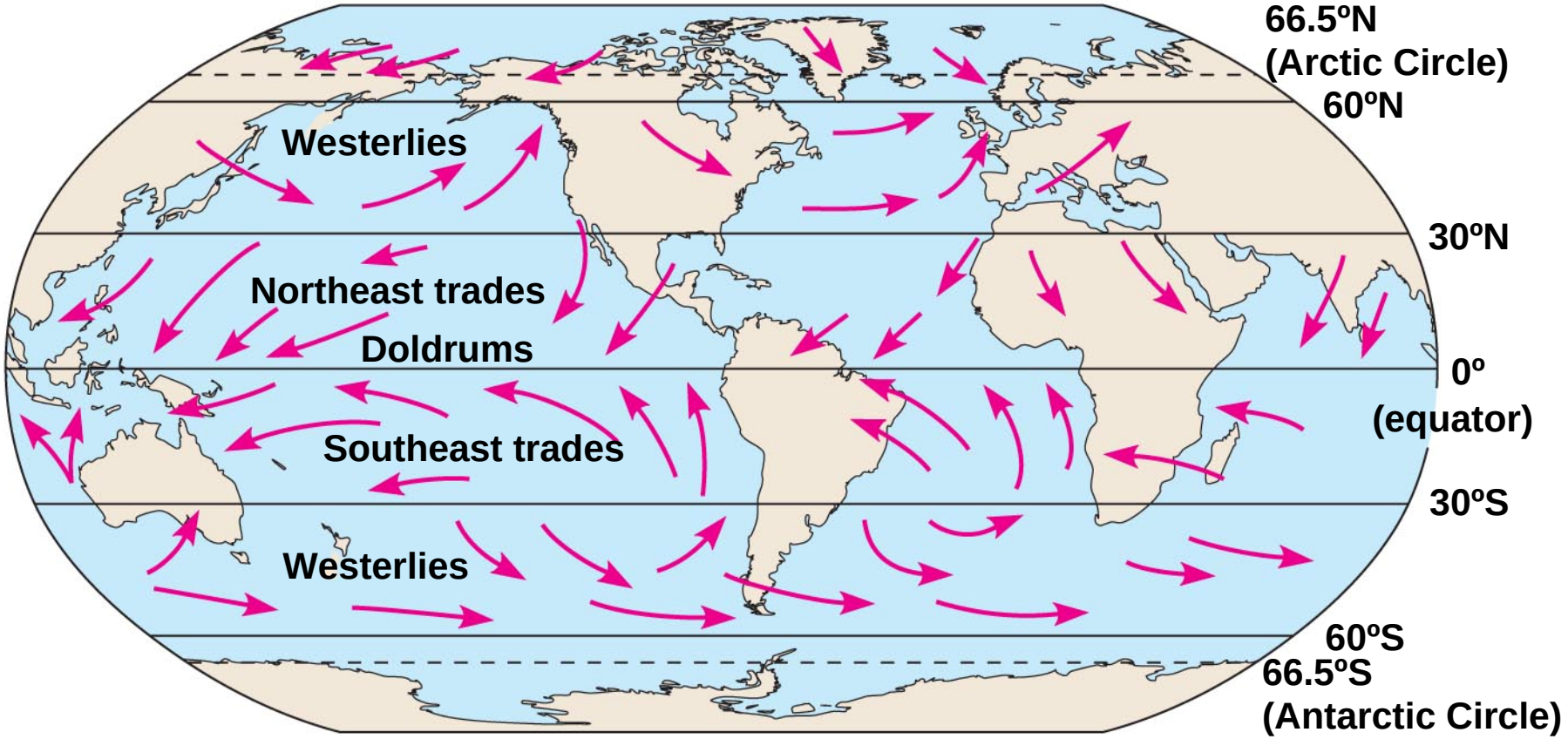


Fig. 52-10e



- 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

Fig. 52-10f



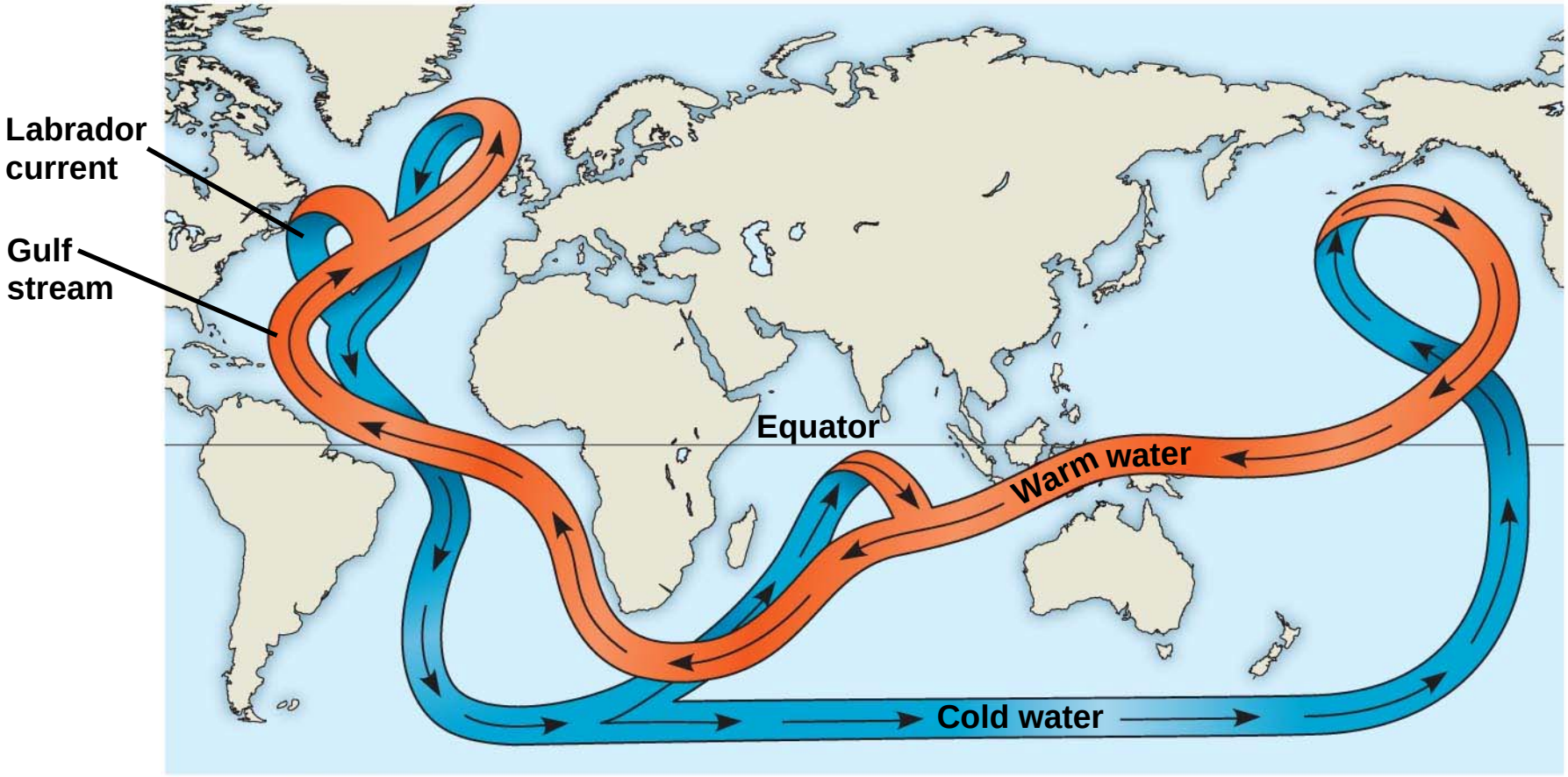
Regional, Local, and Seasonal Effects on Climate

- Proximity to bodies of water and topographic features contribute to local variations in climate
- Seasonal variation also influences climate

Bodies of Water

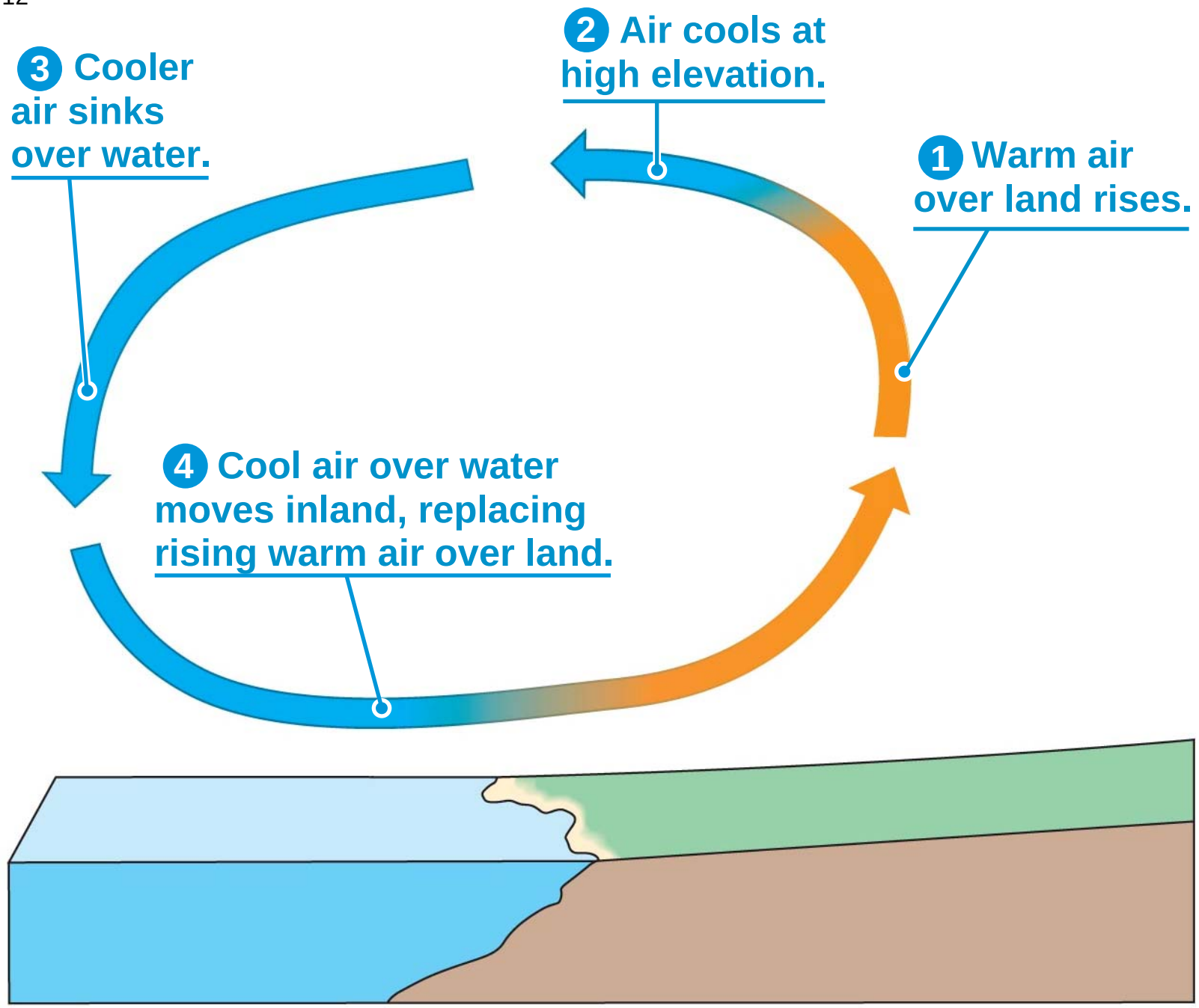
- The Gulf Stream carries warm water from the equator to the North Atlantic
- Oceans and their currents and large lakes moderate the climate of nearby terrestrial environments

Fig. 52-11



- 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

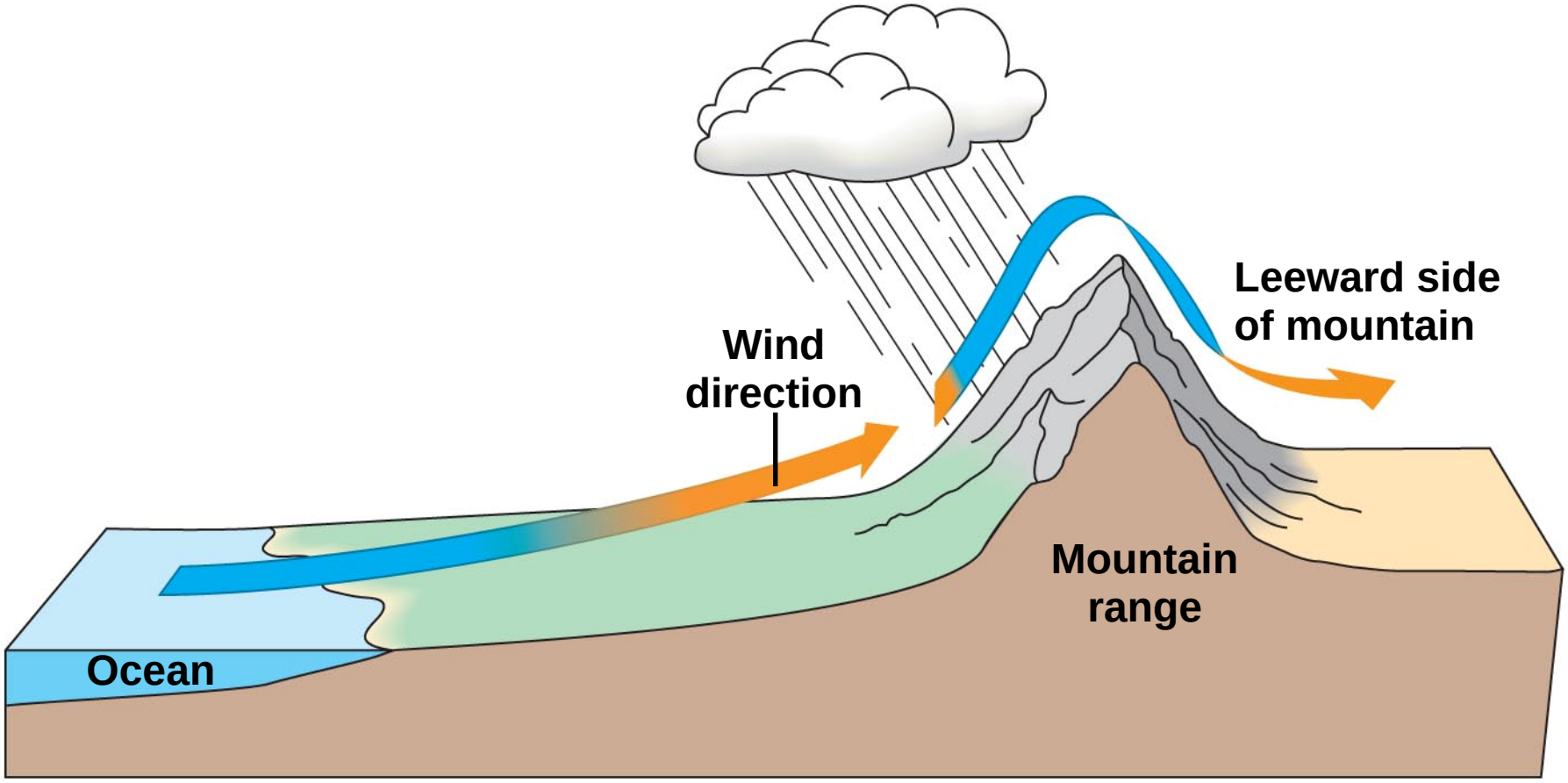
Fig. 52-12



Mountains

- Mountains have a significant effect on
  - The amount of sunlight reaching an area
  - Local temperature
  - Rainfall
- Rising air releases moisture on the windward side of a peak and creates a “rain shadow” as it absorbs moisture on the leeward side

Fig. 52-13



Seasonality

- The angle of the sun leads to many seasonal changes in local environments
- Lakes are sensitive to seasonal temperature change and experience seasonal turnover

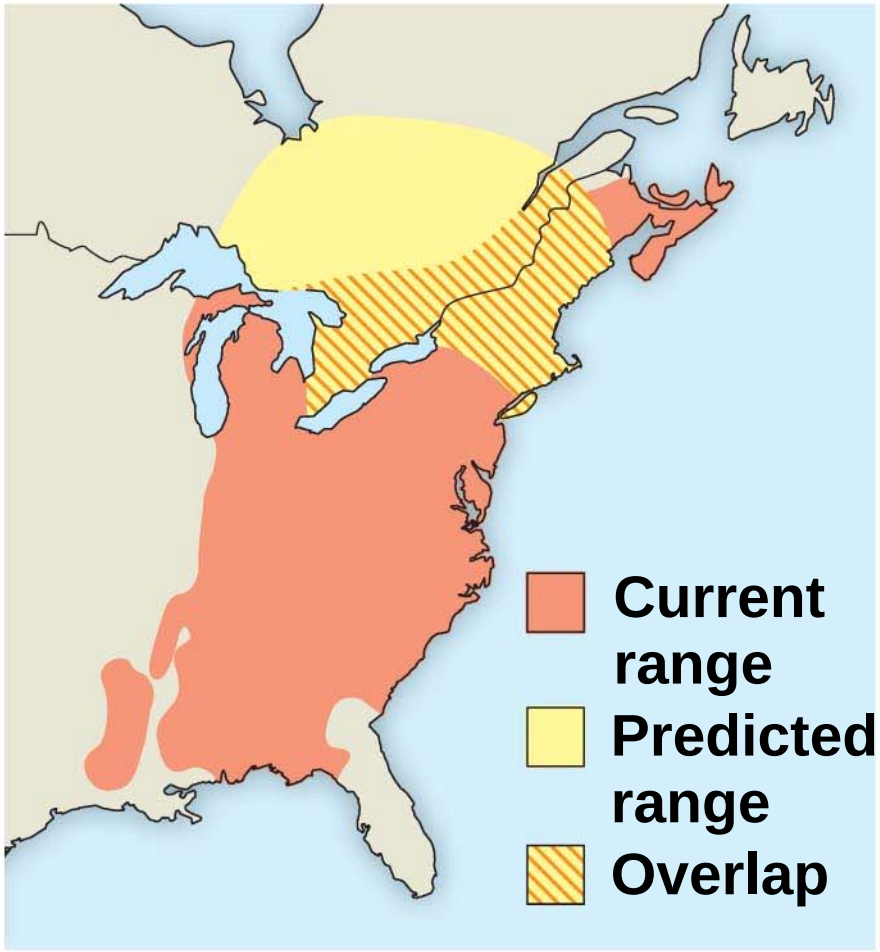
Microclimate

- Microclimate is determined by fine-scale differences in the environment that affect light and wind patterns

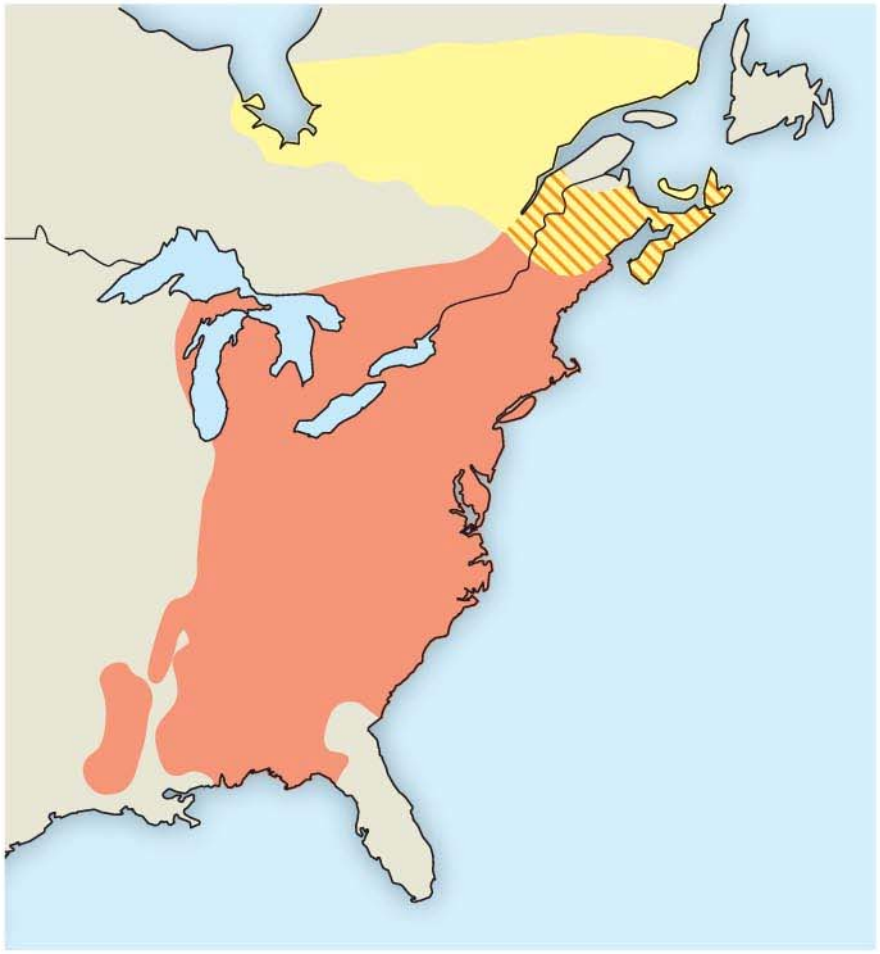
Long-Term Climate Change

- Global climate change will profoundly affect the biosphere
- One way to predict future global climate change is to study previous changes
- As glaciers began retreating 16,000 years ago, tree distribution patterns changed
- As climate changes, species that have difficulty dispersing may have smaller ranges or could become extinct

Fig. 52-14



(a) 4.5ºC warming over next century



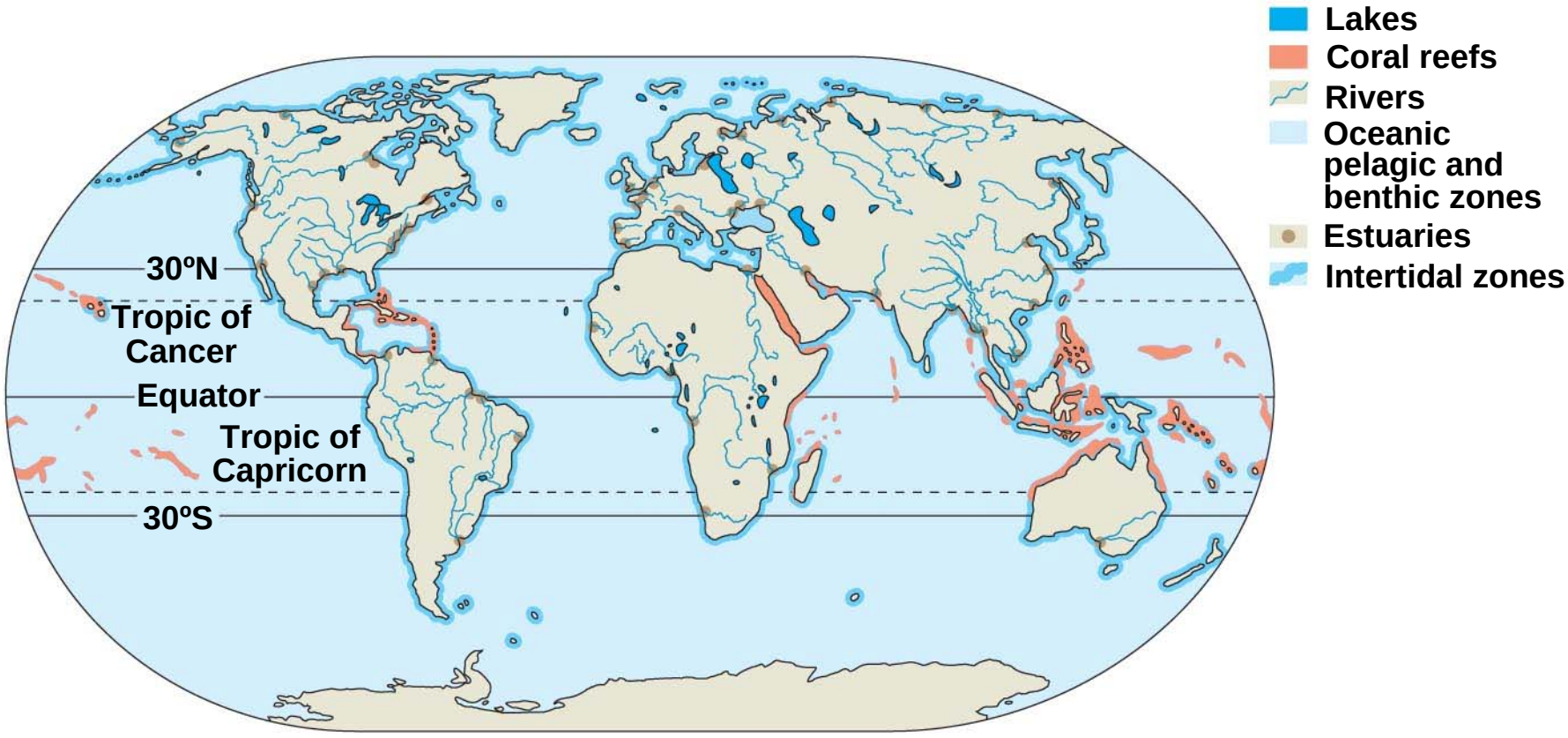
(b) 6.5ºC warming over next century

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

- **Biomes** are the major ecological associations that occupy broad geographic regions of land or water
- Varying combinations of biotic and abiotic factors determine the nature of biomes

- Aquatic biomes account for the largest part of the biosphere in terms of area
- They can contain fresh water or salt water (marine)
- Oceans cover about 75% of Earth's surface and have an enormous impact on the biosphere

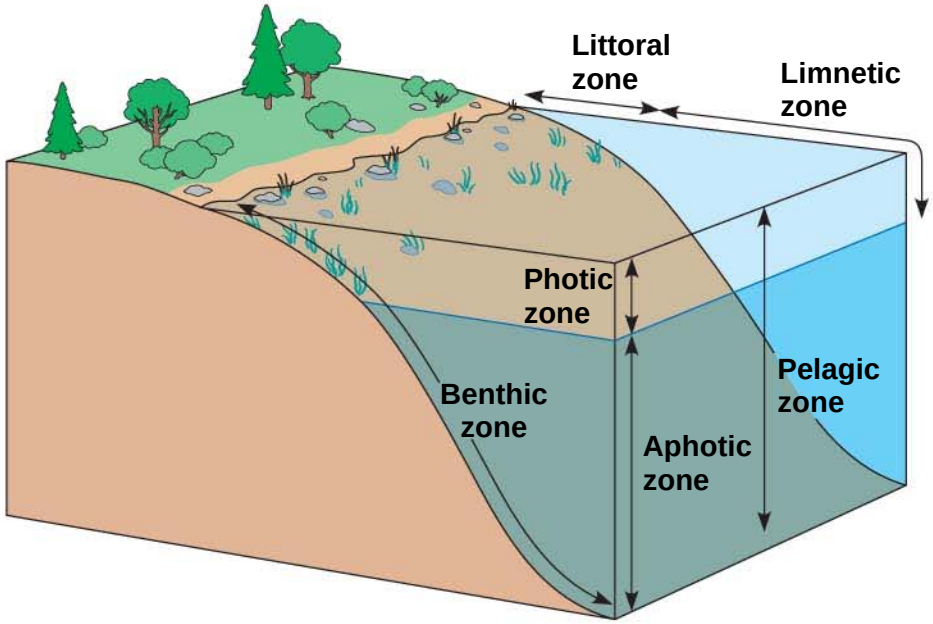
Fig. 52-15



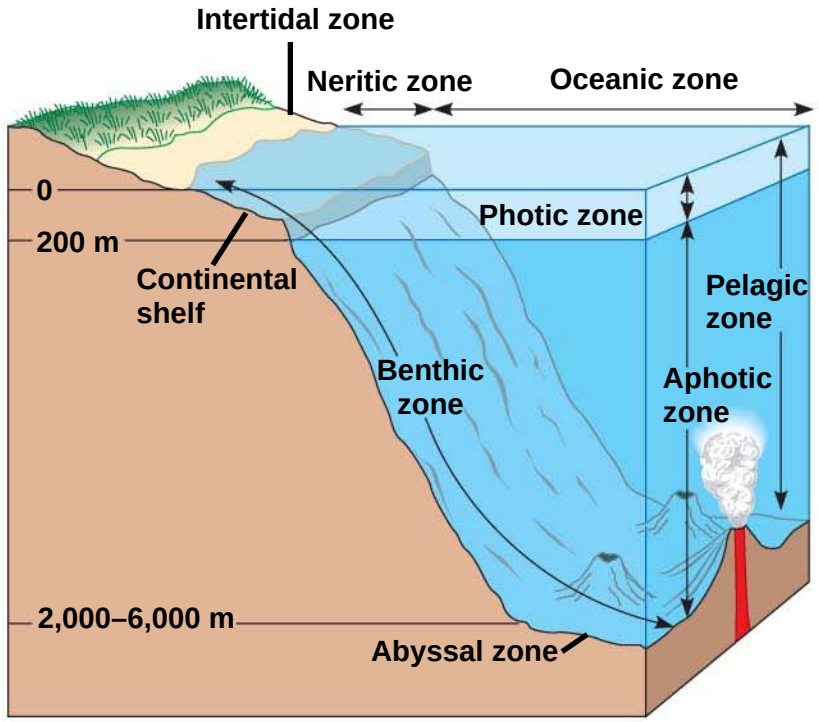
Stratification of Aquatic Biomes

- Many aquatic biomes are stratified into zones or layers defined by light penetration, temperature, and depth

Fig. 52-16

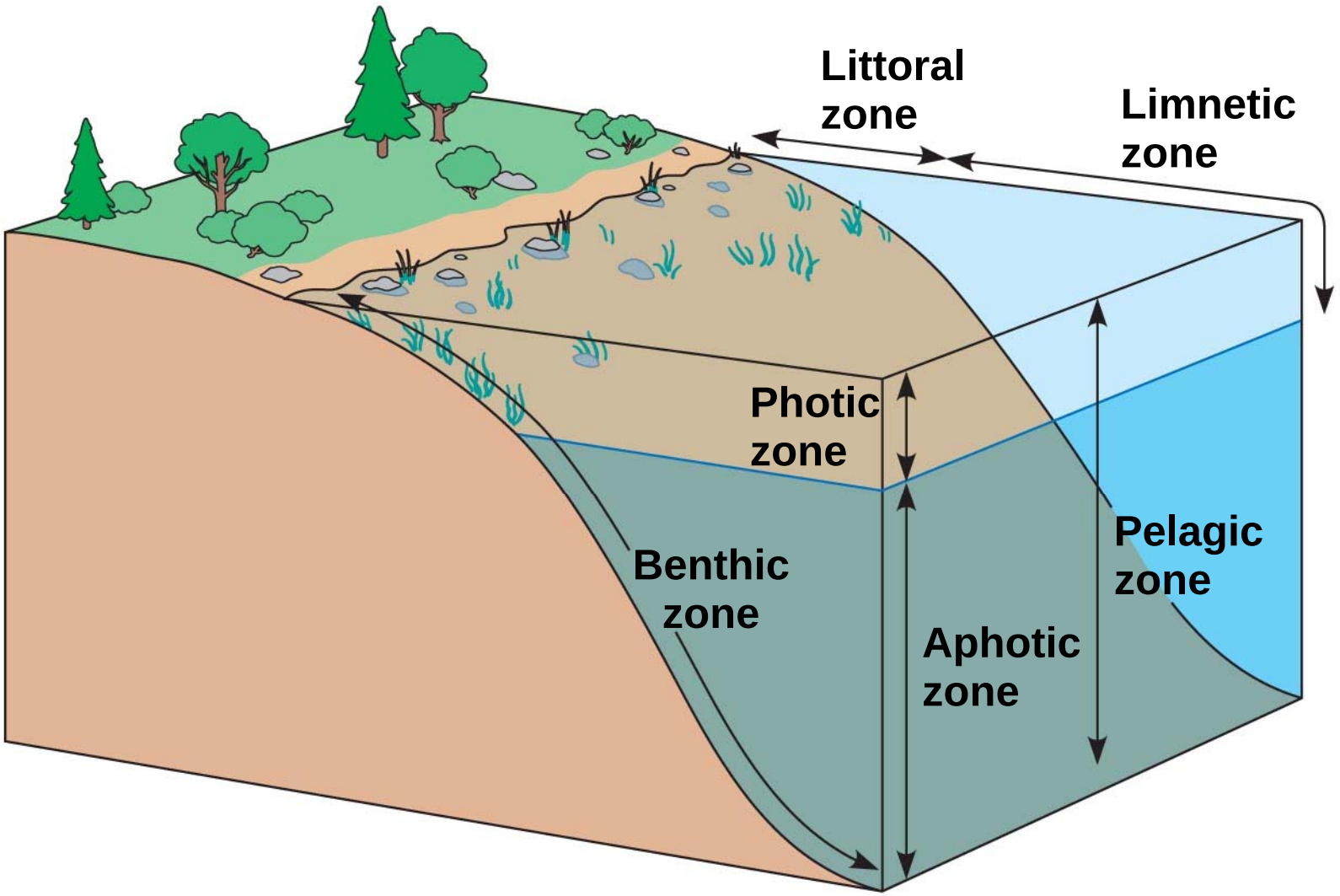


(a) Zonation in a lake



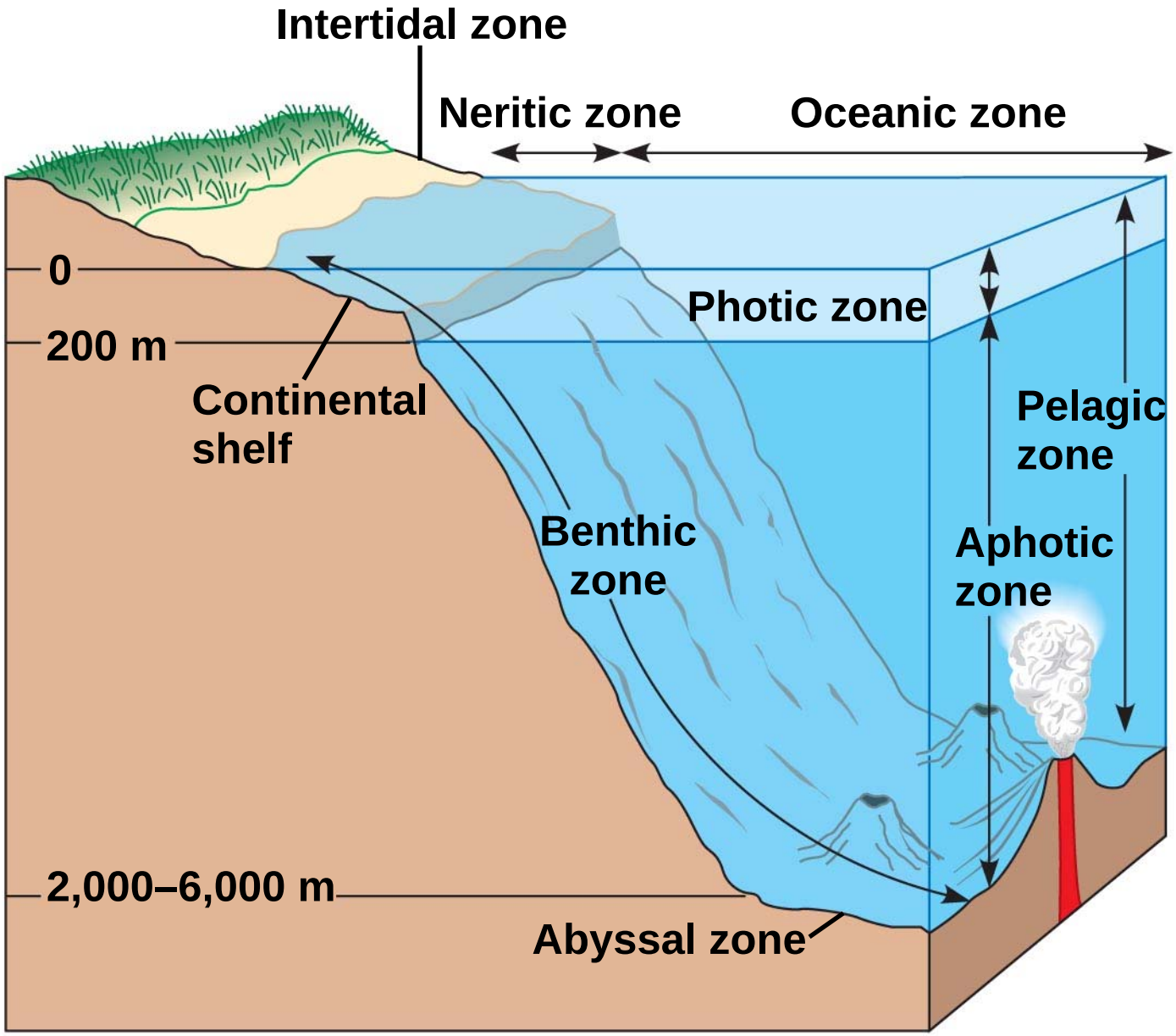
(b) Marine zonation

Fig. 52-16a



(a) Zonation in a lake

Fig. 52-16b



(b) Marine zonation

- The upper **photic zone** has sufficient light for photosynthesis while the lower **aphotic** zone receives little light
- 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

- The most extensive part of the ocean is the **abyssal zone** with a depth of 2,000 to 6,000 m

- 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

Fig. 52-17-1

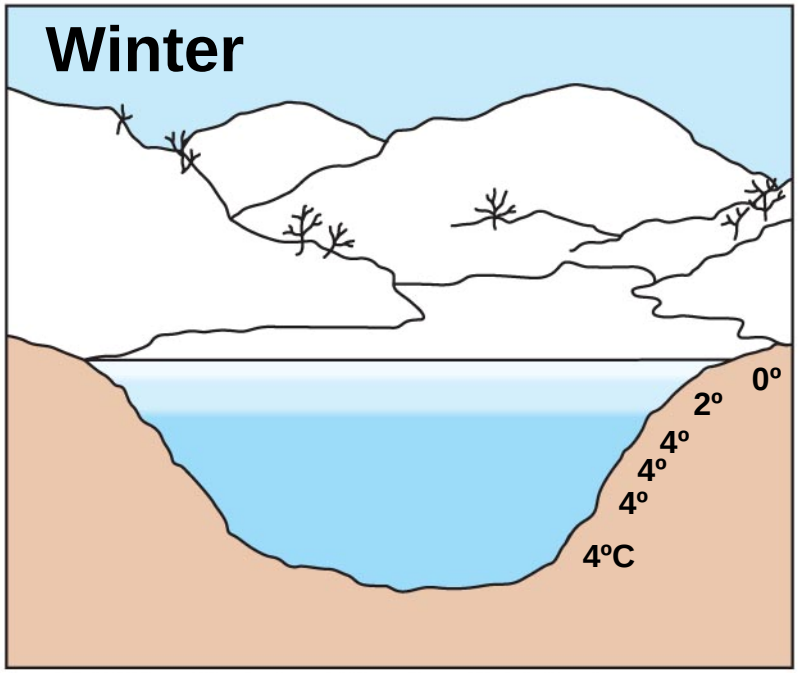


Fig. 52-17-2

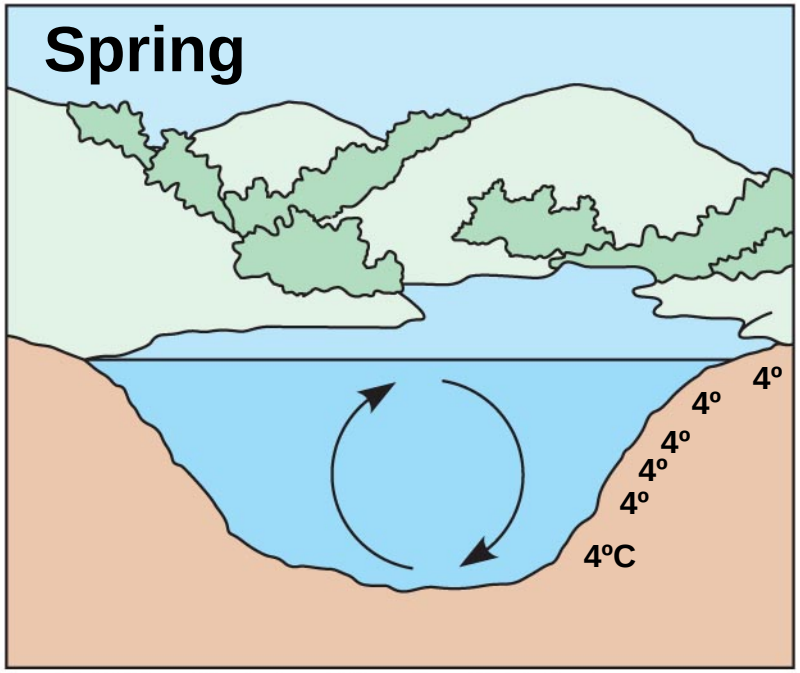


Fig. 52-17-3

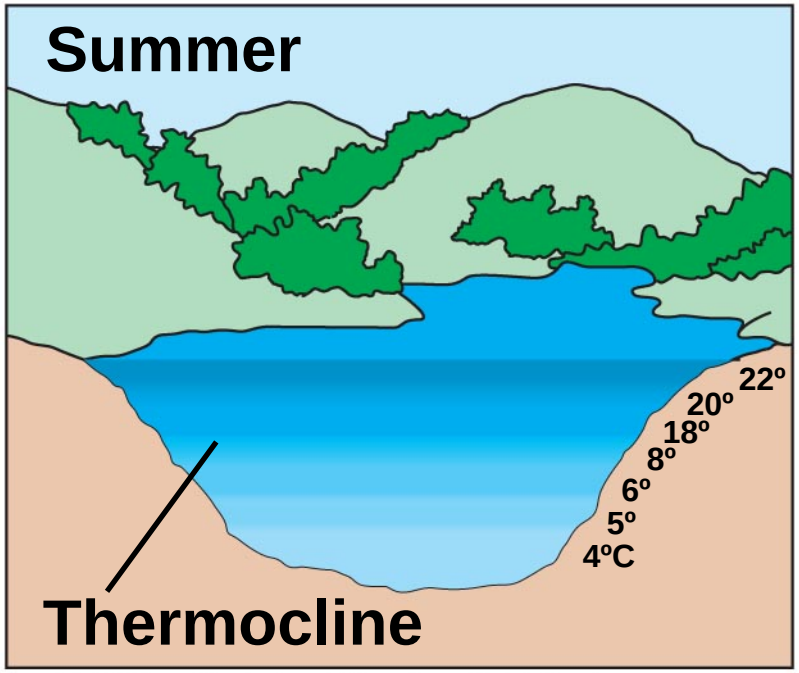


Fig. 52-17-4

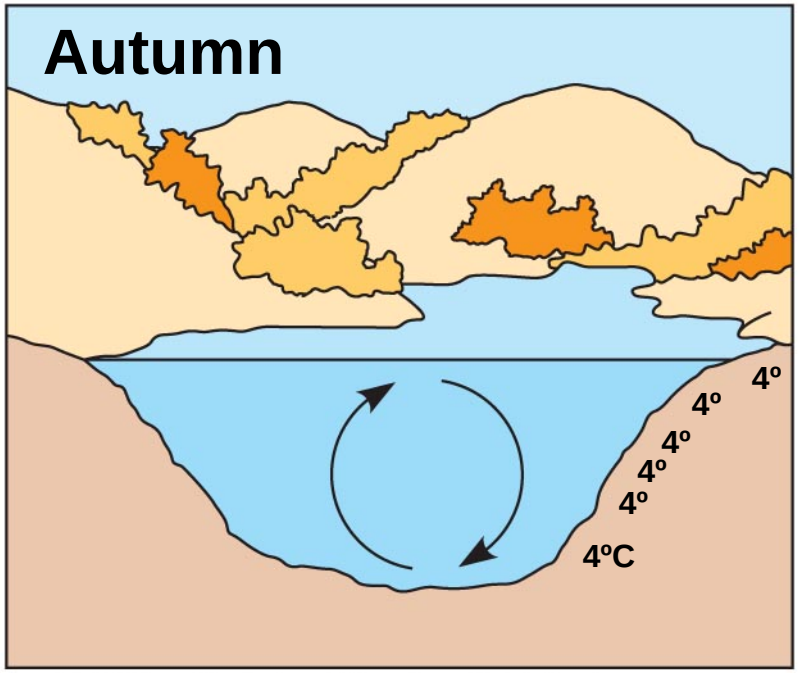
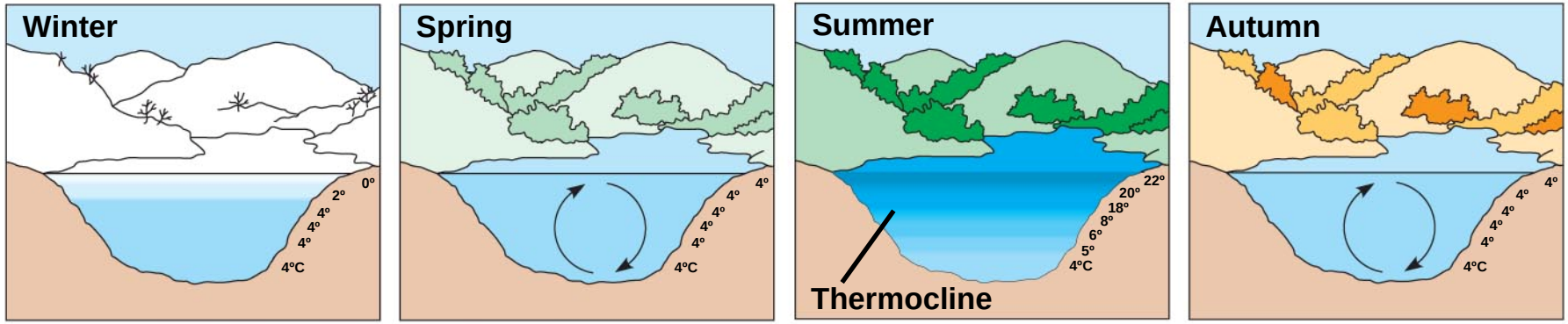


Fig. 52-17-5



Aquatic Biomes

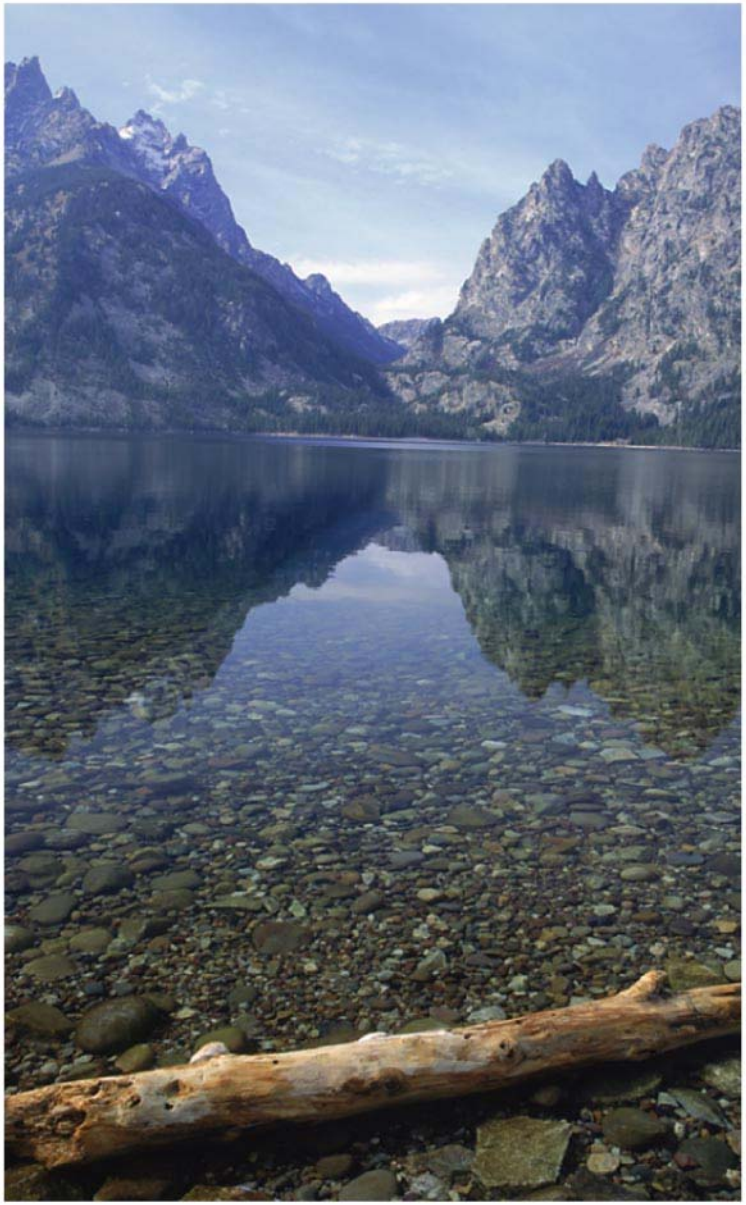
- Major aquatic biomes can be characterized by their physical environment, chemical environment, geological features, photosynthetic organisms, and heterotrophs

Lakes

- **Oligotrophic lakes** are nutrient-poor and generally oxygen-rich
- **Eutrophic lakes** are nutrient-rich and often depleted of oxygen if ice covered in winter
- Rooted and floating aquatic plants live in the shallow and well-lighted **littoral zone**

- Water is too deep in the **limnetic zone** to support rooted aquatic plants; small drifting animals called zooplankton graze on the phytoplankton

Fig. 52-18a



An oligotrophic lake in Grand Teton National Park, Wyoming

Fig. 52-18b

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 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 and are home to diverse invertebrates and birds

PLAY Video: Swans Taking Flight

Fig. 52-18c

Okefenokee National Wetland Reserve in Georgia

Streams and Rivers

- The most prominent physical characteristic of streams and rivers is current
- A diversity of fishes and invertebrates inhabit unpolluted rivers and streams
- Damming and flood control impair natural functioning of stream and river ecosystems

Fig. 52-18d

A headwater stream in the Great Smoky Mountains

Fig. 52-18e

The Mississippi River 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
- An abundant supply of food attracts marine invertebrates and fish

PLAY

Video: Flapping Geese

Fig. 52-18f

An estuary in a low coastal plain of Georgia

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
- Many animals of rocky intertidal environments have structural adaptations that enable them to attach to the hard substrate

Fig. 52-18g

Rocky intertidal zone on the Oregon coast

Oceanic Pelagic Zone

- The **oceanic pelagic biome** is a vast realm of open blue water, constantly mixed by wind-driven oceanic currents
- 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

PLAY Video: Shark Eating a Seal

Fig. 52-18h

Open ocean off the island of Hawaii

Coral Reefs

- **Coral reefs** are formed from the calcium carbonate skeletons of corals (phylum Cnidaria)
- Corals require a solid substrate for attachment
- Unicellular algae live within the tissues of the corals and form a mutualistic relationship that provides the corals with organic molecules

PLAY Video: Coral Reef

PLAY Video: Clownfish and Anemone

Fig. 52-18i

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, or **abyssal**, zone are adapted to continuous cold and extremely high water pressure

- Unique assemblages of organisms are associated with **deep-sea hydrothermal vents** of volcanic origin on mid-oceanic ridges; here the autotrophs are chemoautotrophic prokaryotes

PLAY Video: Hydrothermal Vent

PLAY Video: Tubeworms

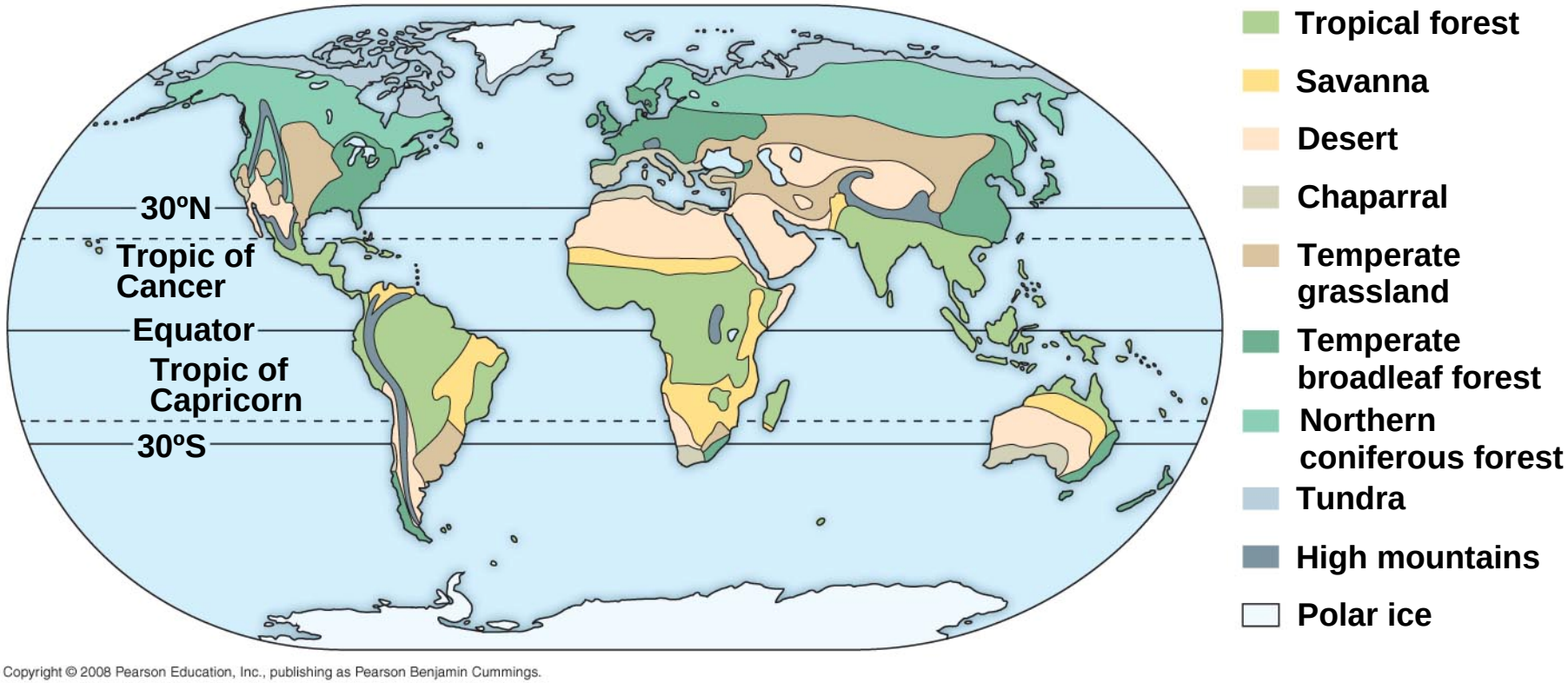
Fig. 52-18j

A deep-sea hydrothermal vent community

Concept 52.4: The structure and distribution of terrestrial biomes are controlled by climate and disturbance

- Climate is very important in determining why terrestrial biomes are found in certain areas
- Biome patterns can be modified by **disturbance** such as a storm, fire, or human activity

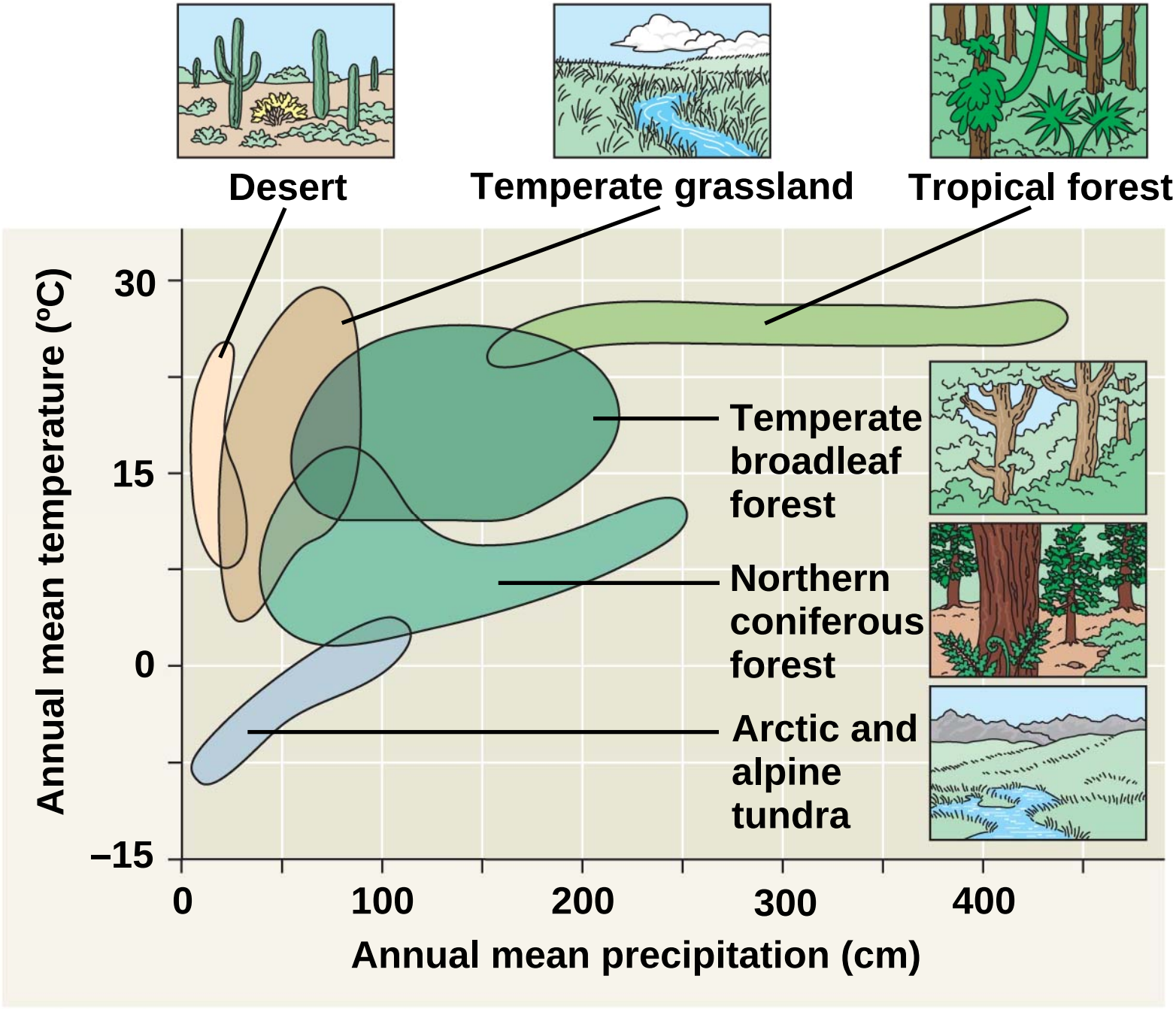
Fig. 52-19



Climate and Terrestrial Biomes

- Climate has a great impact on the distribution of organisms
- This can be illustrated with a **climograph**, a plot of 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

Fig. 52-20



General Features of Terrestrial Biomes and the Role of Disturbance

- 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

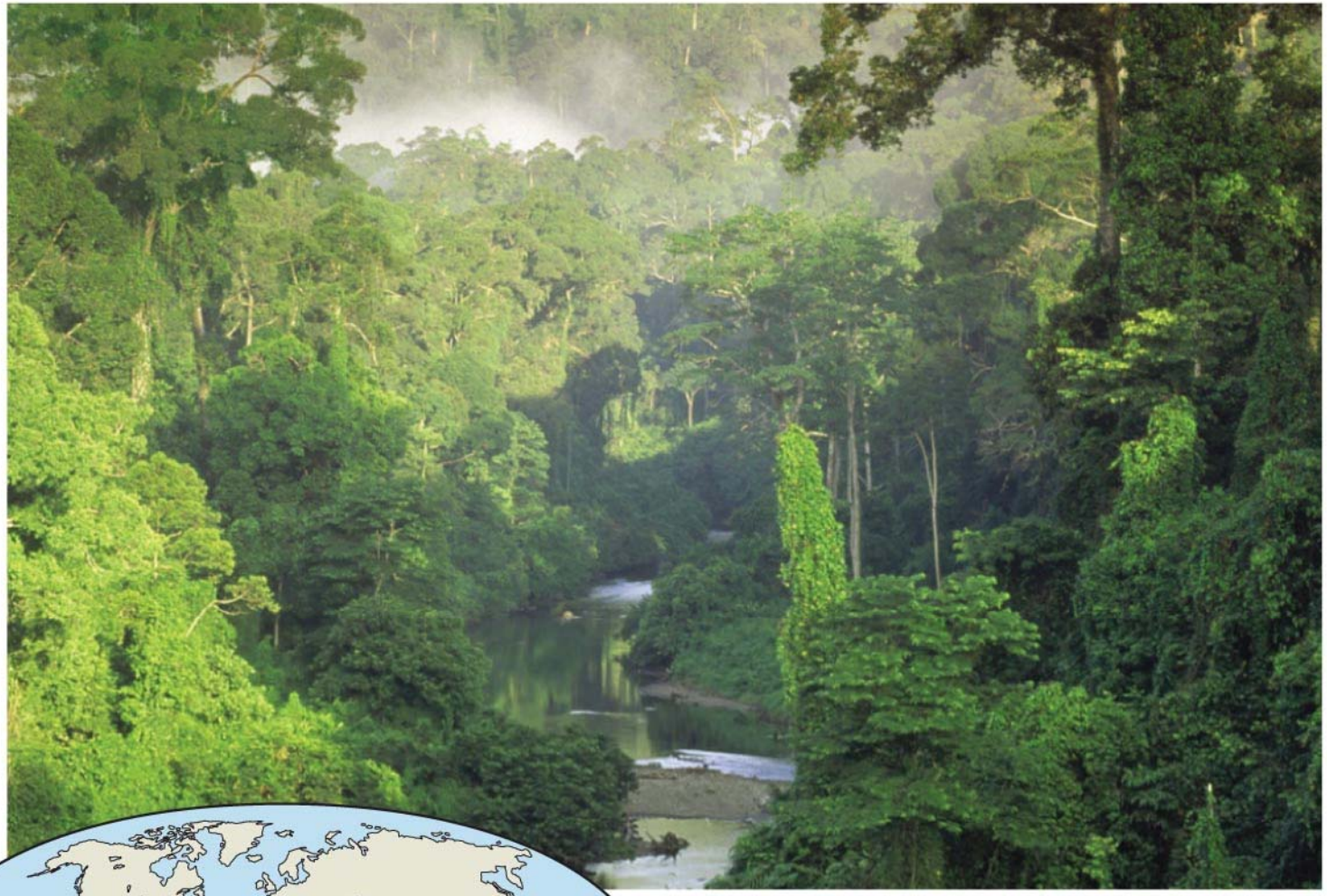
Terrestrial Biomes

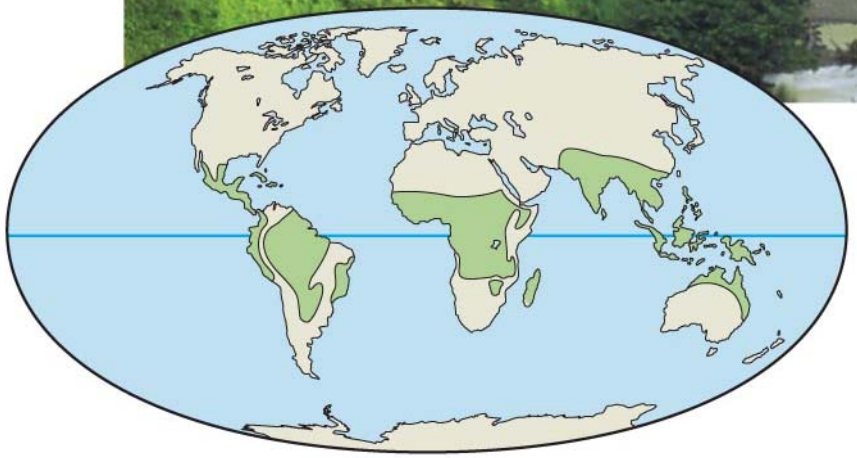
- Terrestrial biomes can be characterized by distribution, precipitation, temperature, plants, and animals

Tropical Forest

- In **tropical rain forests**, rainfall is relatively constant, while in **tropical dry forests** precipitation is highly seasonal
- 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

Fig. 52-21a



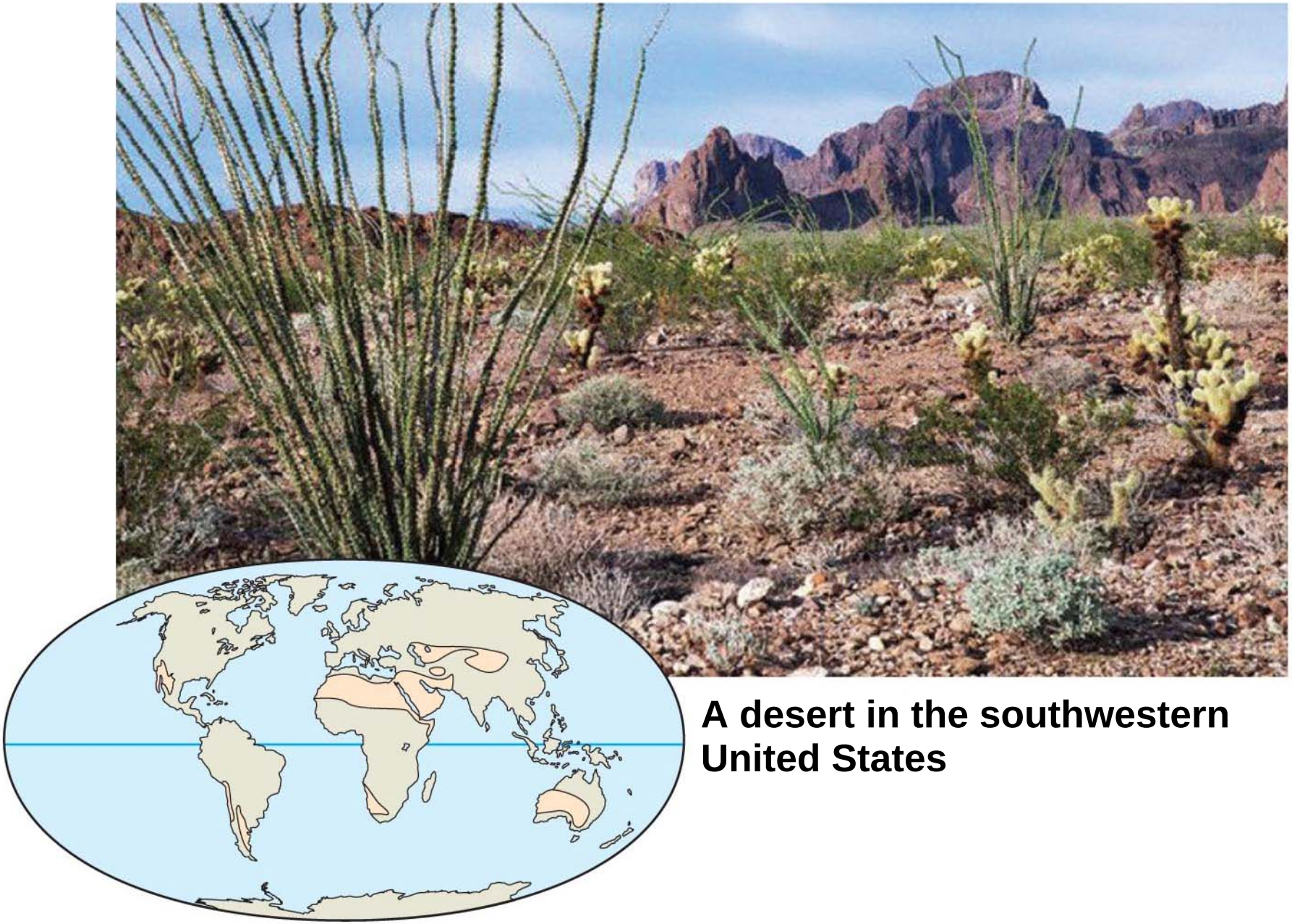


A tropical rain forest in Borneo

Desert

- 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

Fig. 52-21b



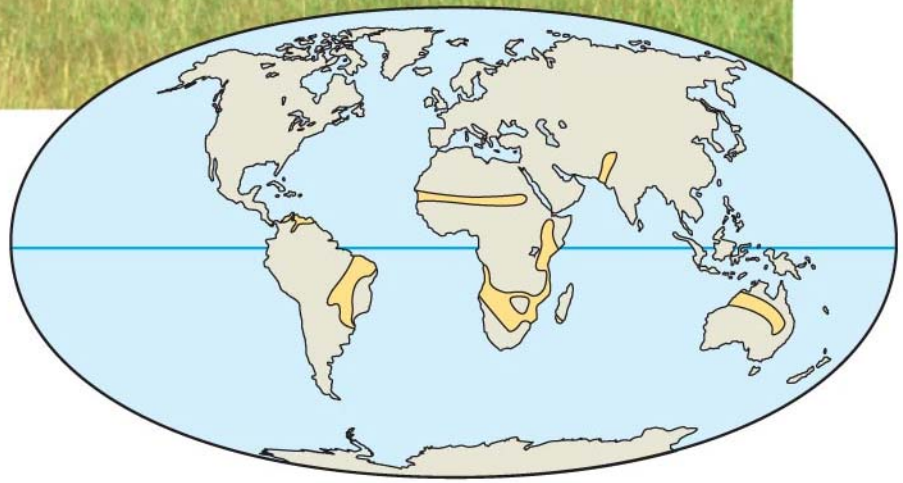
A desert in the southwestern United States

Savanna

- **Savanna** precipitation and temperature are seasonal
- Grasses and forbs make up most of the ground cover
- Common inhabitants include insects and mammals such as wildebeests, zebras, lions, and hyenas

Fig. 52-21c

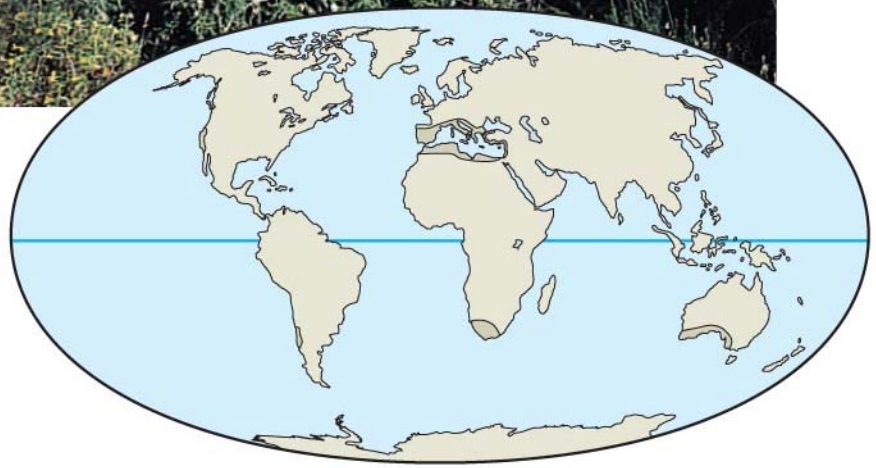
A savanna in Kenya



Chaparral

- **Chaparral** climate is highly seasonal, with cool and rainy winters and hot dry summers
- 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

Fig. 52-21d

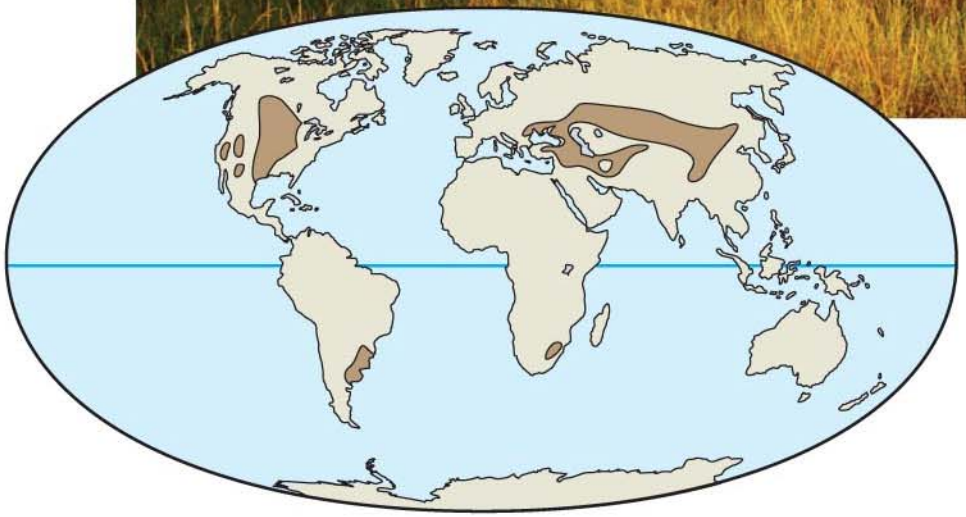


An area of chaparral in California

Temperate Grassland

- **Temperate grasslands** are found on many continents
- Winters are cold and dry, while summers are wet and hot
- The dominant plants, grasses and forbs, are adapted to droughts and fire
- Native mammals include large grazers and small burrowers

Fig. 52-21e



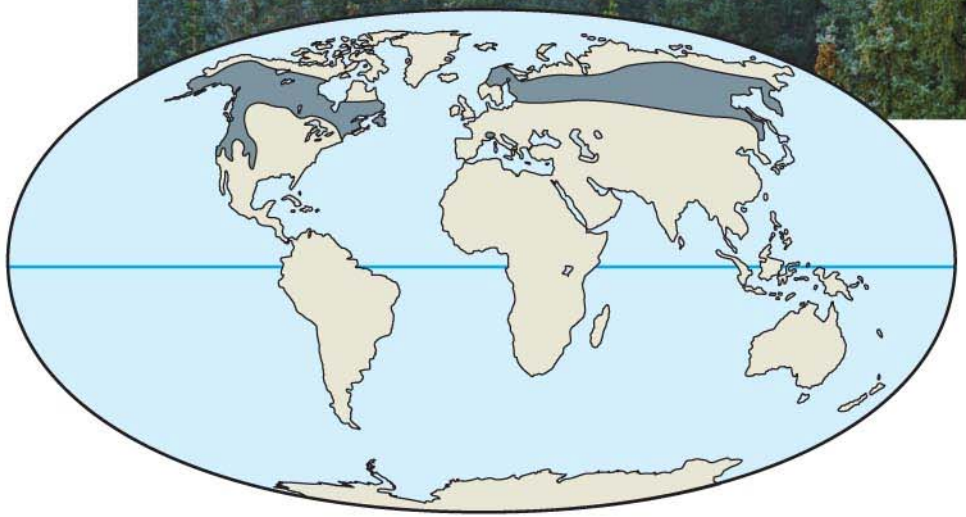
Sheyenne National Grassland in North Dakota

Northern Coniferous Forest

- The **northern coniferous forest**, or *taiga*, extends across northern North America and Eurasia and is the largest terrestrial biome on Earth
- Winters are cold and long while summers may be hot

- The conical shape of conifers prevents too much snow from accumulating and breaking their branches
- Animals include migratory and resident birds, and large mammals

Fig. 52-21f



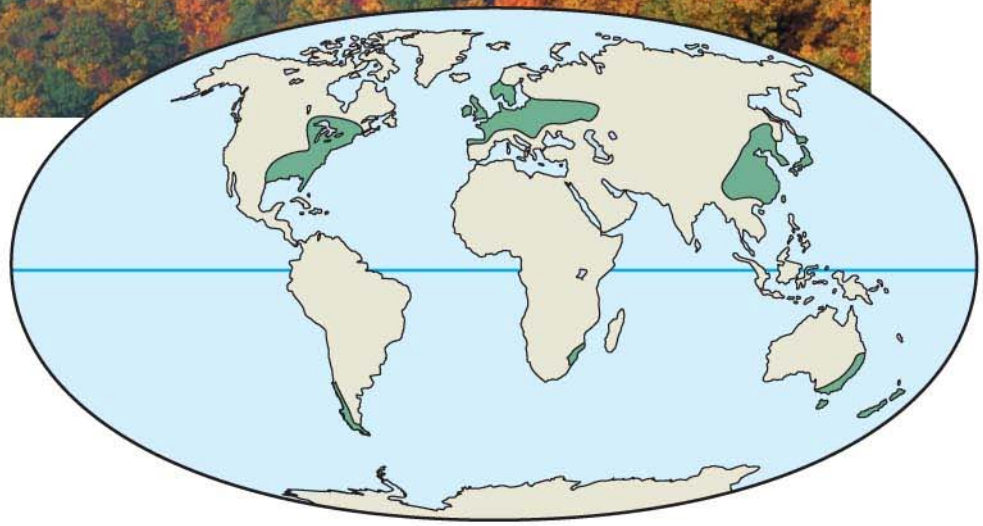
Rocky Mountain National Park in Colorado

Temperate Broadleaf Forest

- Winters are cool, while summers are hot and humid; significant precipitation falls year round as rain and snow
- A mature **temperate broadleaf forest** has vertical layers 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

Fig. 52-21g



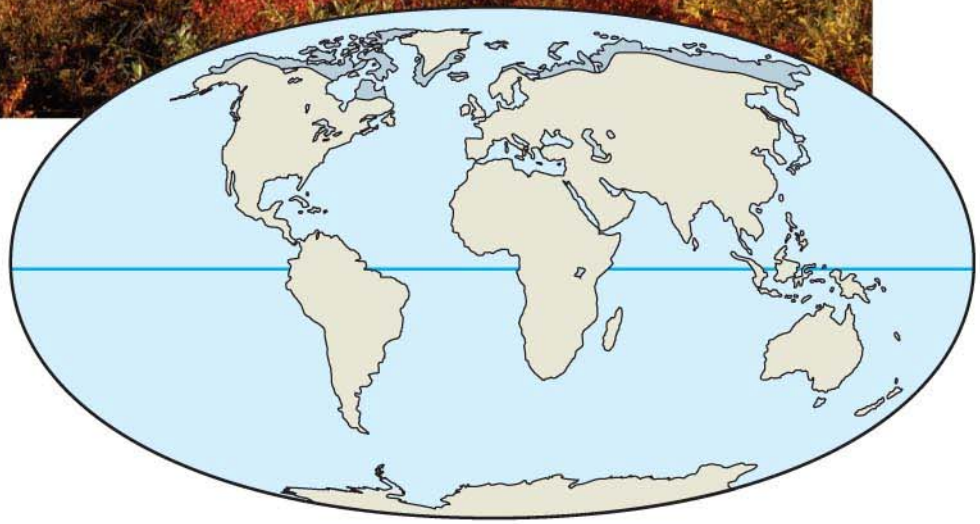
Great Smoky Mountains National Park in North Carolina

Tundra

- **Tundra** covers expansive areas of the Arctic; alpine tundra exists on high mountaintops at all latitudes
- Winters are long and cold while summers are relatively cool; precipitation varies

- **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

Fig. 52-21h



Denali National Park, Alaska, in autumn

Fig. 52-UN1

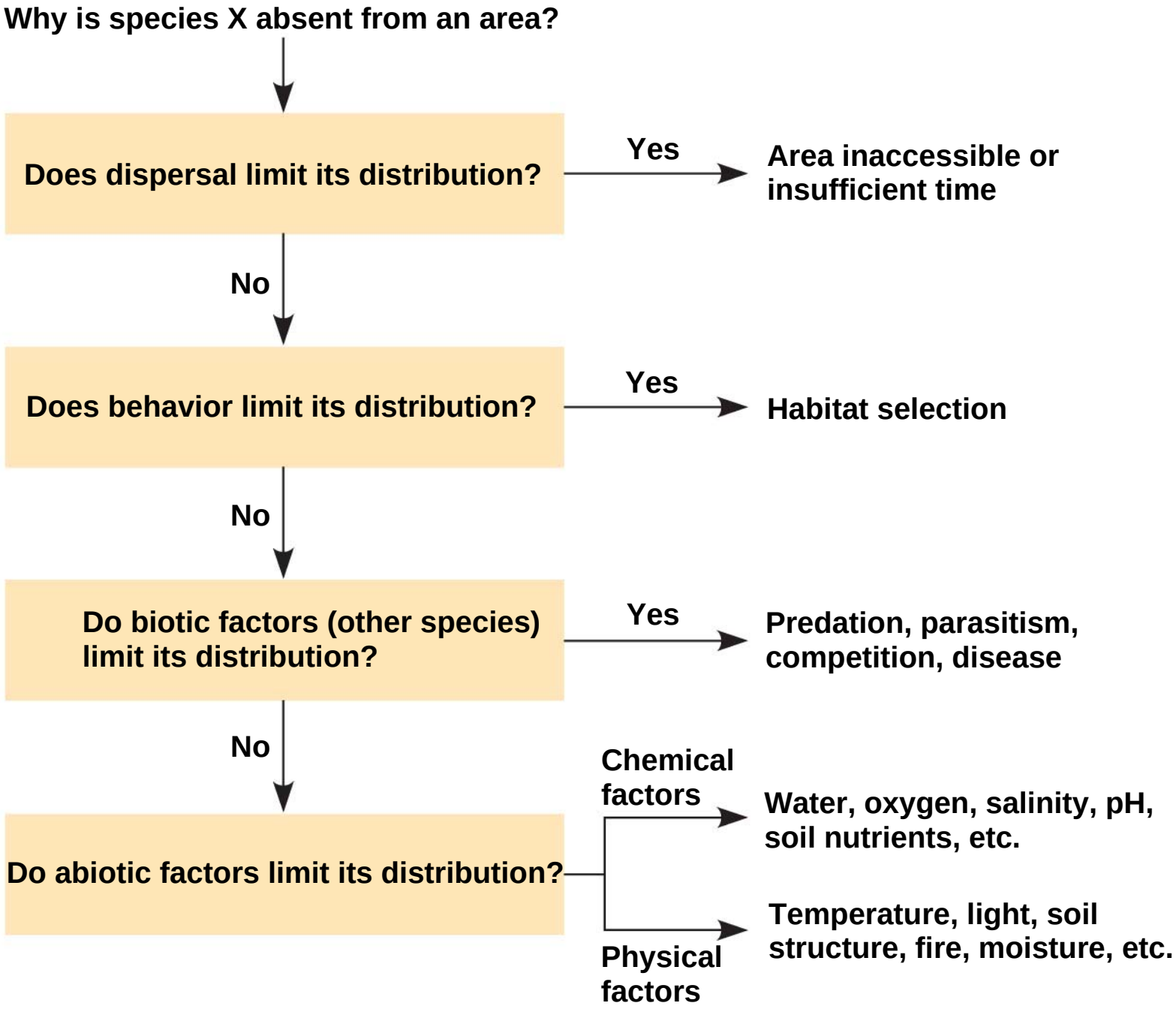


Fig. 52-T1

Site	Kelp Abundance (% cover)	Otter Density (# sightings per day)
1	75	98
2	15	18
3	60	85
4	25	36

Fig. 52-UN2

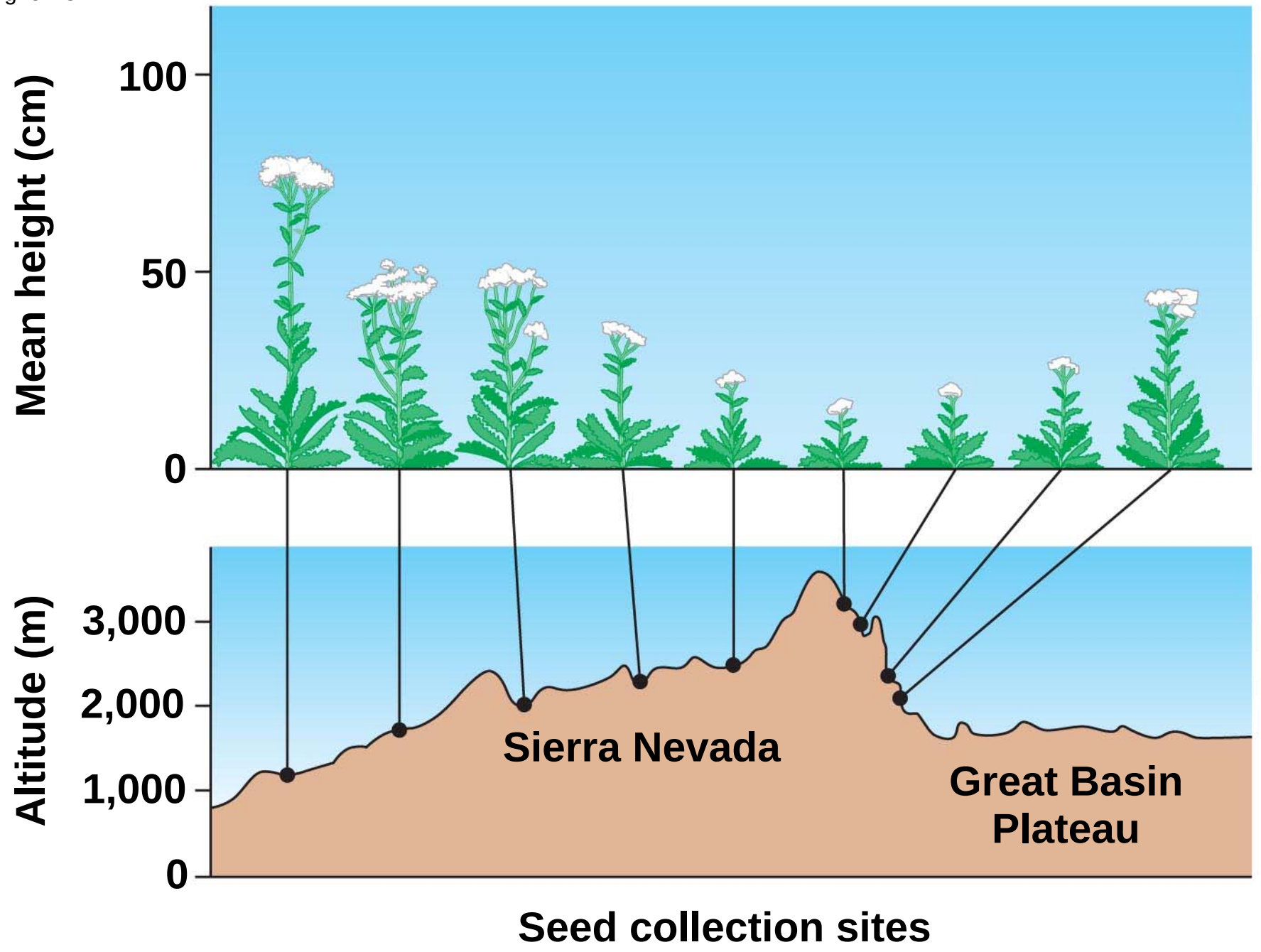
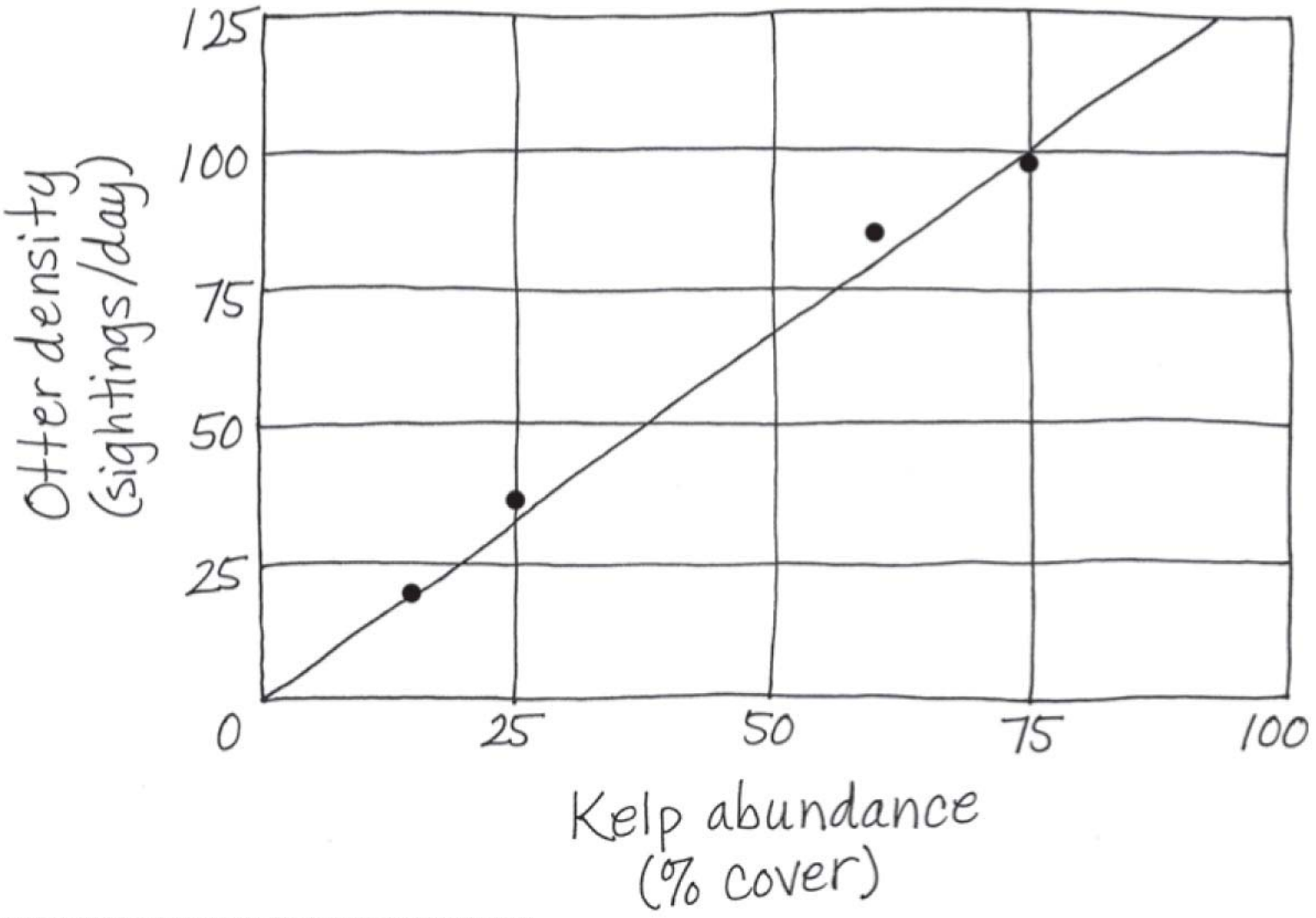


Fig. 52-UN3



You should now be able to:

1. Distinguish among the following types of ecology: organismal, population, community, ecosystem, and landscape
2. Explain how dispersal may contribute to a species' distribution
3. Distinguish between the following pairs of terms: potential and actual range, biotic and abiotic factors, macroclimate and microclimate patterns

4. Explain how a body of water or mountain range might affect regional climatic conditions

5. Define the following terms: photic zone, aphotic zone, benthic zone, abyssal zone, thermal stratification, thermocline, seasonal turnover, climograph, disturbance

6. List and describe the characteristics of the major aquatic biomes

7. List and describe the characteristics of the major terrestrial biomes

8. Compare the vertical layering of a forest and grassland