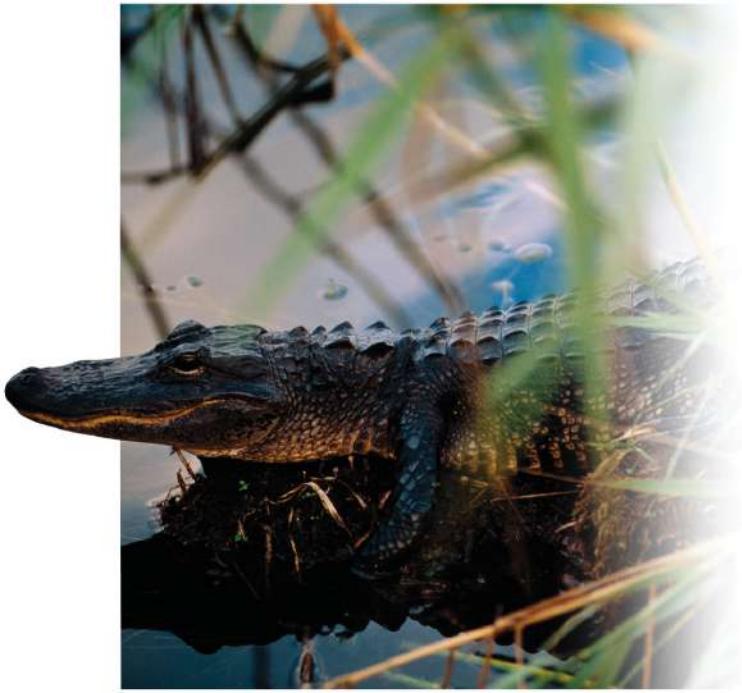
Visualizing Environmental Science

Ecosystems and Evolution

Chapter 6



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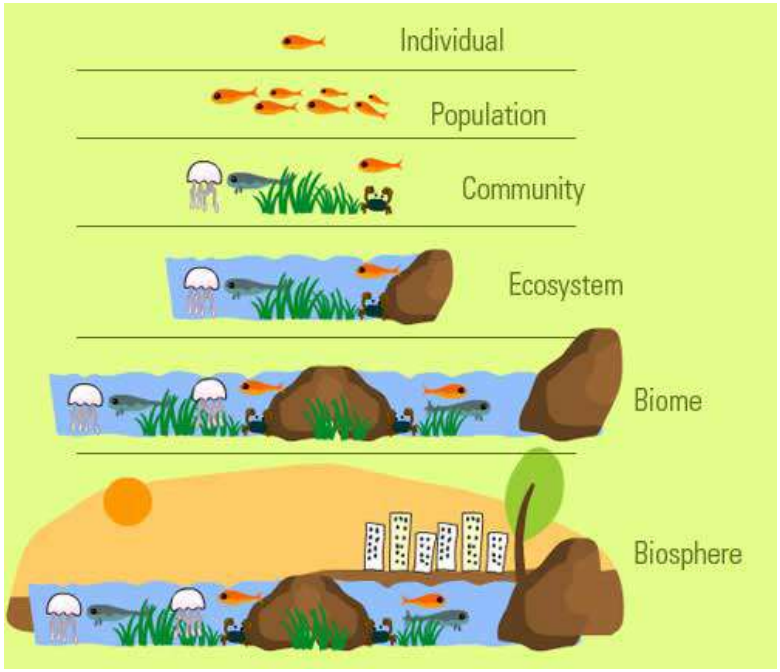
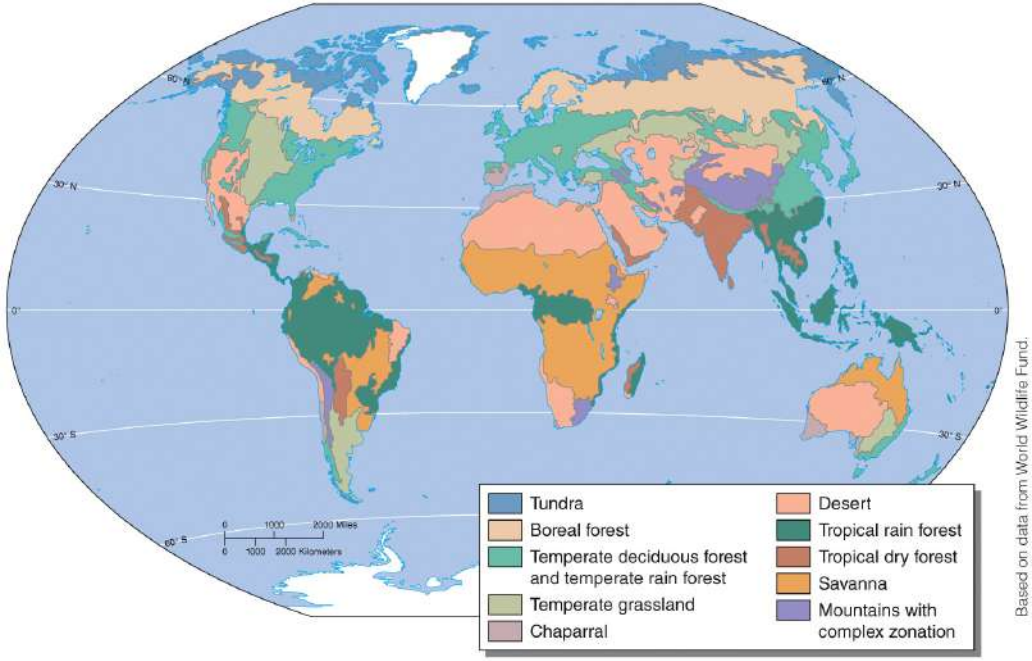
Factors That Shape Biomes

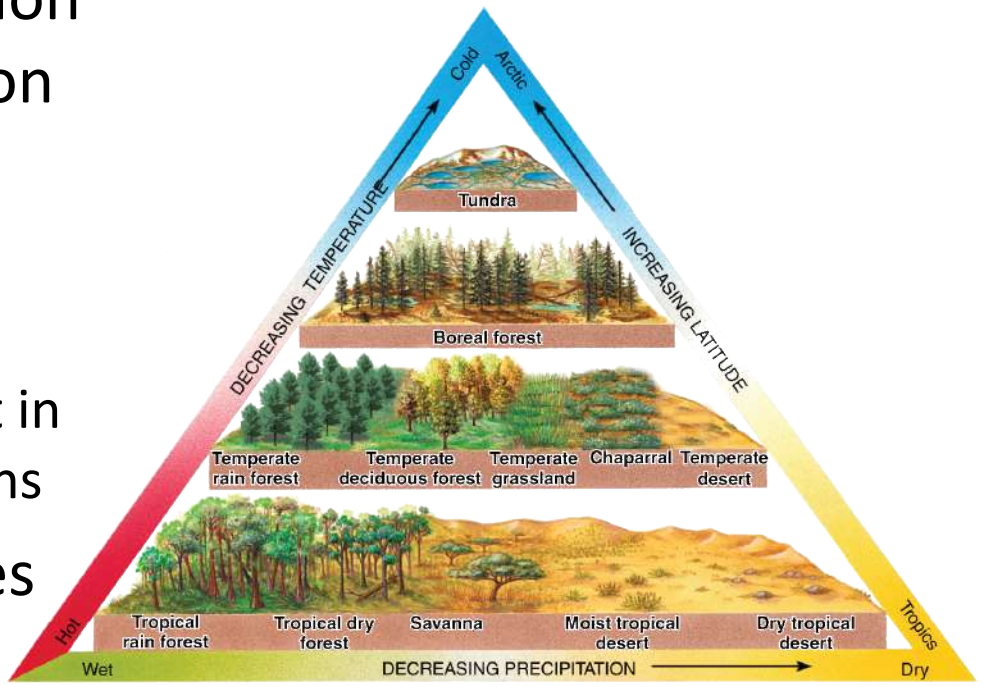
- **Biome**—a large, relatively distinct terrestrial region with similar climate (long-term weather pattern), soil, plants, and animals, regardless of where it occurs in the world





Factors That Shape Biomes

- Temperature and precipitation have a predominant effect on biome distribution
  - Temperature most important factor near poles
  - Precipitation more important in tropical and temperate regions
- Elevation also affects biomes
  - Vegetation changes with increasing elevation resembles the changes in vegetation from warmer to colder climates



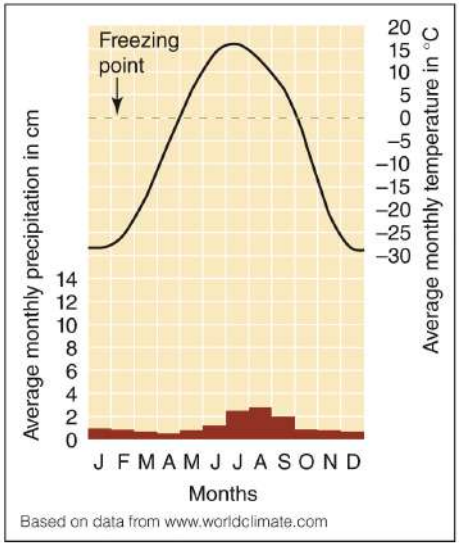
Based on Holdridge, L. *Life Zone Ecology*. Tropical Science Center, San Jose, Costa Rica (1967).

Describing Earth's Major Biomes

- There are nine major terrestrial biomes on earth
  - Tundra
  - Boreal forest
  - Temperate rain forest
  - Temperate deciduous forest
  - Temperate grassland
  - Chaparral
  - Desert
  - Savanna
  - Tropical rain forest

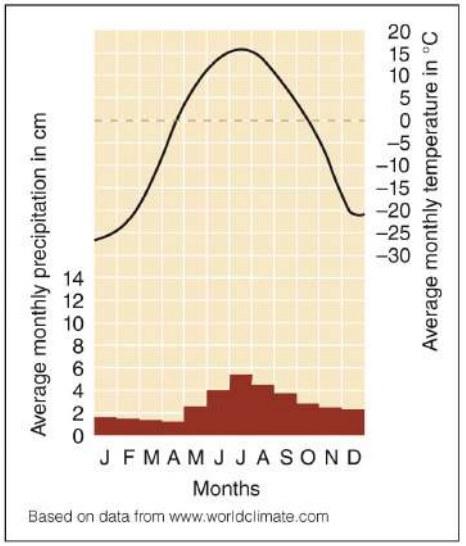
Arctic Tundra

- Treeless biome in the far north that consists of boggy plains covered by lichens and mosses
- Harsh, cold winters and extremely short summers and seasonal snow melting
- Low primary productivity and low resilience
- Permafrost—layer of permanently frozen ground
  - Climate change causing permafrost to thaw



Boreal Forest/Taiga

- Coniferous forests of pine, spruce, and fir, in the Northern Hemisphere, just south of tundra
- Winters extremely cold and severe
- Little precipitation, 20 in/year
- Soil is acidic and mineral poor
- Ponds and lakes dug by glaciers
- Caribou, wolves, bear, moose, rodents, rabbits, lynx, birds in summer, lots of insects
- Top source of industrial wood and fiber, leading to loss of forest



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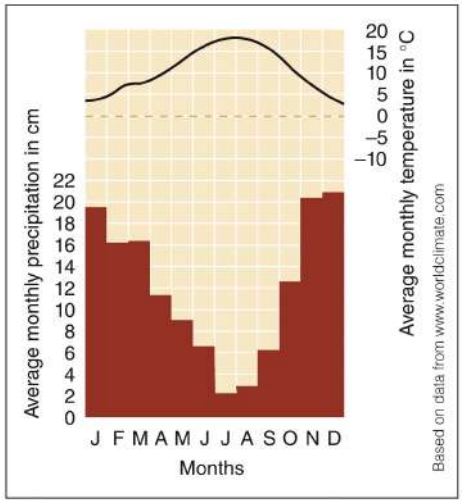
Temperate Rain Forest

- Coniferous forest with high precipitation, dense fog and cool weather
- Northwest coast of North America, SE Australia, South America
- Mild winters, cool summers
- Slow decay, poor soil
- Hemlock, fir, cedar, spruce, epiphytes, mosses, lichens and ferns
- Squirrels, wood rats, elk, mule deer, birds, amphibians and reptiles
- High producer of lumber and pulpwood
  - Overharvesting old-growth forest is an issue

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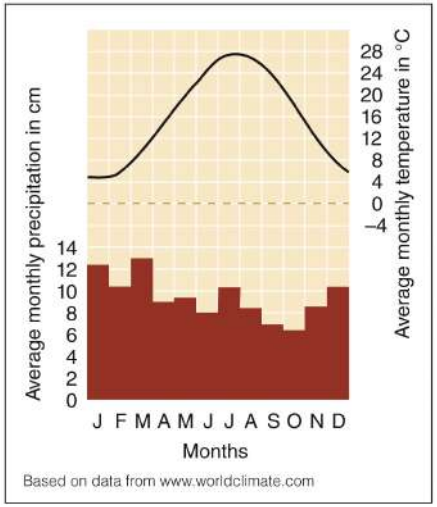
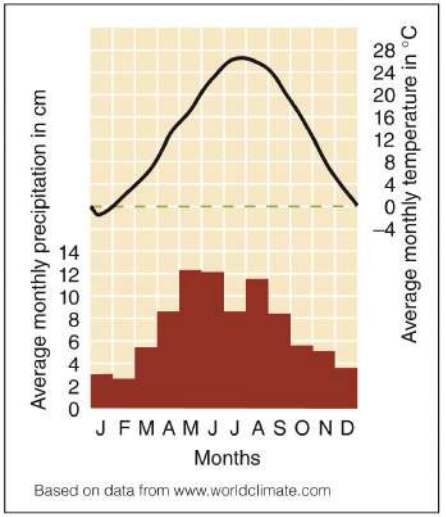
Temperate Deciduous Forest

- Forest biome that occurs in temperate areas where precipitation ranges from 30–60 in/year
- Hot summers, cold winters
- Topsoil rich in organic matter
- Broad-leaf hardwood trees, lose leaves seasonally
- Originally home to puma, wolves, and bison; now deer, bears, small mammals, birds remain
- Original forests in Europe and North America mostly destroyed by logging and urbanization
- Deciduous forest biomes were the first converted to agricultural use



Temperate Grassland

- Tallgrass prairies and shortgrass prairies
- Hot summers, cold winters, and less rainfall (10 – 30 in/year) than in temperate deciduous forest biome
- Soil rich in organic matter
- More than 90% of tallgrass prairies were plowed for agriculture, now North America's rarest biome



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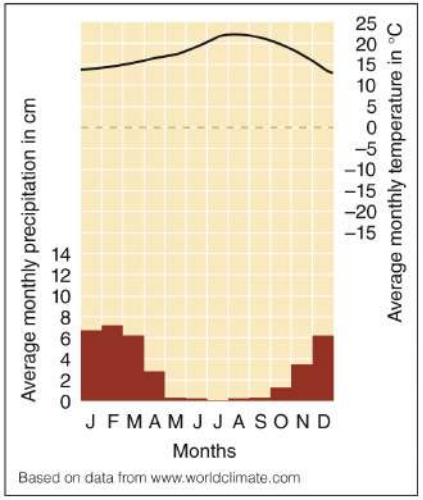
Chaparral

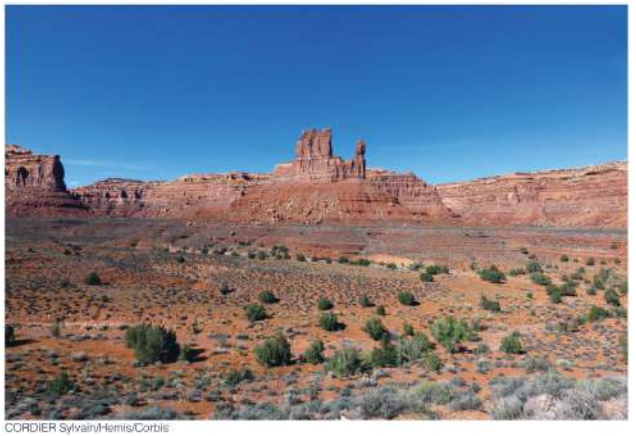
- Mild, moist winters; hot, dry summers
- Small-leaved evergreen shrubs and small trees dominate
- Lush vegetation during rainy winter season
- Wildfires common in late summer and autumn
  - Many fire adapted plants that grow after a fire
- Thin, unfertile soil



Earl Scott/Photo Researchers, Inc.

Desert

- Plant growth limited by lack of precipitation
- Daily temperature extremes
- Less than 10 inches of rain/year
- Sparse vegetation that includes cacti, yucca, and sagebrush
- Animals
  - Typically small, mostly nocturnal
  - Insects, arachnids, desert-adapted amphibians, many reptiles
- Threatened by human encroachment and environmental damage from off-road vehicles
  - Soil easily eroded and less vegetation grows to support native animals



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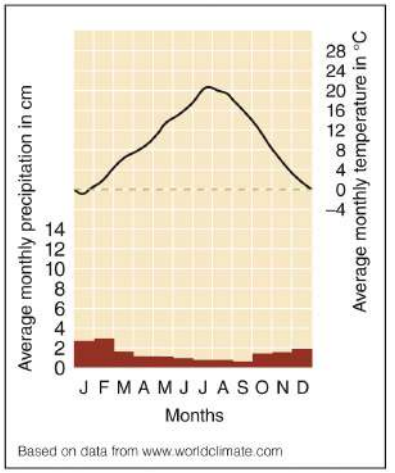
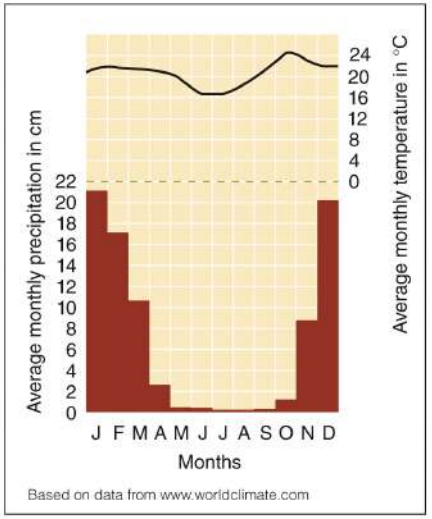


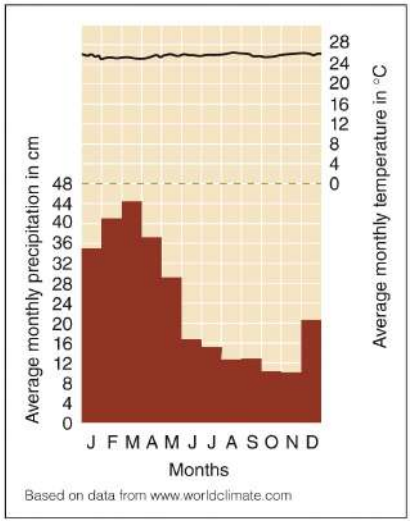
Savanna

- Tropical grassland
- Widely scattered or clumped trees
- Low or intense seasonal rainfall, 34–60 in/year, but with prolonged dry periods
- Low mineral-content soil
- Large herds of herbivores such as wildebeest, antelope, giraffe, zebra, elephant
- Large carnivores such as lions and hyenas
- Savanna is lost as it is converted into rangeland for cattle
- Africa, North Australia, South America, West India



Tropical Rain Forest

- Lush, species-rich forest that occurs where the climate is warm and moist year-round
- Rains almost daily, 80–180 in/year
- Weathered, mineral-poor soil
- High species richness and diversity
  - Most species live in the canopy
- High rate of decomposition
- In tropical dry forests precipitation is lower and more seasonal
- Industrial expansion and human population growth threaten the rain forests

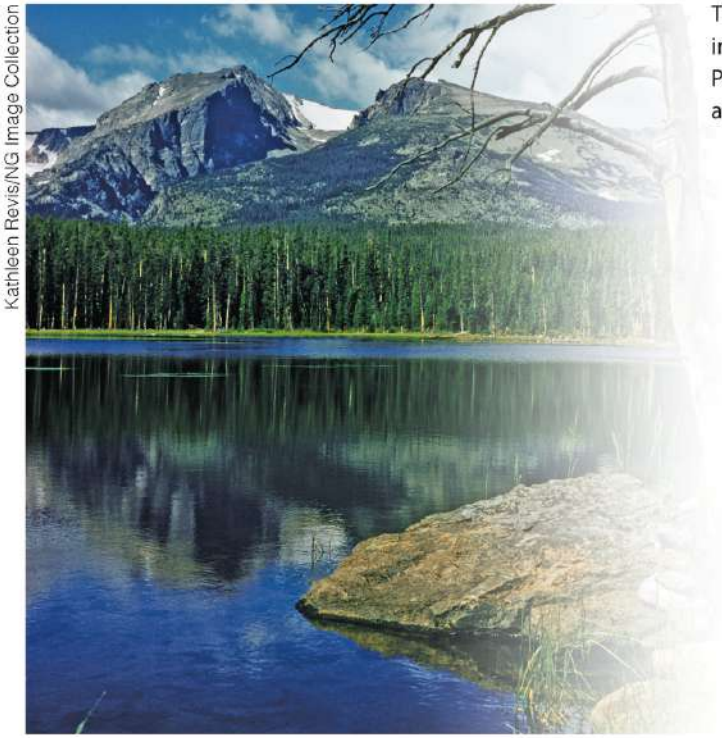


Aquatic Ecosystems

- Aquatic ecology
  - Freshwater or saltwater
  - Salinity, light availability, nutrient concentration, and dissolved oxygen all affect location and type of species present in a body of water
  - Aquatic ecosystems contain three main categories of organisms
    - Plankton—phytoplankton and zooplankton
      - Microscopic, free floating
    - Nekton—fish and turtles
      - Larger, swimming organisms
    - Benthos—sponges, oysters, worms, crabs, etc.
      - Bottom dwelling organisms, either fixed, burrowing, or walk on bottom

Freshwater Ecosystems

- Freshwater ecosystems include
  - Standing-water (lakes and ponds)
  - Flowing-water (rivers and streams)
  - Wetlands (marshes and swamps)
- Occupy 2% of earth's surface, yet play important role in hydrologic cycle

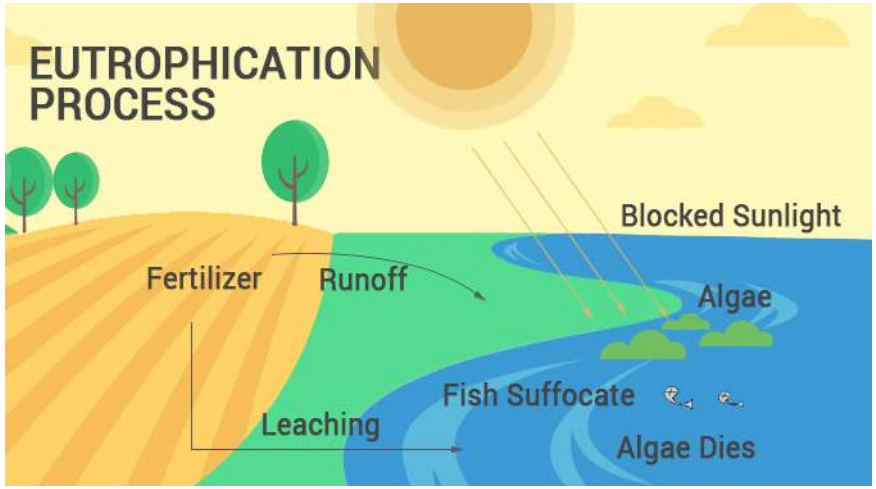


Kathleen Revis/NG Image Collection

The zonation in Bear Lake, in Rocky Mountain National Park, Colorado, is not apparent to a visitor.

Freshwater Ecosystems

- Standing water ecosystem
  - A body of fresh water surrounded by land and whose water does not flow; a lake or a pond.
  - Human effects include unintended eutrophication - unnatural nutrient enrichment which can significantly affect the ecological balance of the body of water



Freshwater Ecosystems

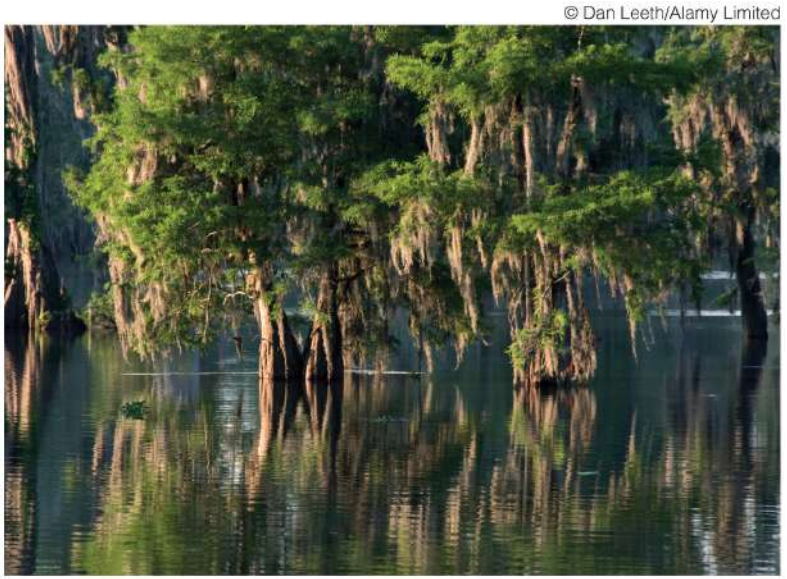
- Flowing water ecosystem
  - A freshwater ecosystem such as a river or stream in which water flows in a current
    - Highly variable, as the surrounding environment changes between the river's source and mouth
      - Shading by trees in some areas, sunlight in others
      - Groundwater infiltrate changes water temperatures locally
      - Types of organisms present depend on strength of current
    - Adverse human impacts include pollution and dam construction

Freshwater Ecosystems

- Freshwater wetlands
  - Lands that shallow fresh water covers for at least part of the year; wetlands have a characteristic soil and water-tolerant vegetation
  - Marshes: dominated by grass-like plants
  - Swamps: dominated by woody trees or shrubs
  - Waterlogged soils
    - Anaerobic, low rate of decomposition
    - Rich in organic material
  - Productive plant communities

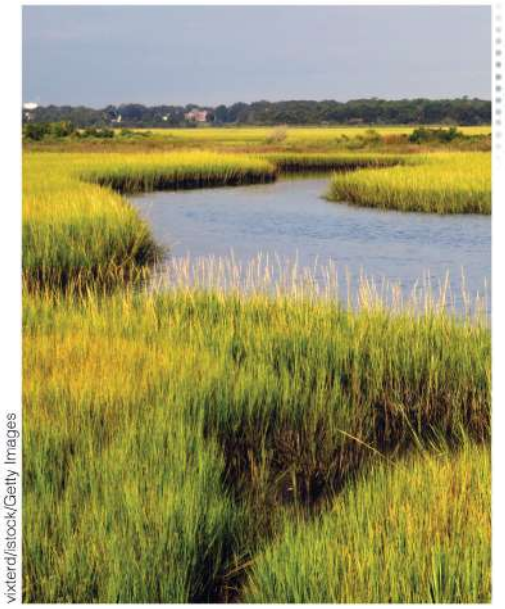
Freshwater Ecosystems

- Freshwater wetlands provide important environmental functions known as *ecosystem services*
  - Ecosystem services include:
    - Providing wildlife habitat
    - Flood mitigation
    - Serving as groundwater recharge areas
    - Trapping pollutants from floodwaters
  - Wetlands are threatened by pollution, development and agriculture



Estuaries

- Estuary
  - Coastal body of water, partly surrounded by land, with access to both the ocean and fresh water from a river
- Salt marshes—shallow wetlands with salt-tolerant grasses in temperate areas
- Mangrove forests—tropical equivalent of salt marshes
  - Provide extensive habitat/breeding grounds for fish, shellfish and birds
  - Prevent coastal erosion



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Population Responses to Changing Conditions Over Time: Evolution

- Evolution—the cumulative genetic changes in populations that occur during successive generations
- Charles Darwin proposed the mechanism of evolution (i.e., not idea of evolution)
- Environment plays crucial role in which traits are inherited
  - Accumulation of favorable traits leads to increased survival

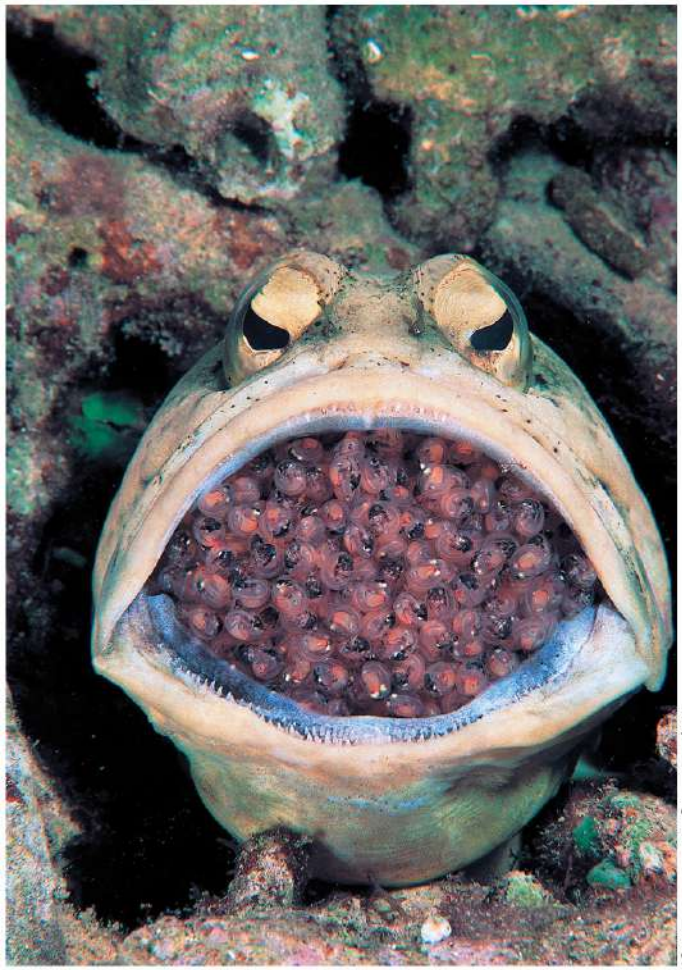
JAMES L. STANFIELD/NG Image Collection

Natural Selection

- Natural selection
  - The tendency of better-adapted individuals—those with a combination of genetic traits best suited to environmental conditions—to survive and reproduce, increasing their proportion in the population
- Evolution occurs through the process of natural selection
  - As favorable traits increase in frequency in successive generations, and as unfavorable traits decrease or disappear, the collection of characteristics of a given population changes

Natural Selection

- Four naturally occurring phenomena guide natural selection (NS)
  - High reproductive capacity
  - Limits on population growth
  - Heritable variation
  - Differential reproductive success
- Mutations provide genetic variation
  - Mutations may be beneficial, harmful, or have no effect
  - Beneficial mutations will convey a survival advantage to those that possess them



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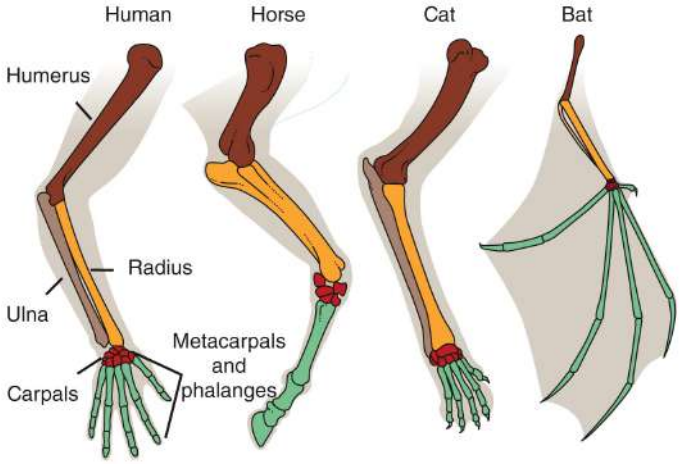
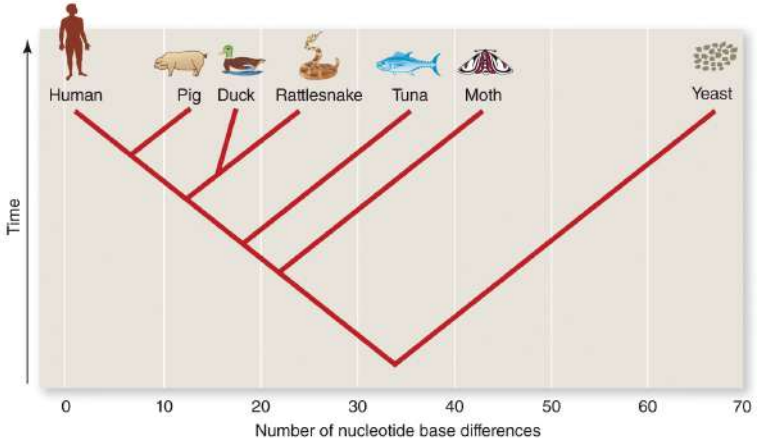
Environmental InSight
Evidence for Evolution

- Comparative anatomy
  - Similarities among organisms demonstrate how they are related
- Molecular biology
  - Showing relationships on a molecular level such as sharing an enzyme or nucleotide base



Adapted from Figure 15.13 on p. 244, in S. A. Alters and B. Alters, *Biology: Understanding Life*, Hoboken, NJ: John Wiley and Sons, Inc. (2009).



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Community Responses to Changing Conditions Over Time: Succession

- Ecological succession
  - The process of community development over time, which involves species in one stage being replaced by different species
- Resident species modify the environment, making it more suitable for later species
- Former concept of a stable 'climax community' has been replaced with understanding that communities continue to change over time
- Succession is described by the changes in plant species in a given area over tens, hundreds, or thousands of years
- Two types of succession: Primary and secondary

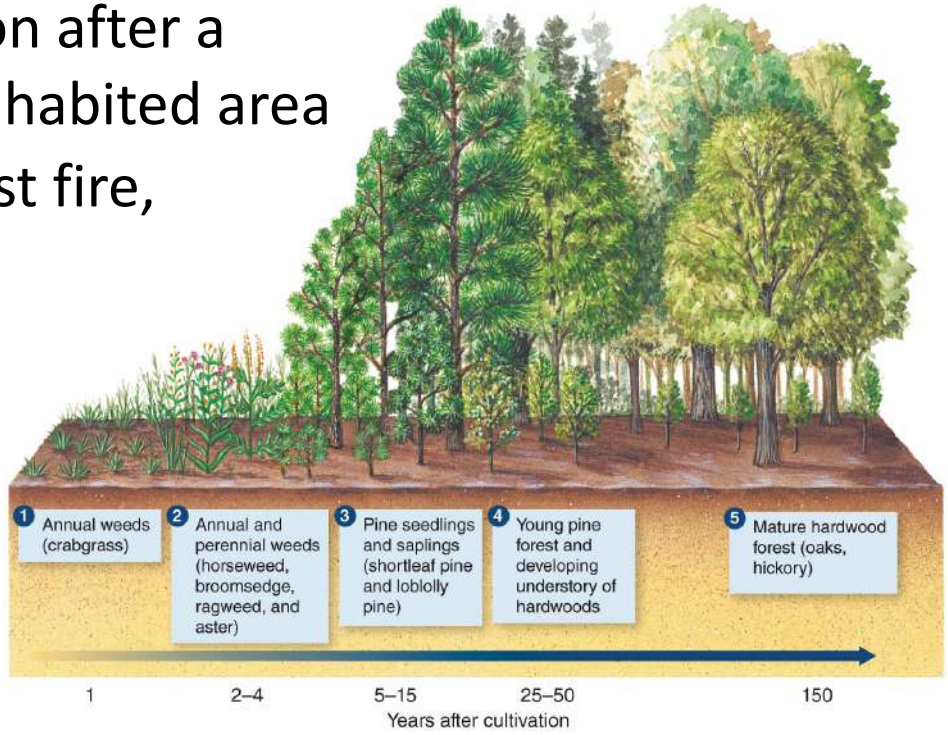
Primary Succession

- Primary succession
  - The change in species composition over time in a previously uninhabited environment
    - Begins with bare rock surfaces
    - Colonization with lichens first occurs, forming a pioneer community
    - Rock breakdown begins soil formation
    - Lichens→mosses→shrubs→eventually specific trees

Martin Shields/Science Source Charles D. Winters/Science Source Mira/Alamy

Secondary Succession

- Secondary Succession
  —Change in species composition after a disturbance in a previously inhabited area
    - Abandoned farmland, forest fire, clear-cut forest
- Soil already present
- Can take more than 100 years for secondary succession to occur



- Typically crabgrass→horseweed→pine trees→hardwood trees

Case Study: Wildfires

- Any unexpected fire that burns in grass, shrub, and forest areas
- Has ecosystem impact
  - Frees nutrients from dry organic matter
  - Removes plant cover and stimulates seed germination
  - Increases soil erosion
- Fires part of natural environment
  - Many fire-adapted plants rely on fire for successful reproduction
- Human fire prevention over the years has made wildfire destruction worse
  - Allows debris to accumulate, makes fires hotter, more destructive
  - Prescribed burning is a management tool now used that reduces organic debris and decreases fire severity