Biodiversity and Evolution

Chapter 4

Core Case Study: Why Should We Care about the American Alligator?

- Largest reptile in North America
- 1930s: Hunters and poachers
- Importance of gator holes and nesting mounds
- 1967: endangered species
- 1977: comeback, threatened species

The American Alligator

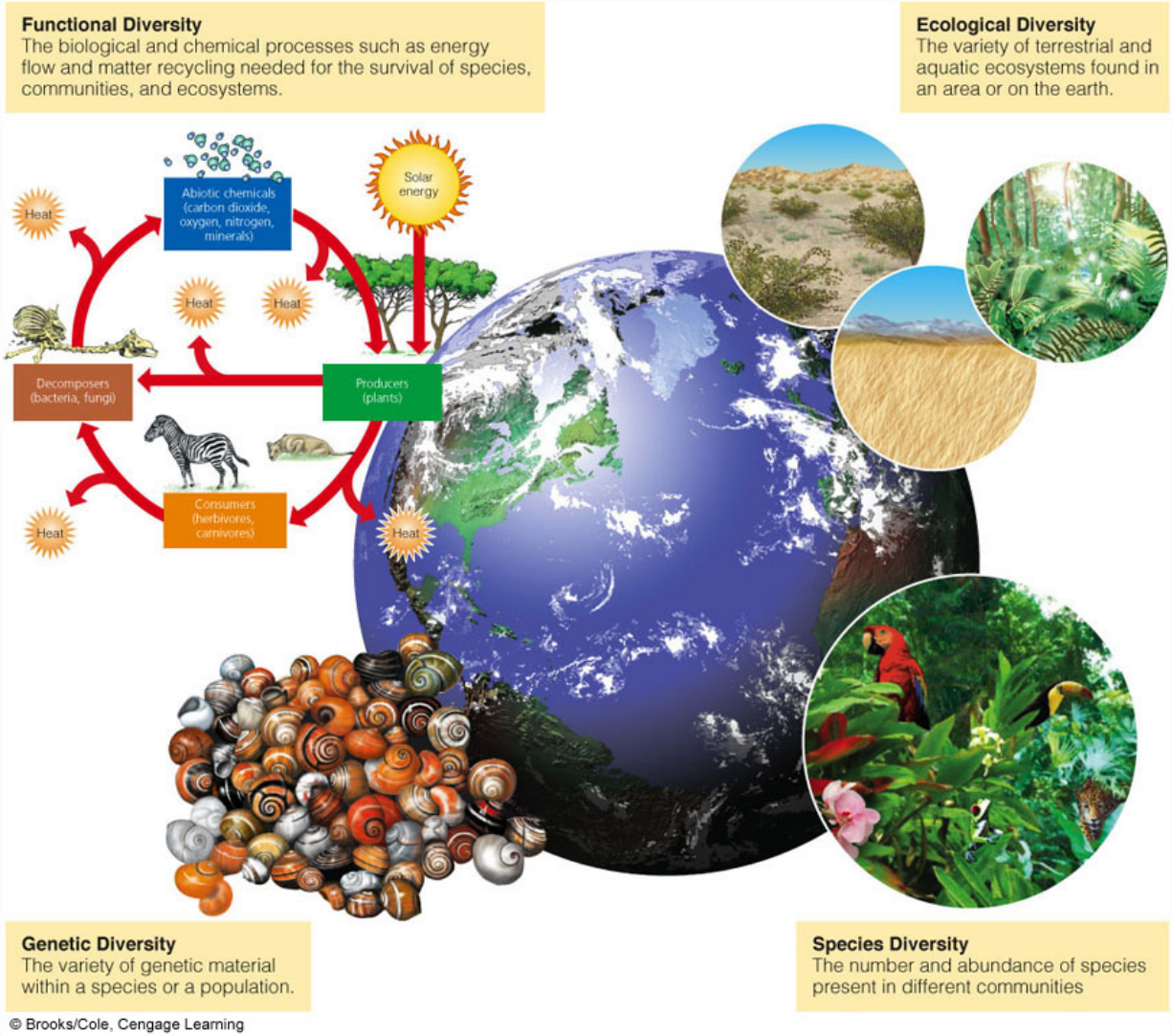
4-1 What Is Biodiversity and Why Is It Important?

- ***Concept 4-1*** *The biodiversity found in genes, species, ecosystems, and ecosystem processes is vital to sustaining life on earth.*

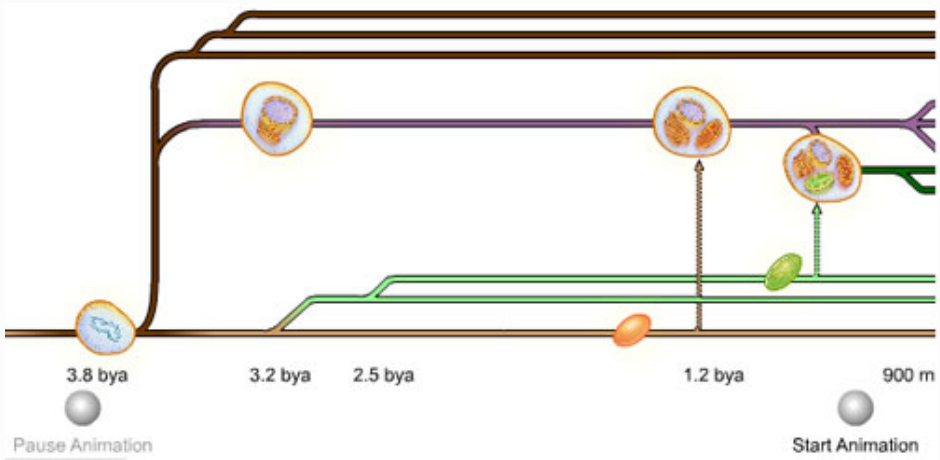
Biodiversity Is a Crucial Part of the Earth's Natural Capital

- Vital renewable resource
- Species diversity
- Ecosystem diversity
- Functional diversity

Natural Capital: Major Components of the Earth's Biodiversity

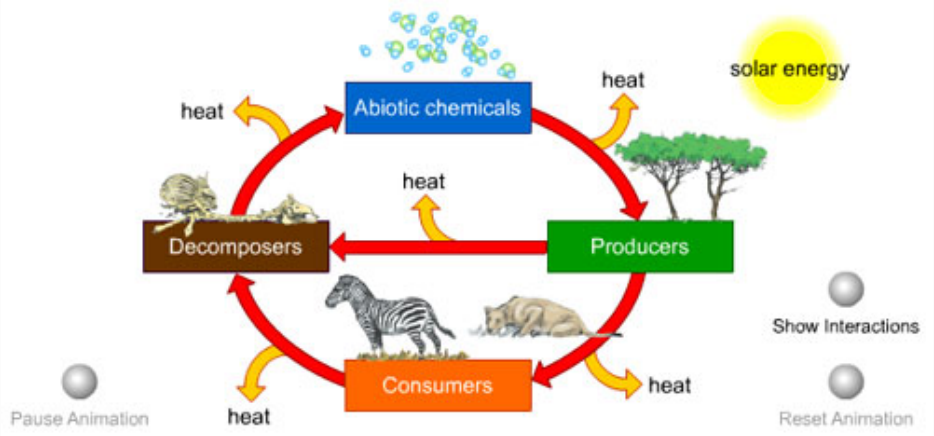


Animation: Evolutionary tree of life



PLAY

Active Figure: Matter recycling and energy flow



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Video: Frogs galore

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4-2 Where Do Species Come From?

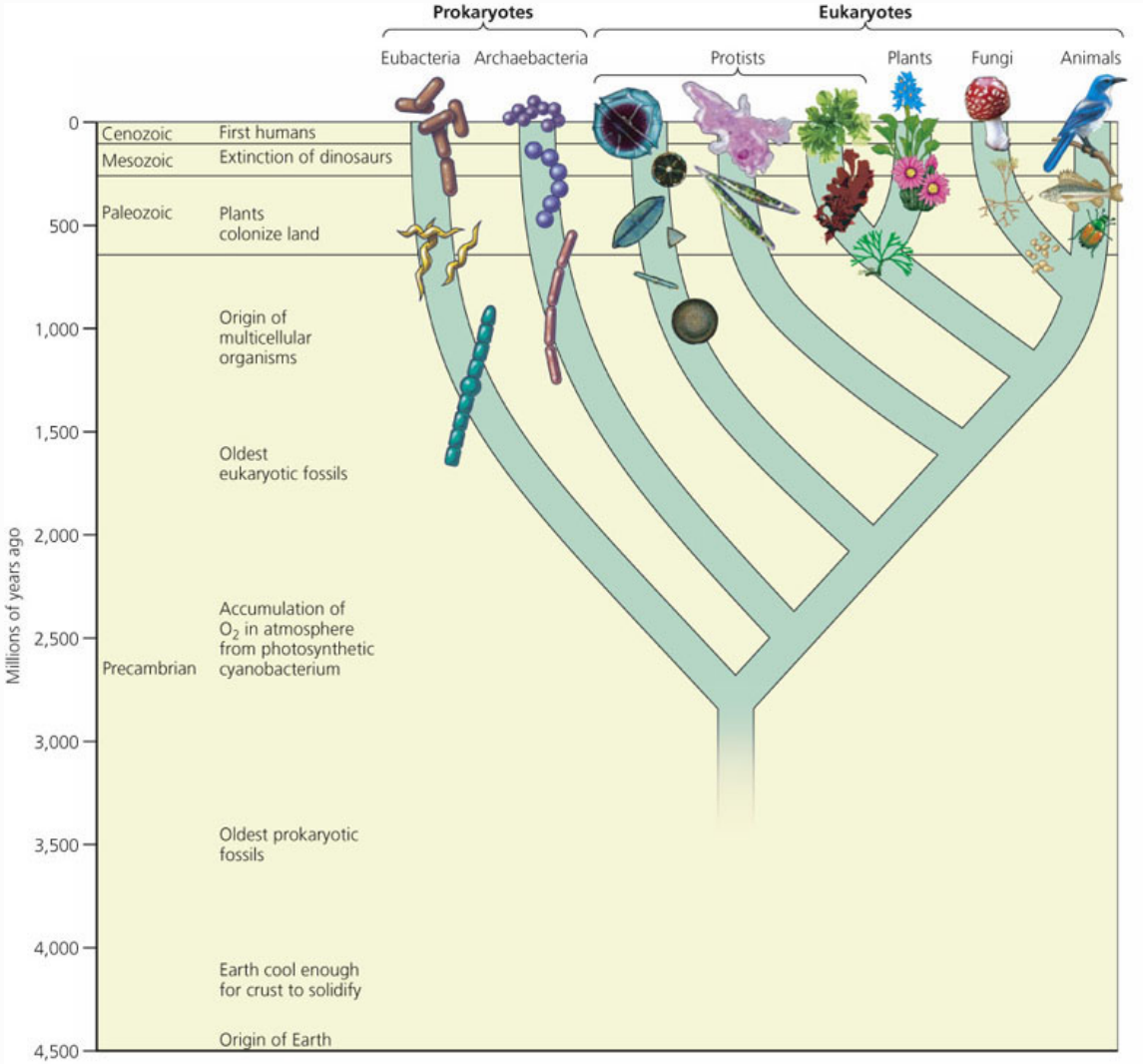
- ***Concept 4-2A*** *The scientific theory of evolution explains how life on earth changes over time through changes in the genes of populations.*

- ***Concept 4-2B*** *Populations evolve when genes mutate and give some individuals genetic traits that enhance their abilities to survive and to produce offspring with these traits (natural selection).*

Biological Evolution by Natural Selection Explains How Life Changes over Time

- Biological evolution
- Natural selection
  - Charles Darwin
  - Alfred Russel Wallace
- Tree of Life

Six Major Kingdoms of Species as a Result of Natural Selection



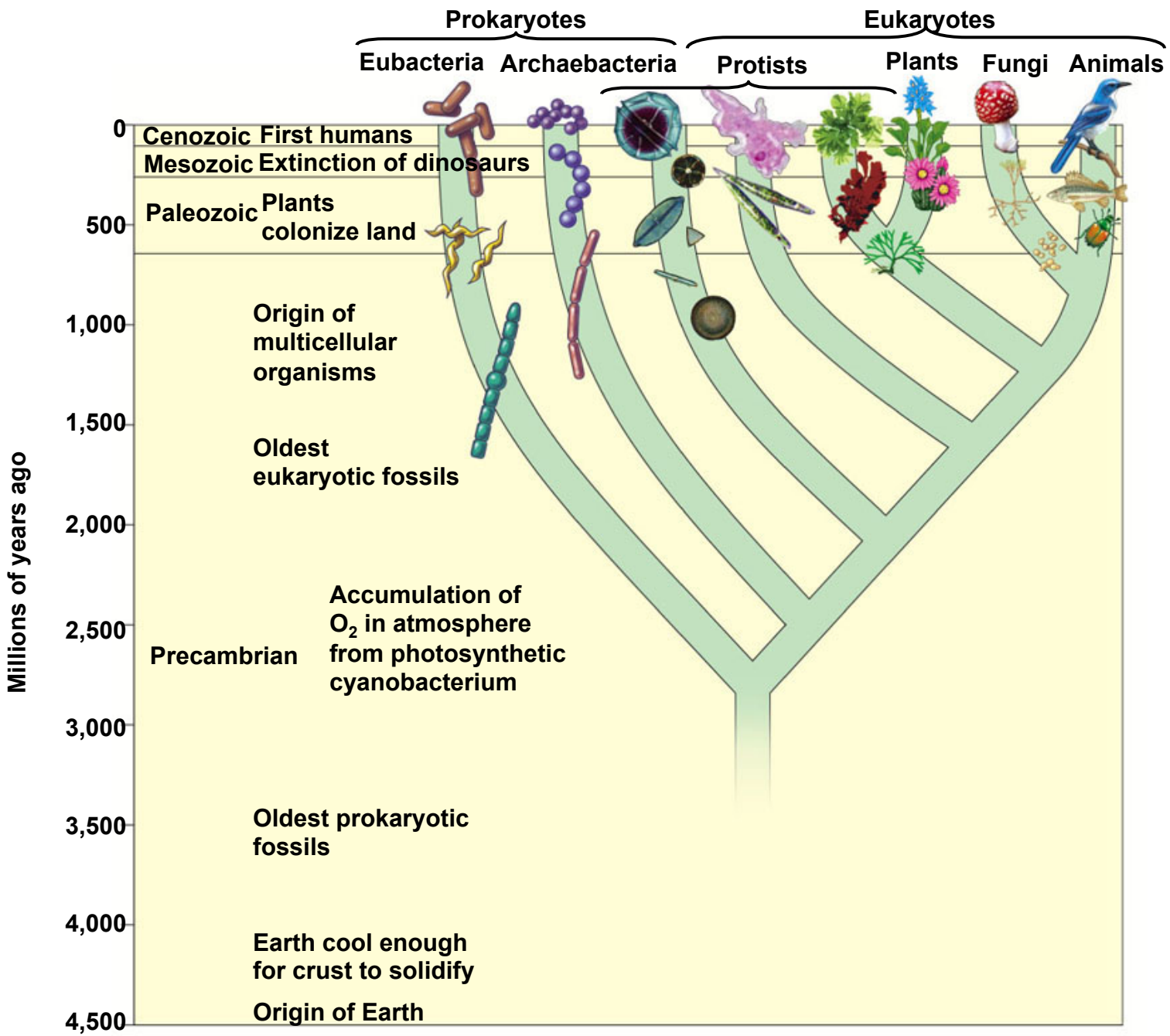


Fig. 4-3, p. 81

The Fossil Record Tells Much of the Story of Evolution

- **Fossils**
  - Physical evidence of ancient organisms
  - Reveal what their internal structures looked like

- Fossil record is incomplete: why?

Fossilized Skeleton of an Herbivore that Lived during the Cenozoic Era

The Genetic Makeup of a Population Can Change

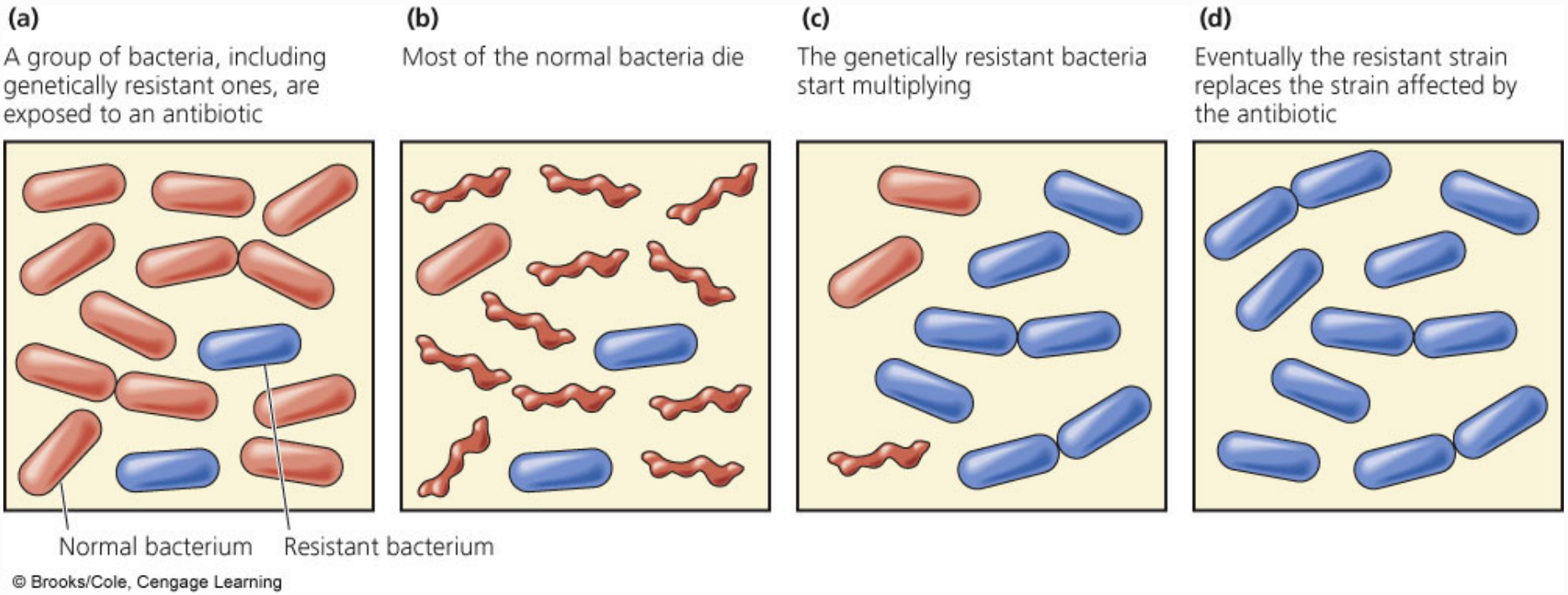
- Populations evolve by becoming genetically different

- Genetic variations
  - First step in biological evolution
  - Occurs through mutations in reproductive cells

Individuals in Populations with Beneficial Genetic Traits Can Leave More Offspring

- Natural selection: acts on individuals
  - Second step in biological evolution
  - Adaptation may lead to **differential reproduction**
  - Genetic resistance
- When environmental conditions change, populations
  - Adapt
  - Migrate
  - Become extinct

Evolution by Natural Selection



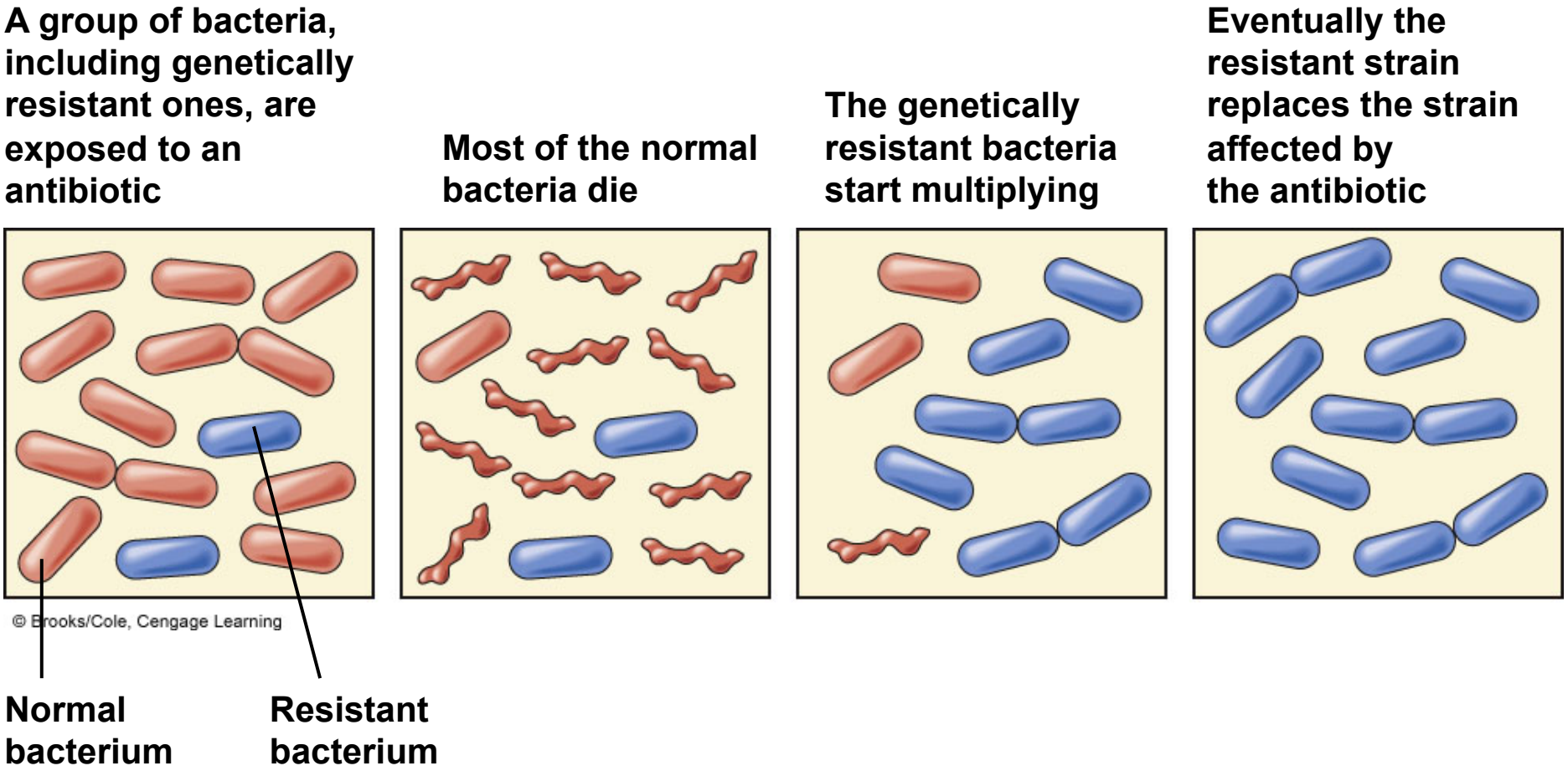
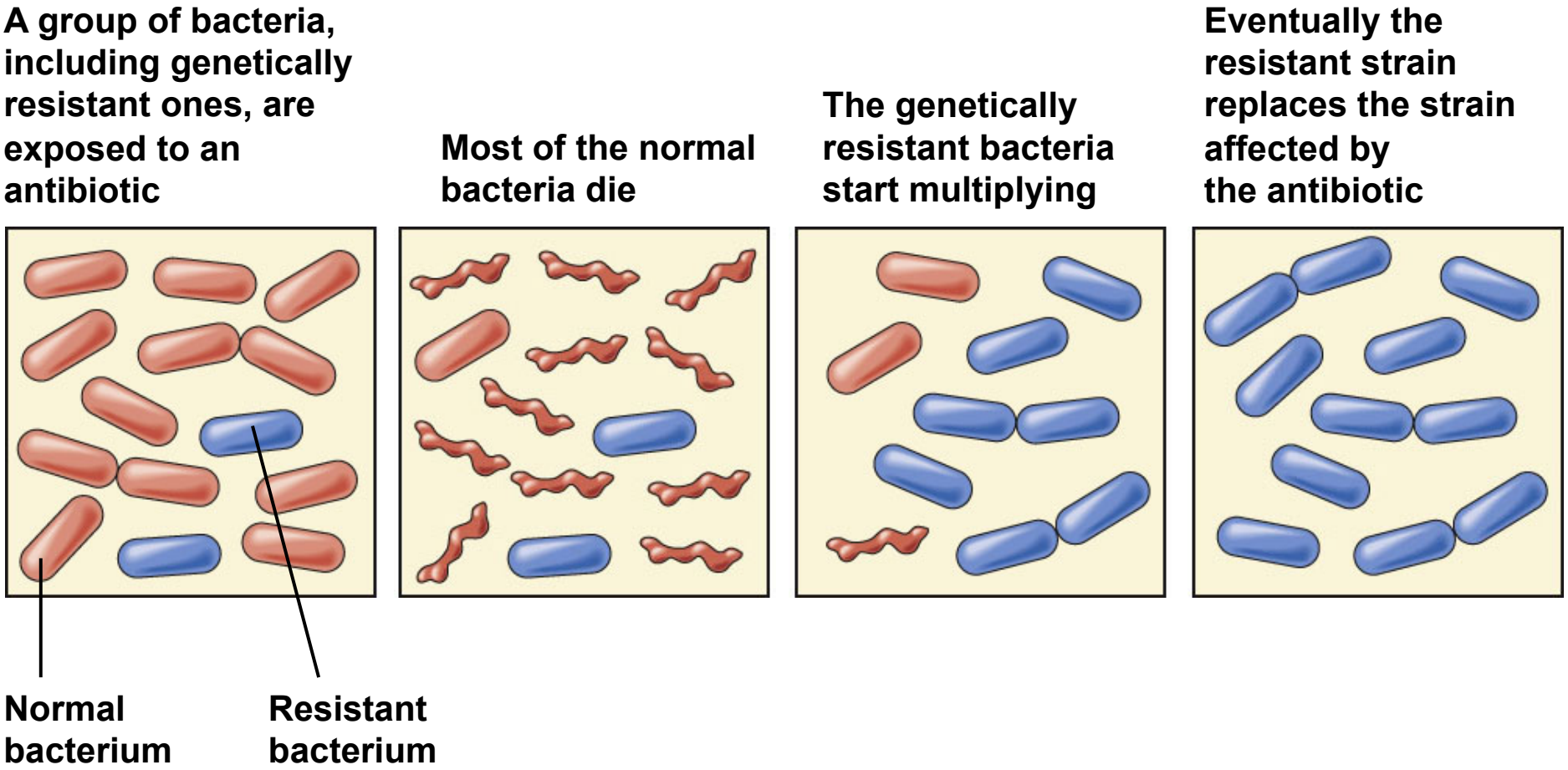

A group of bacteria, including genetically resistant ones, are exposed to an antibiotic
Most of the normal bacteria die
The genetically resistant bacteria start multiplying
Eventually the resistant strain replaces the strain affected by the antibiotic
© Brooks/Cole, Cengage Learning
Normal bacterium
Resistant bacterium

Fig. 4-5, p. 83



Stepped Art

Fig. 4-5, p. 83

Case Study: How Did Humans Become Such a Powerful Species?

- Three human adaptations
  - Strong opposable thumbs
  - Walk upright
  - Complex brain

Adaptation through Natural Selection Has Limits

- Genetic change must precede change in the environmental conditions
- Reproductive capacity

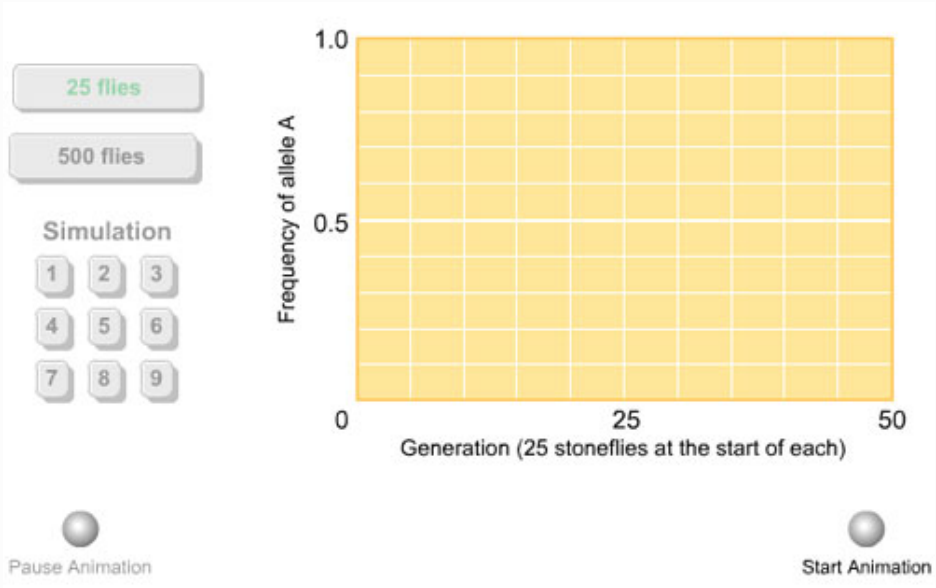
Three Common Myths about Evolution through Natural Selection

- “Survival of the fittest” is not “survival of the strongest”
- Organisms do not develop traits out of need or want
- No grand plan of nature for perfect adaptation

Animation: Adaptive trait

PLAY

Animation: Modeling genetic drift



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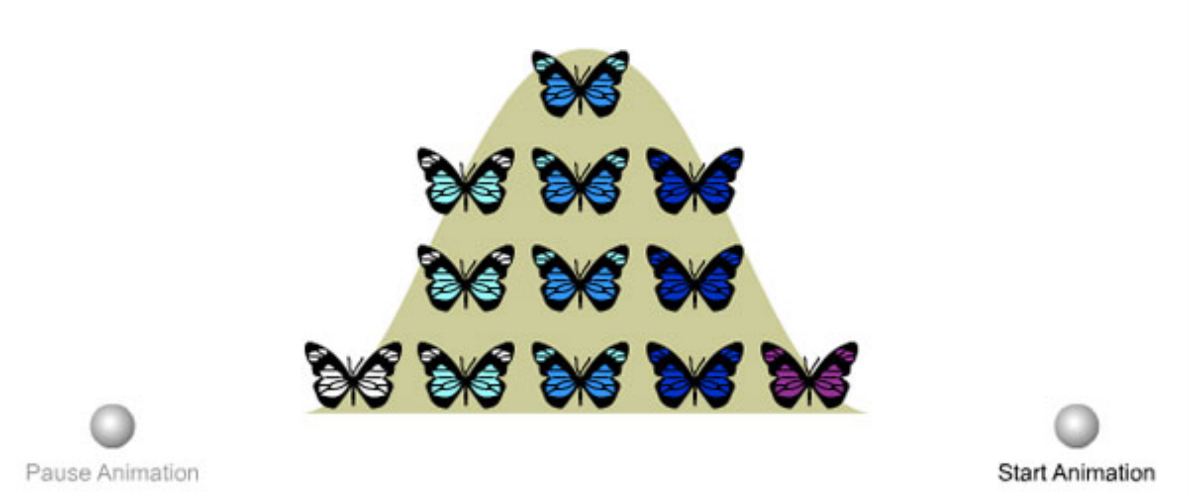
Animation: Disruptive selection



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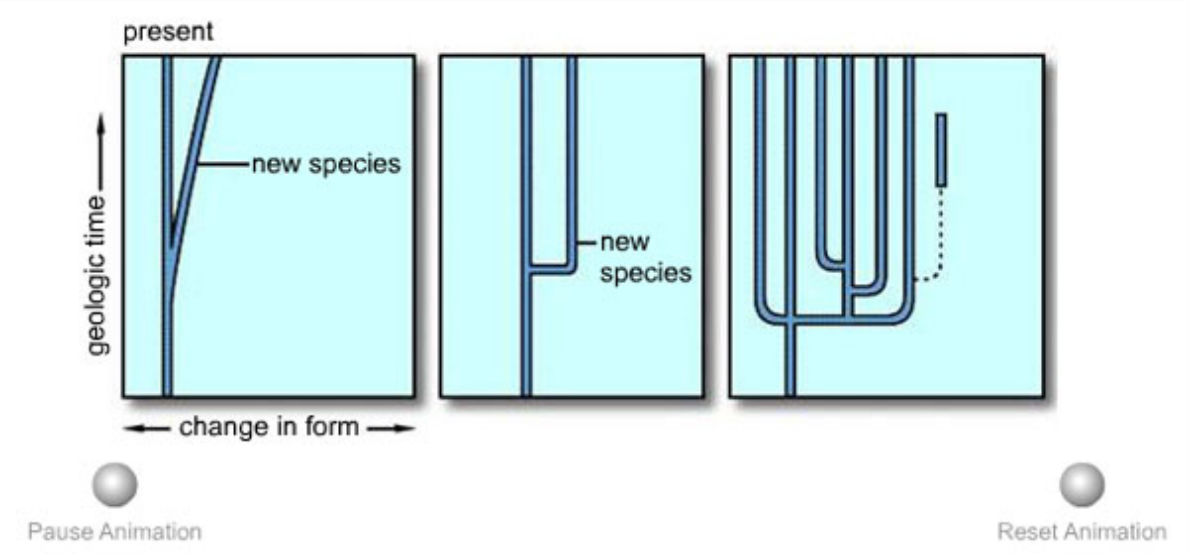
Animation: Evolutionary tree diagrams



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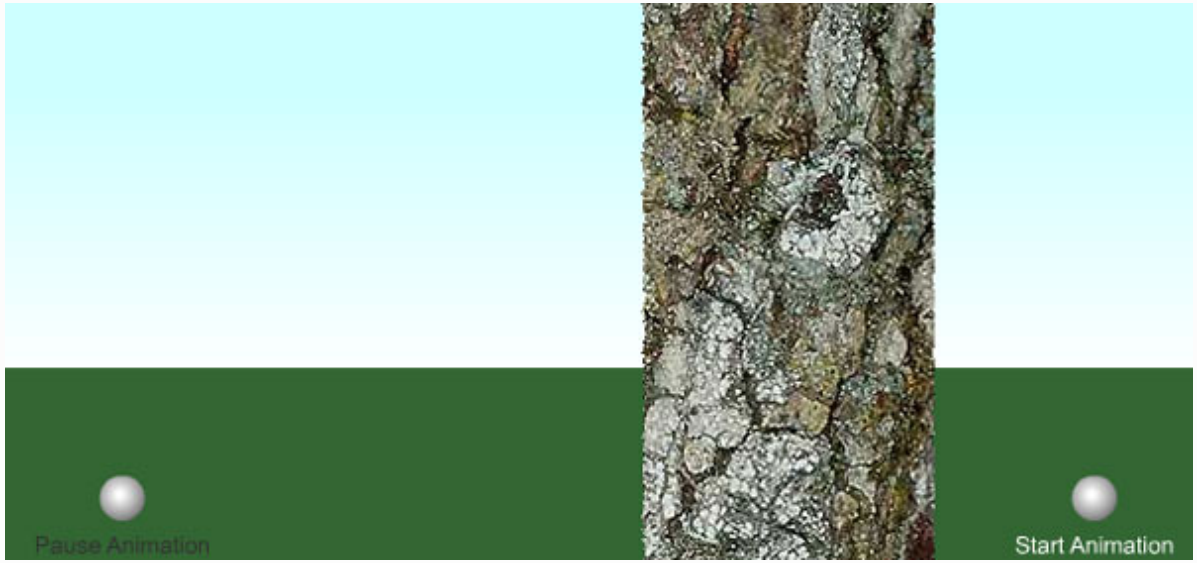
Animation: Change in moth population



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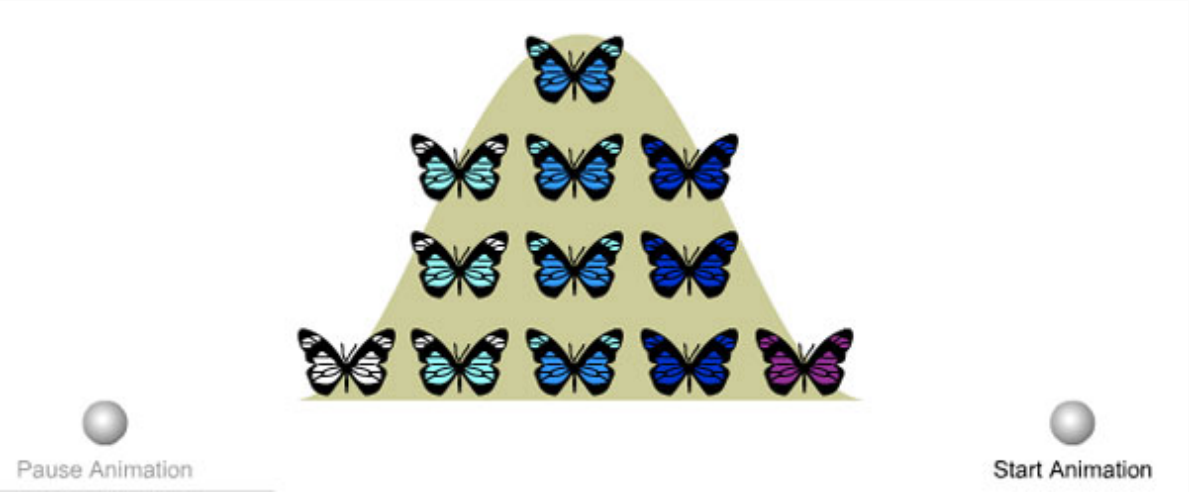
Animation: Stabilizing selection



PLAY

Video: Dinosaur discovery

PLAY

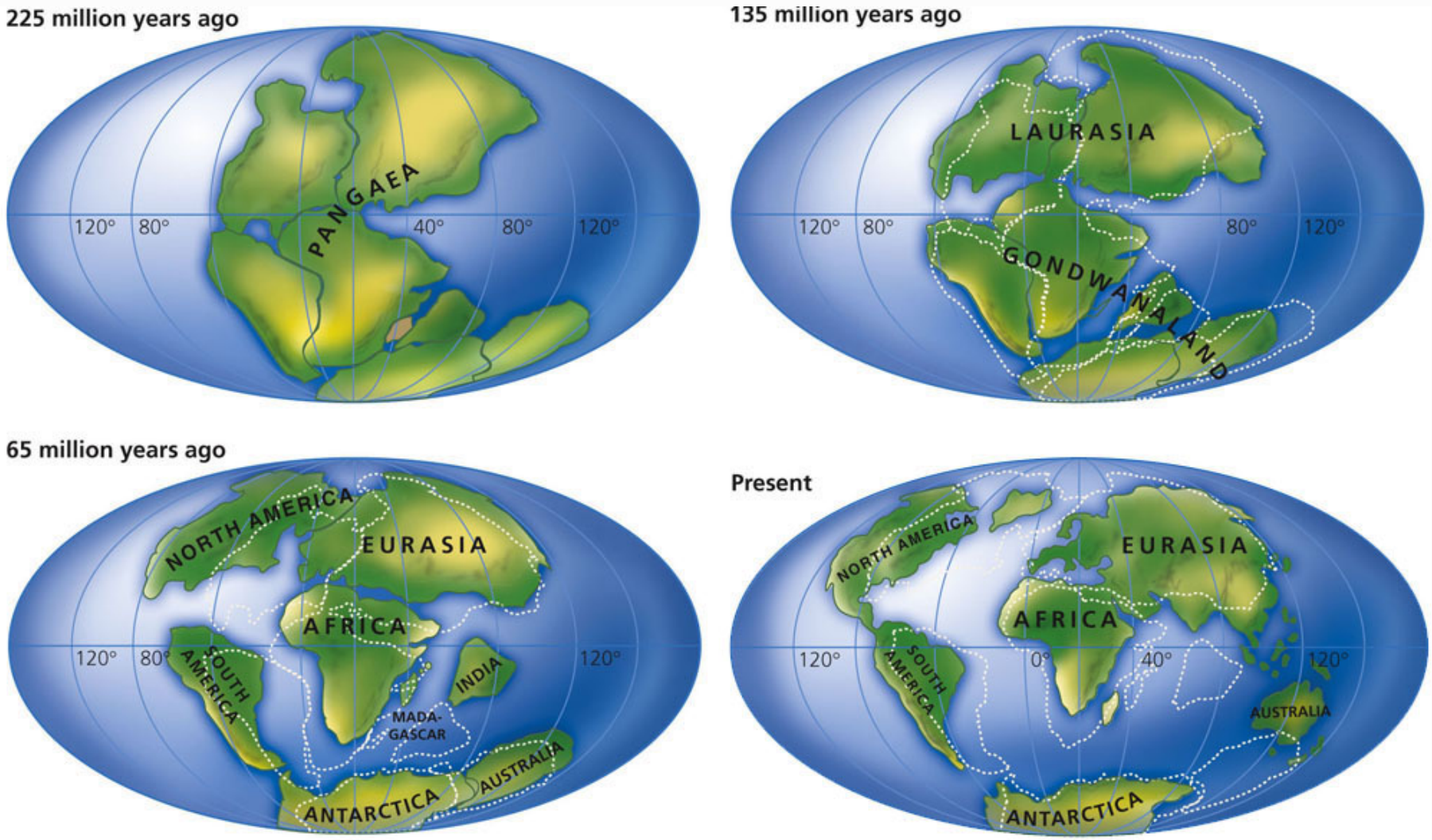
4-3 How Do Geological Processes and Climate Change Affect Evolution?

- ***Concept 4-3*** *Tectonic plate movements, volcanic eruptions, earthquakes, and climate change have shifted wildlife habitats, wiped out large numbers of species, and created opportunities for the evolution of new species.*

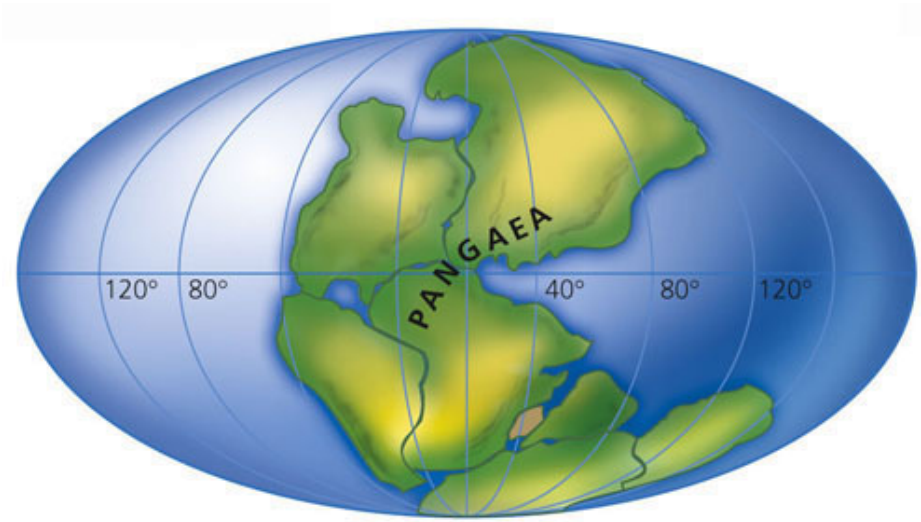
Geologic Processes Affect Natural Selection

- Tectonic plates affect evolution and the location of life on earth
  - Location of continents and oceans
  - Species physically move, or adapt, or form new species through natural selection
- Earthquakes
- Volcanic eruptions

Movement of the Earth's Continents over Millions of Years



225 million years ago



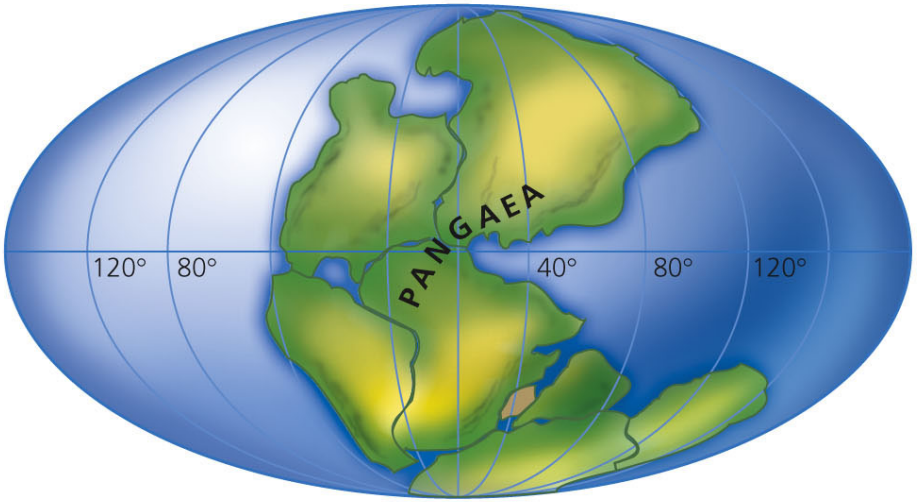
135 million years ago

65 million years ago

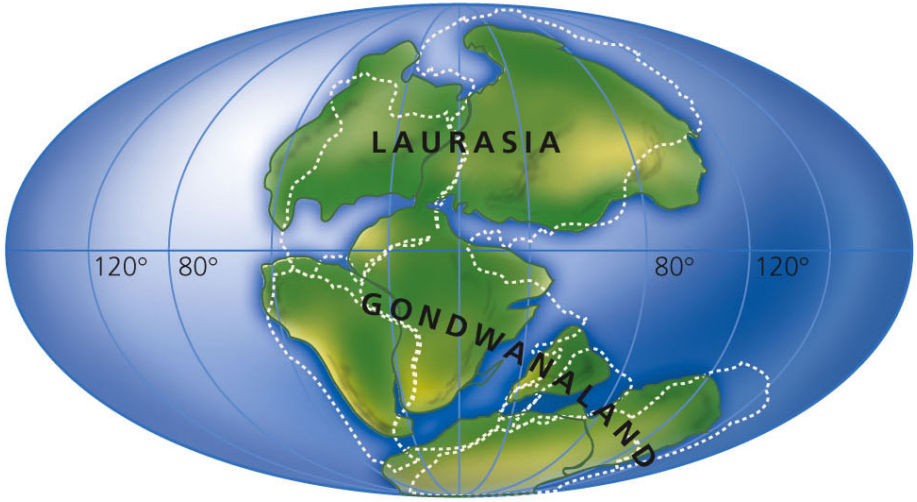
Present

Fig. 4-6, p. 85

225 million years ago



135 million years ago



65 million years ago

Present

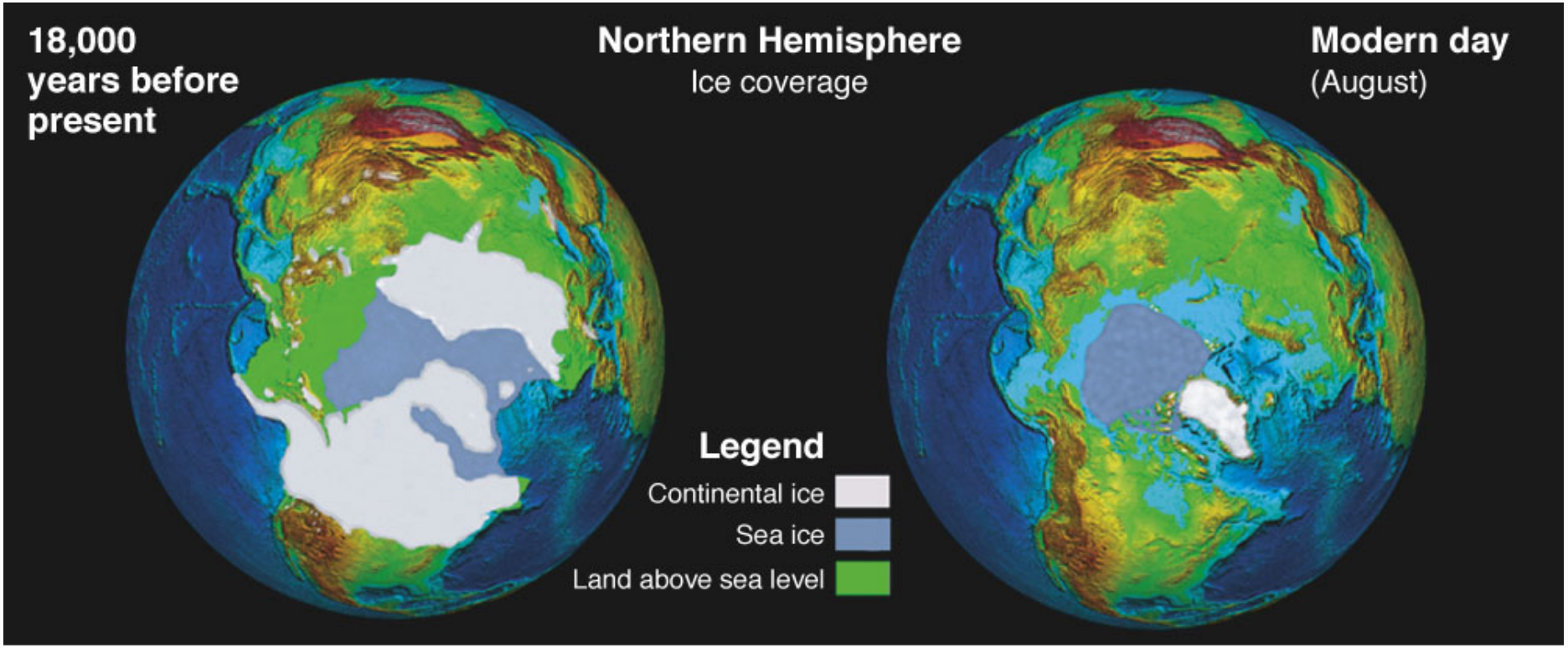
Stepped Art

Fig. 4-6, p. 85

Climate Change and Catastrophes Affect Natural Selection

- Ice ages followed by warming temperatures
- Collisions between the earth and large asteroids
  - New species
  - Extinction

Changes in Ice Coverage in the Northern Hemisphere During the last 18,000 Years



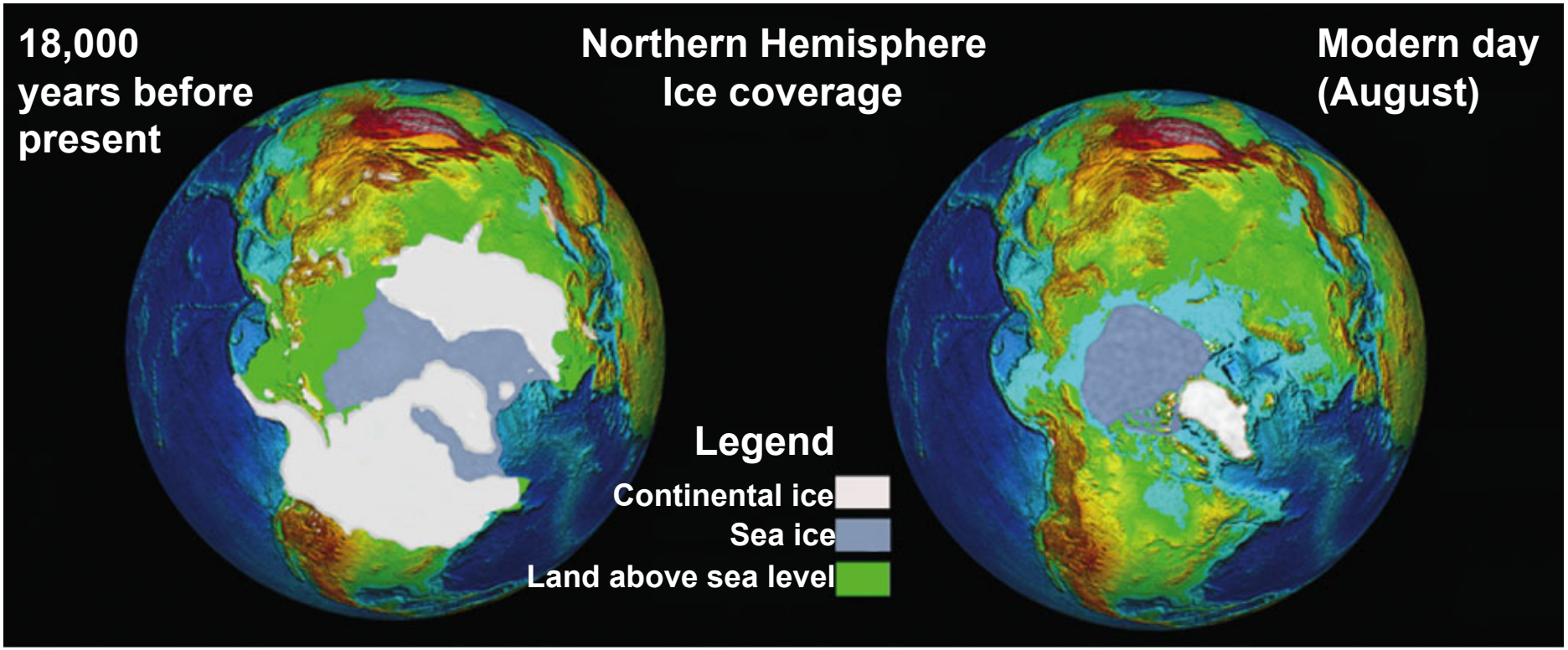


Fig. 4-7, p. 85

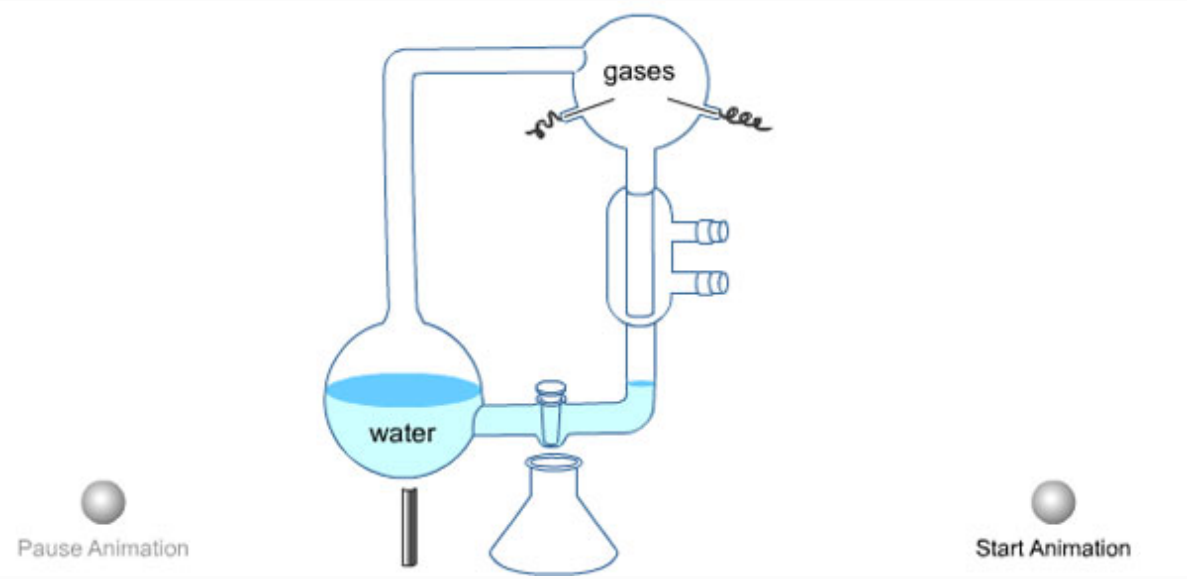
Science Focus: Earth Is Just Right for Life to Thrive

- Certain temperature range
- Dependence on water
- Rotation on its axis
- Revolution around the sun
- Enough gravitational mass

Animation: Continental drift

PLAY

Animation: Stanley Miller's experiment



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4-4 How Do Speciation, Extinction, and Human Activities Affect Biodiversity?

- ***Concept 4-4A*** *As environmental conditions change, the balance between formation of new species and extinction of existing species determines the earth's biodiversity.*

- ***Concept 4-4B*** *Human activities can decrease biodiversity by causing the premature extinction of species and by destroying or degrading habitats needed for the development of new species.*

How Do New Species Evolve?

- Geographic isolation
- Reproductive isolation

Geographic Isolation Can Lead to Reproductive Isolation

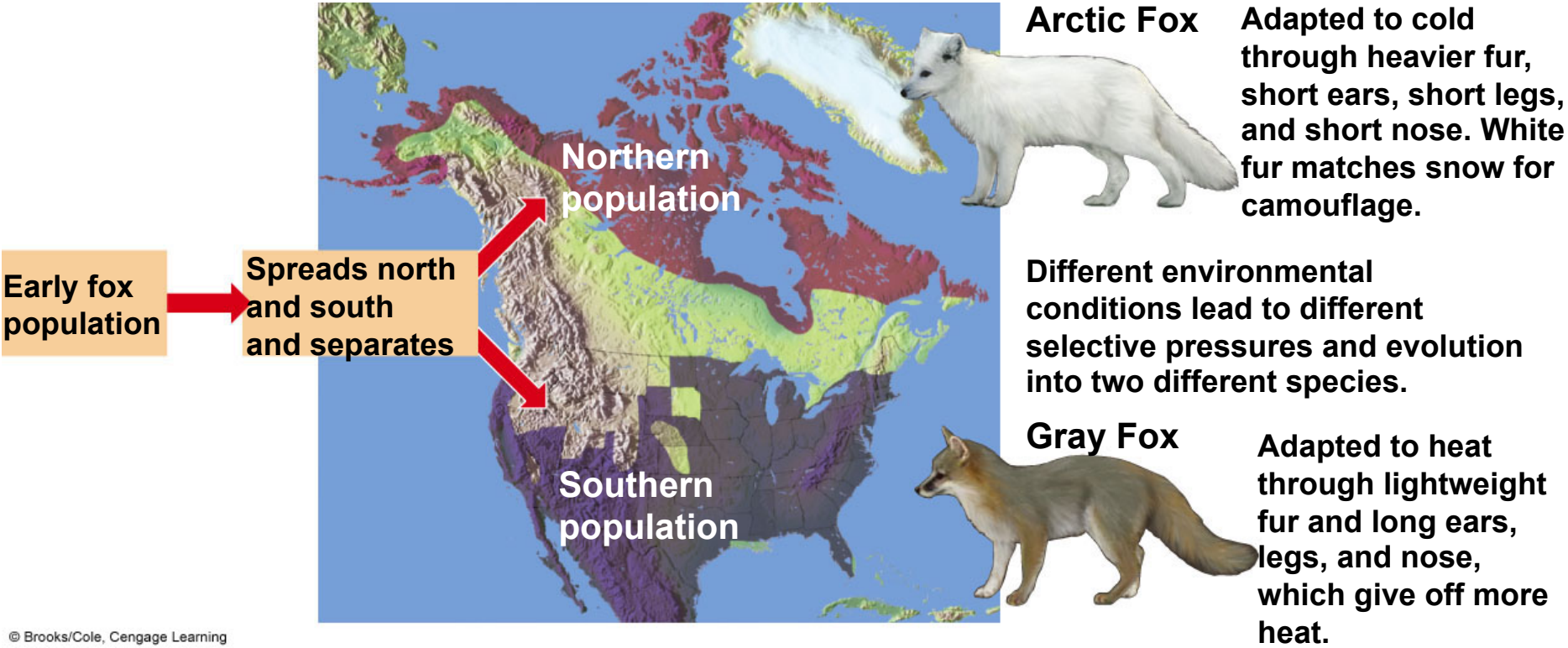


Fig. 4-8, p. 87

Extinction is Forever

- **Extinction**
- **Endemic species**
  - Particularly vulnerable

Golden Toad of Costa Rica, Extinct

Extinction Can Affect One Species or Many Species at a Time

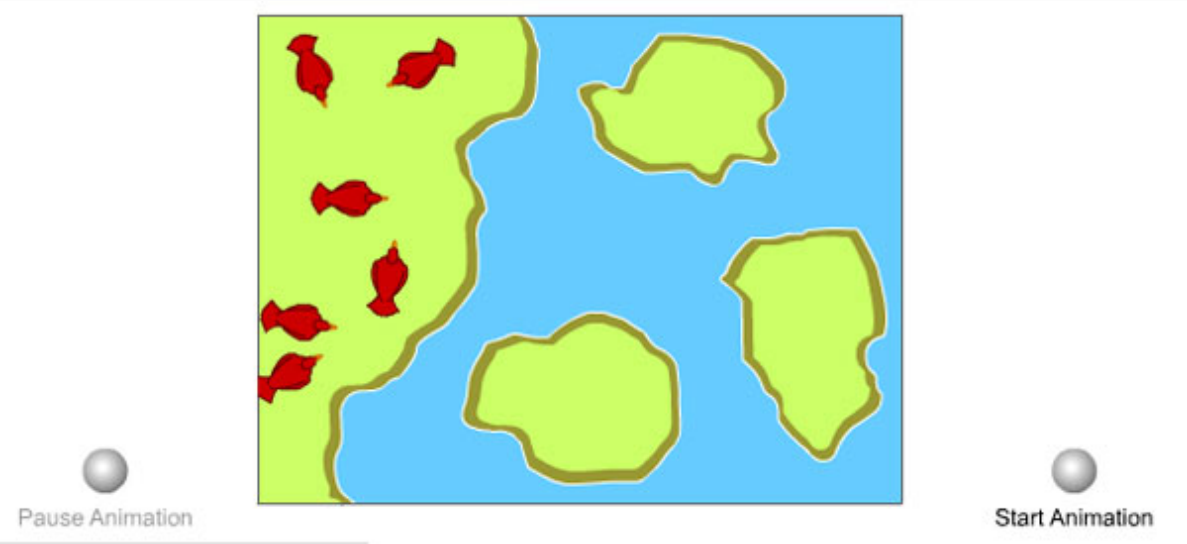
- **Background extinction**
- **Mass extinction**
  - How numbered is debated: 3–5

Science Focus: We Have Two Ways to Change the Genetic Traits of Populations

- **Artificial selection**
- **Genetic engineering, gene splicing**
- Consider
  - Ethics
  - Morals
  - Privacy issues
  - Harmful effects

Genetically Engineered Mice

Animation: Speciation on an archipelago



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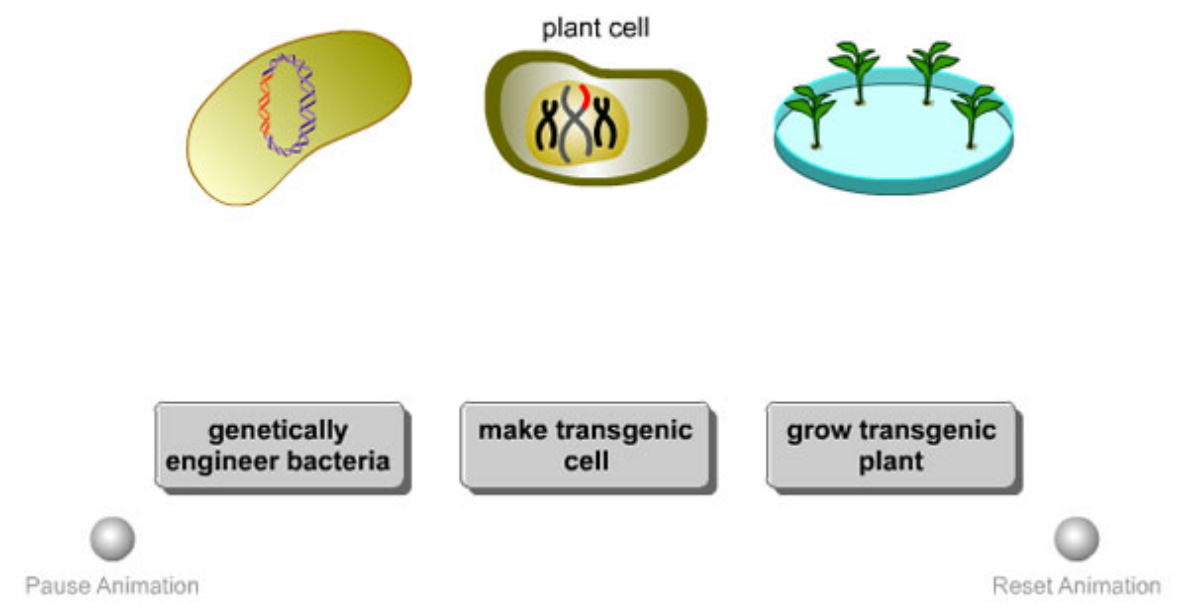
Animation: Transferring genes into plants



PLAY

Video: Cloned pooch

PLAY

Video: Creation vs. evolution

PLAY

4-5 What Is Species Diversity and Why Is It Important?

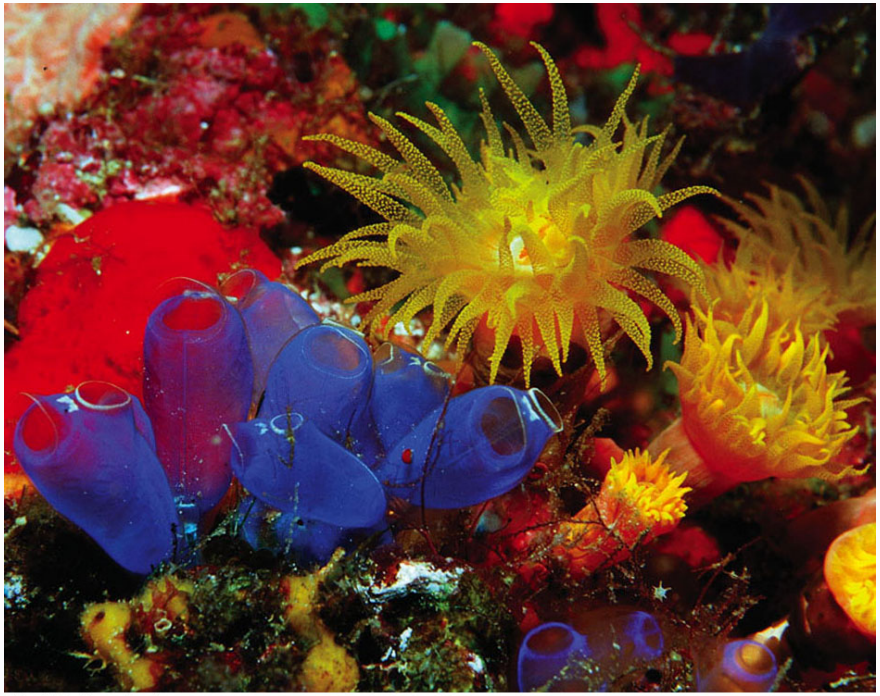
- ***Concept 4-5*** *Species diversity is a major component of biodiversity and tends to increase the sustainability of ecosystems.*

Species Diversity: Variety, Abundance of Species in a Particular Place

- **Species diversity**
  - **Species richness**
  - **Species evenness**

- Diversity varies with geographical location
  - Most species-rich communities
    - Tropical rain forests
    - Coral reefs
    - Ocean bottom zone
    - Large tropical lakes

Variations in Species Richness and Species Evenness



Science Focus: Species Richness on Islands

- **Species equilibrium model, theory of island biogeography**
  - Rate of new species immigrating should balance with the rate of species extinction
- Island size and distance from the mainland need to be considered

Species-Rich Ecosystems Tend to Be Productive and Sustainable

- Species richness seems to increase productivity and stability or sustainability
- How much species richness is needed is debatable

4-6 What Roles Do Species Play in Ecosystems?

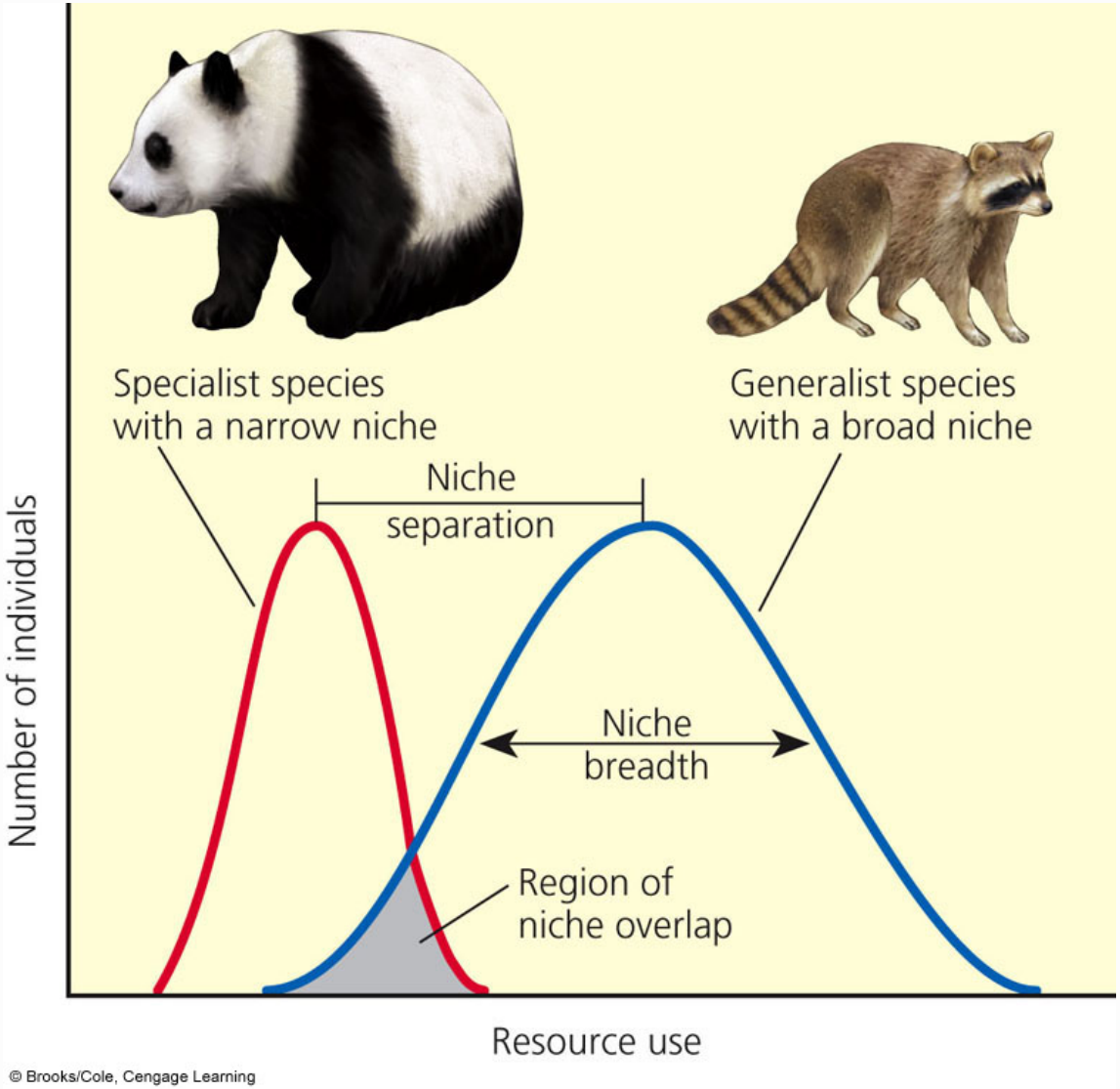
- ***Concept 4-6A*** *Each species plays a specific ecological role called its niche.*

- ***Concept 4-6B*** *Any given species may play one or more of five important roles—native, nonnative, indicator, keystone, or foundation roles—in a particular ecosystem.*

Each Species Plays a Unique Role in Its Ecosystem

- **Ecological niche, niche**
  - Pattern of living
- **Generalist species**
  - Broad niche
- **Specialist species**
  - Narrow niche

Specialist Species and Generalist Species Niches



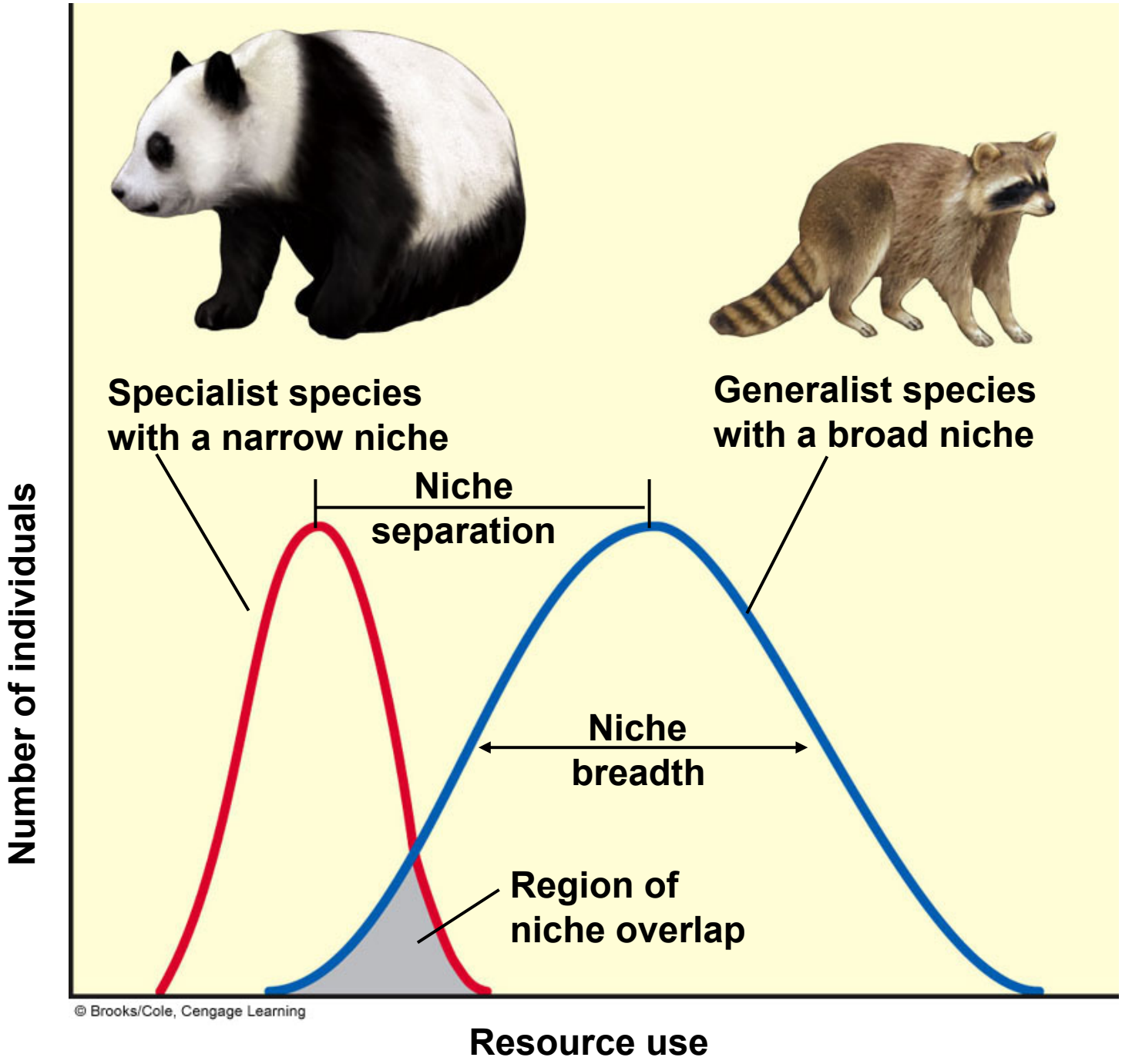


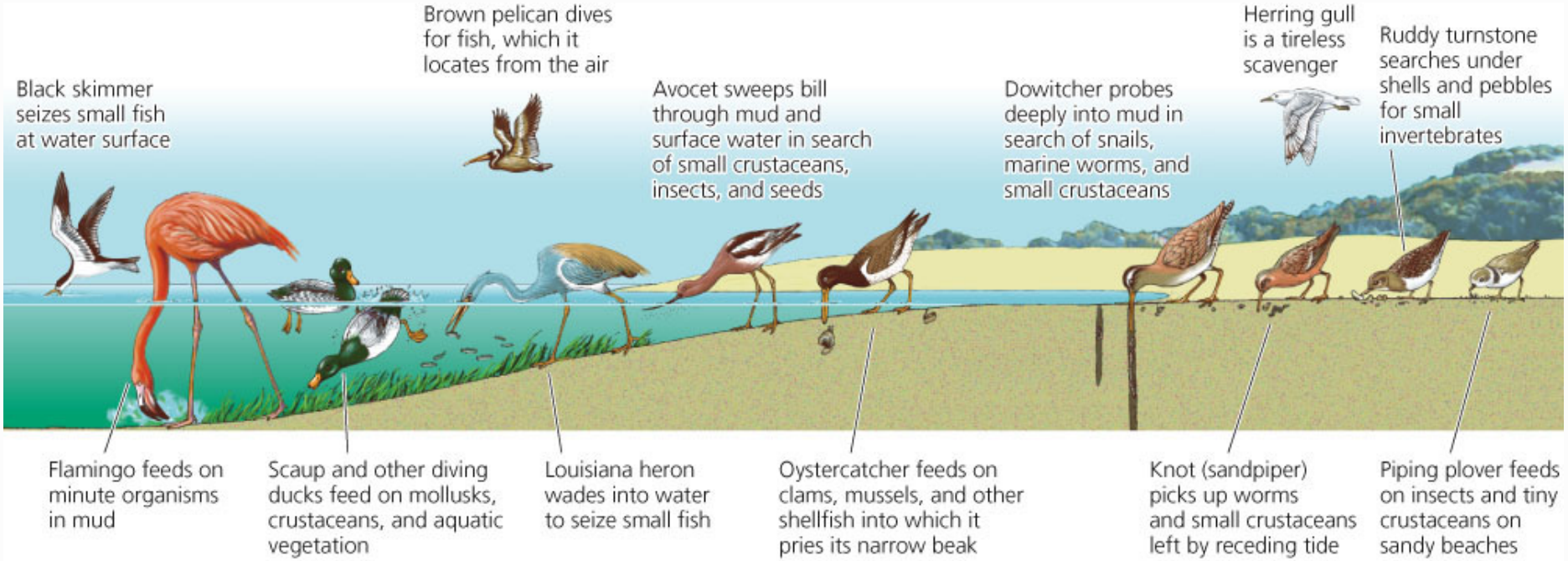
Fig. 4-11, p. 91

Case Study: Cockroaches: Nature's Ultimate Survivors

- Cockroaches
  - Generalists
  - High reproductive rates
- Giant panda and tiger salamanders
  - Specialists
  - Low reproductive rates

Cockroach

Specialized Feeding Niches of Various Bird Species in a Coastal Wetland



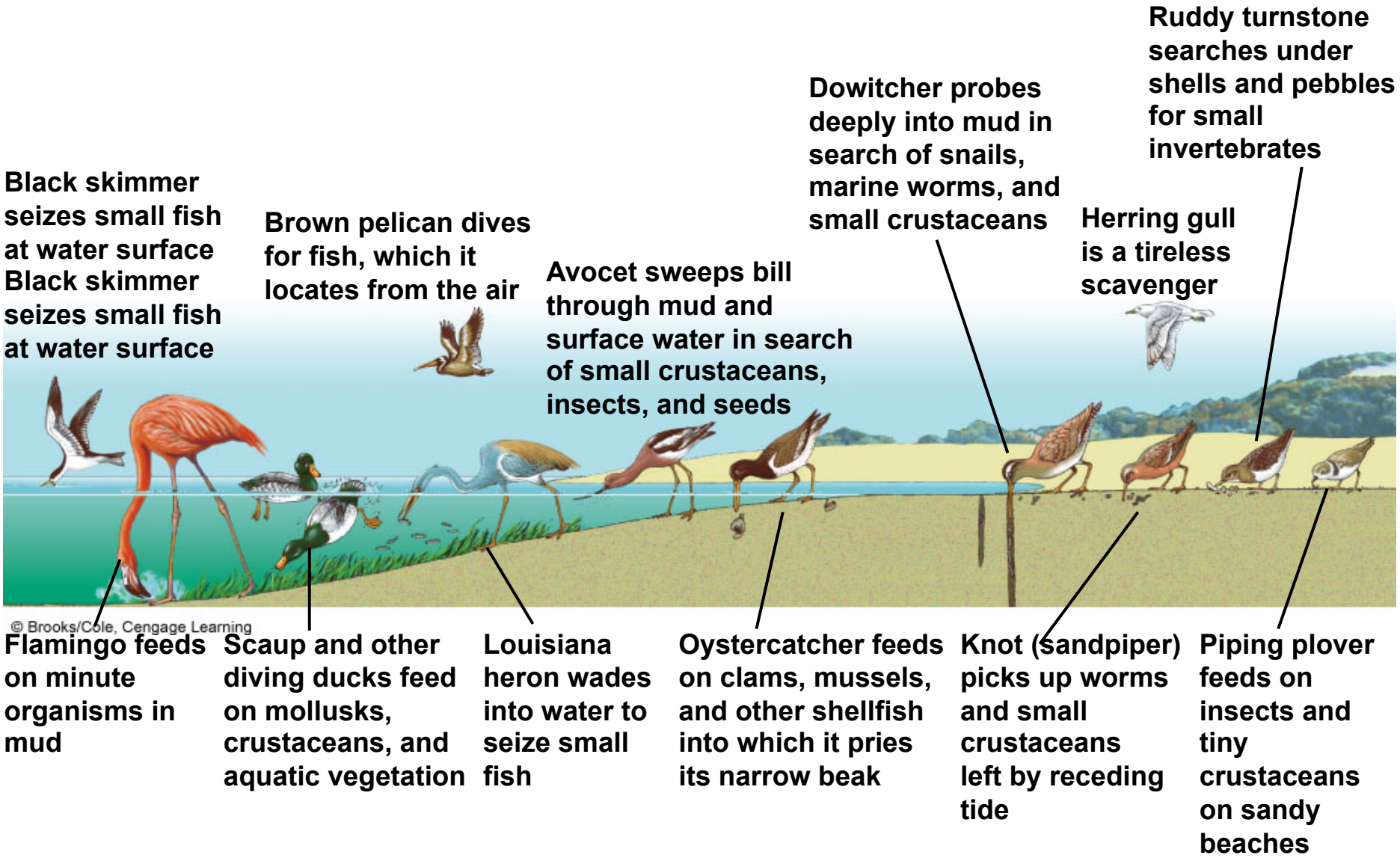

Black skimmer seizes small fish at water surface
Black skimmer seizes small fish at water surface
Brown pelican dives for fish, which it locates from the air
Avocet sweeps bill through mud and surface water in search of small crustaceans, insects, and seeds
Dowitcher probes deeply into mud in search of snails, marine worms, and small crustaceans
Herring gull is a tireless scavenger
Ruddy turnstone searches under shells and pebbles for small invertebrates
© Brooks/Cole, Cengage Learning
Flamingo feeds on minute organisms in mud
Scaup and other diving ducks feed on mollusks, crustaceans, and aquatic vegetation
Louisiana heron wades into water to seize small fish
Oystercatcher feeds on clams, mussels, and other shellfish into which it pries its narrow beak
Knot (sandpiper) picks up worms and small crustaceans left by receding tide
Piping plover feeds on insects and tiny crustaceans on sandy beaches

Fig. 4-13, p. 93

Niches Can Be Occupied by Native and Nonnative Species

- Native species
- Nonnative species; invasive, alien, or exotic species
  - May spread rapidly
  - Not all are villains

Indicator Species Serve as Biological Smoke Alarms

- **Indicator species**
  - Can monitor environmental quality
    - Trout
    - Birds
    - Butterflies
    - Frogs

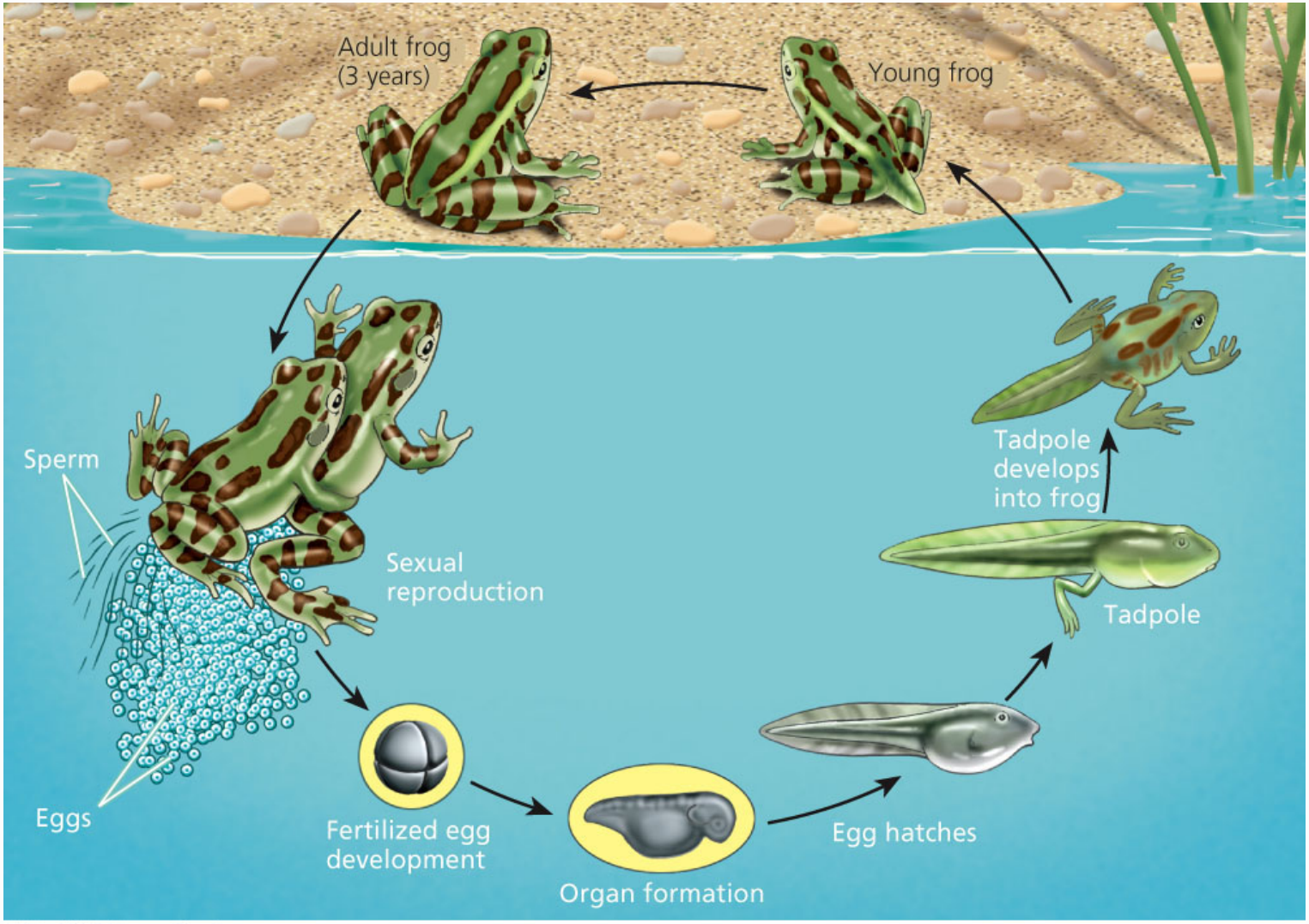
Case Study: Why Are Amphibians Vanishing? (1)

- Habitat loss and fragmentation
- Prolonged drought
- Pollution
- Increase in UV radiation
- Parasites
- Viral and fungal diseases
- Climate change
- Overhunting
- Nonnative predators and competitors

Case Study: Why Are Amphibians Vanishing? (2)

- Importance of amphibians
  - Sensitive biological indicators of environmental changes
  - Adult amphibians
    - Important ecological roles in biological communities
  - Genetic storehouse of pharmaceutical products waiting to be discovered

Life Cycle of a Frog



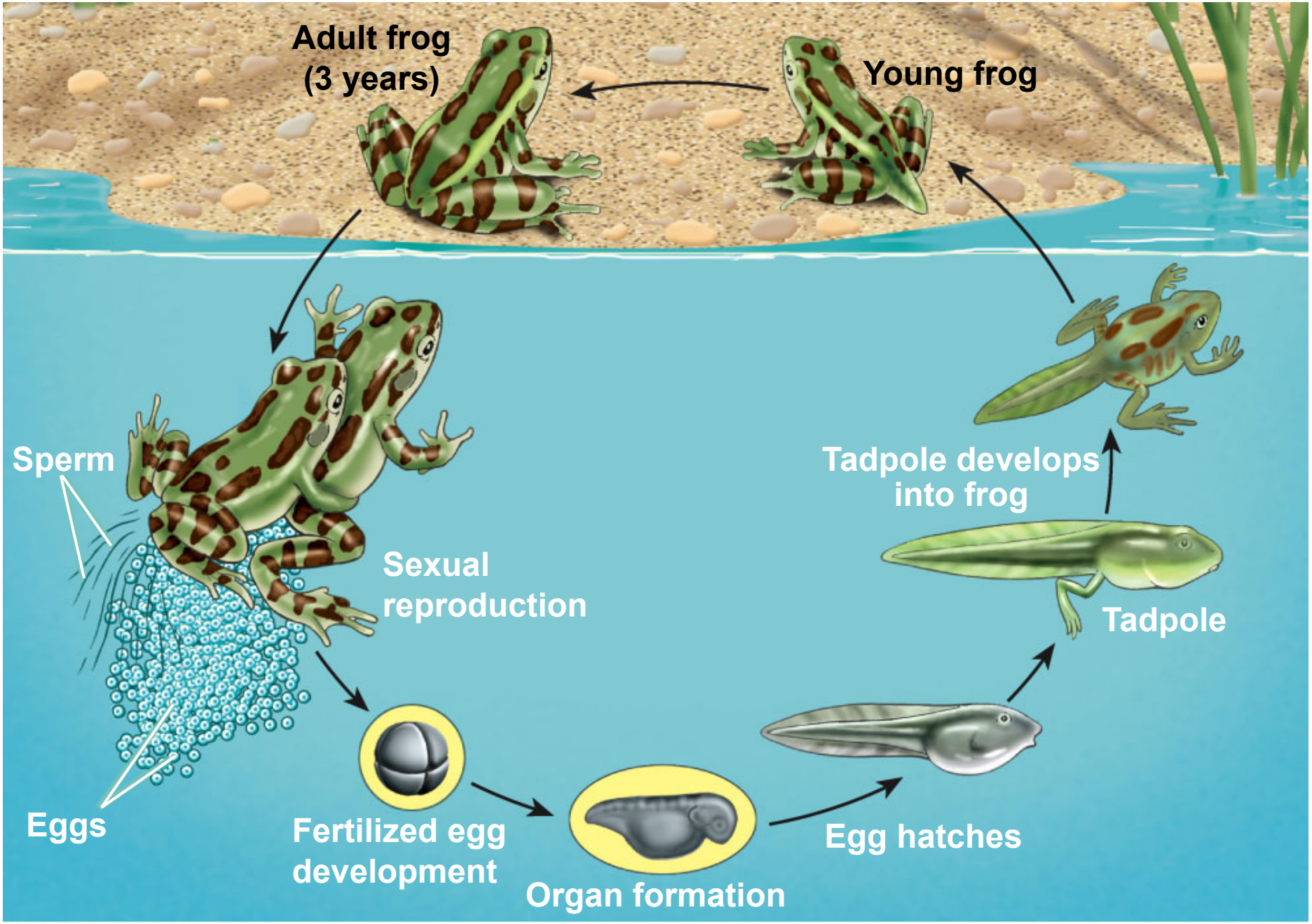


Fig. 4-14, p. 94

Keystone, Foundation Species Determine Structure, Function of Their Ecosystems

- **Keystone species**
  - Pollinators
  - Top predator

- **Foundation species**
  - Create or enhance their habitats, which benefit others
    - Elephants
    - Beavers

Case Study: Why Should We Protect Sharks?

- Keystone species
  - Eat dead and dying fish in the ocean
  - Strong immune systems
    - Wounds do not get infected
    - Almost never get cancer
    - Could help humans if we understood their immune system