Biodiversity and Evolution

Chapter 4

The American Alligator

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

Ecosystem Stability

An ecosystem’s **stability** refers to its apparently unchanging nature over time.

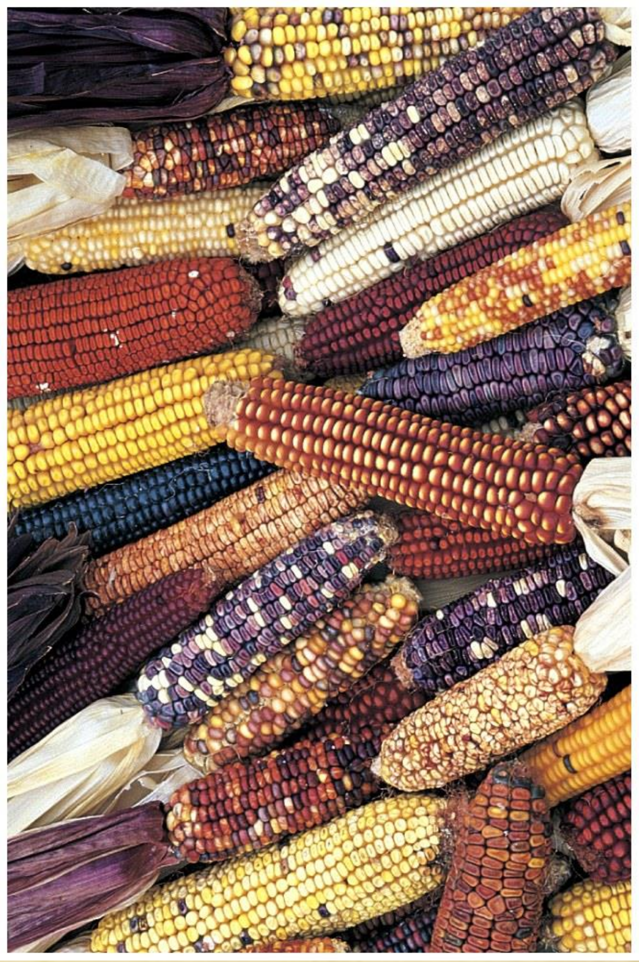
inertia -the ability to resist disturbance

resilience - the ability to recover from external disturbance

Biological Diversity

Number, variety and variability of Earth's organisms

1. Genetic diversity (right)
2. Species Diversity
   - Species Richness (how many species)
   - Species Evenness (how many of those animals within the species there are)
   - (we will go more into these during our lab)
3. Ecosystem diversity



The Need for Biodiversity

- Biodiversity is required in order to maintain ecosystem stability.
- More diverse ecosystems are generally better able to withstand disturbances.
- A great deal of effort is being put into maintaining numbers and varieties of plants and animals.

Low Diversity Systems

- **Monocultures** (single species crops), are **low species diversity systems**.
- Vulnerable to disease, pests, and disturbance.
  - Ex: lawns & crops.
- **Natural ecosystems** may appear like monocultures, but contain many species which vary in their predominance seasonally.

Monoculture

Savanna

High Diversity Systems

The biodiversity of ecosystems at **low latitudes** is generally higher than that at high latitudes, (and altitudes)

Tropical rainforests are amongst the highest diversity ecosystems on Earth. They are generally quite resistant to disturbance, <u>but once degraded they have little ability to recover</u>.

Deforestation of tropical rainforest

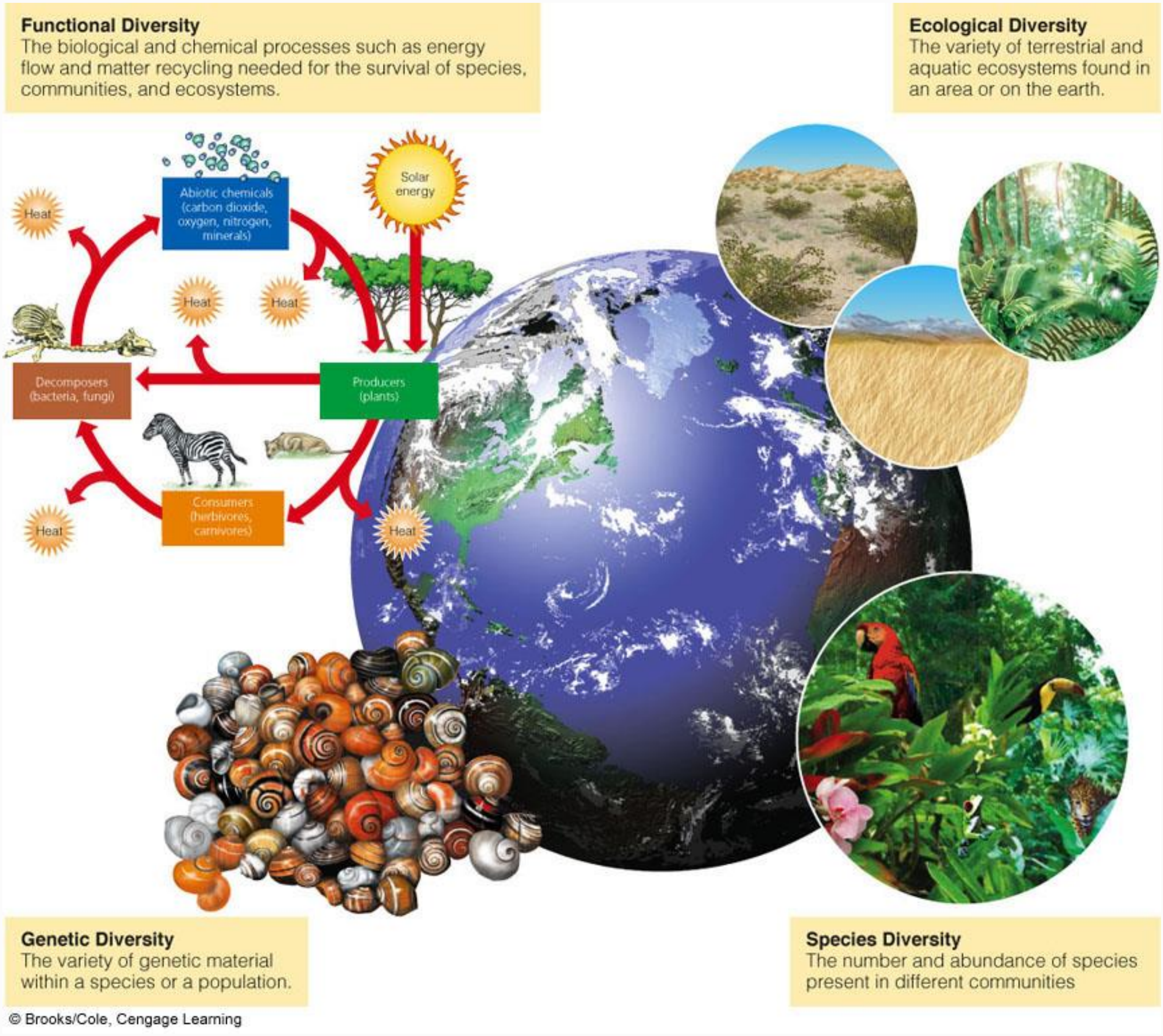
4-1 What Is Biodiversity and Why Is It Important?

- ***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 (with limitations)
- Species diversity (ca. 1.7 – 1.8 million spp. ID'd)
- Genetic diversity (allows adaptation)
- Ecosystem diversity (e.g., deserts, grasslands, …)
- Functional diversity (variety of processes)

Natural Capital: Major Components of the Earth's Biodiversity



Ecosystem Services

- Important environmental benefits that ecosystems provide to people
  - Clean air
  - Clean water
  - Fertile soil
- Contributions to human life:
  - Food
  - Clothing
  - Shelter
  - Pollination of crops
  - Antibiotics and medicines
  - Biological processes (nitrogen fixation)

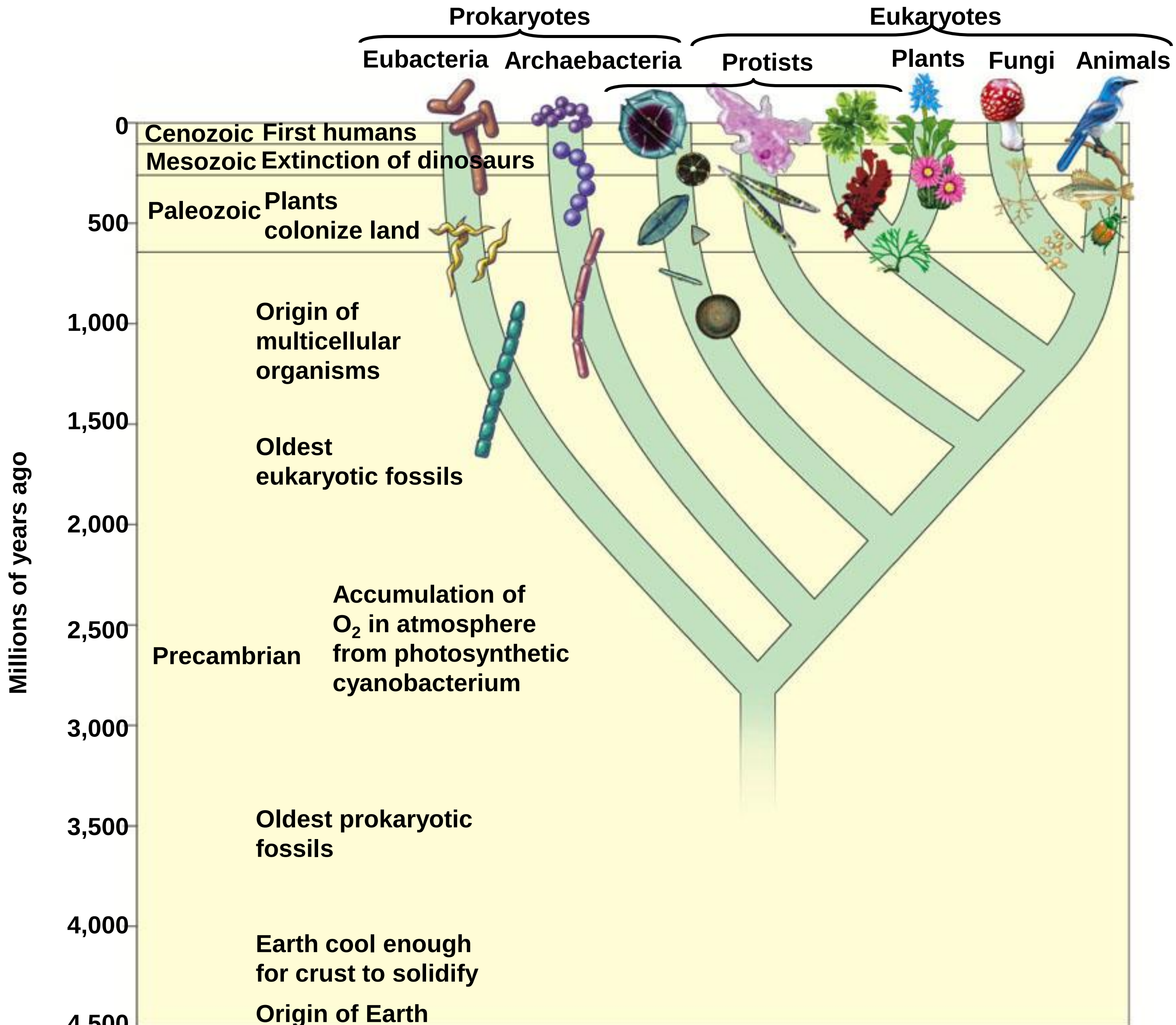
4-2 Where Do Species Come From?

- ***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 (Earth's life changes over time through changes in genes of populations)
- Natural selection
  - Charles Darwin
  - Alfred Russel Wallace
- Evolution (Change in genetic characteristics)
- Tree of Life (Fig. 4-3): evolution of life into 6 major kingdoms



Prokaryotes
Eukaryotes
Eubacteria
Archaebacteria
Protists
Plants
Fungi
Animals
0
500
1,000
1,500
2,000
2,500
3,000
3,500
4,000
4,500
Millions of years ago
Cenozoic
First humans
Mesozoic
Extinction of dinosaurs
Paleozoic
Plants colonize land
Origin of multicellular organisms
Oldest eukaryotic fossils
Precambrian
Accumulation of O_2 in atmosphere from photosynthetic cyanobacterium
Oldest prokaryotic fossils
Earth cool enough for crust to solidify
Origin of Earth

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?

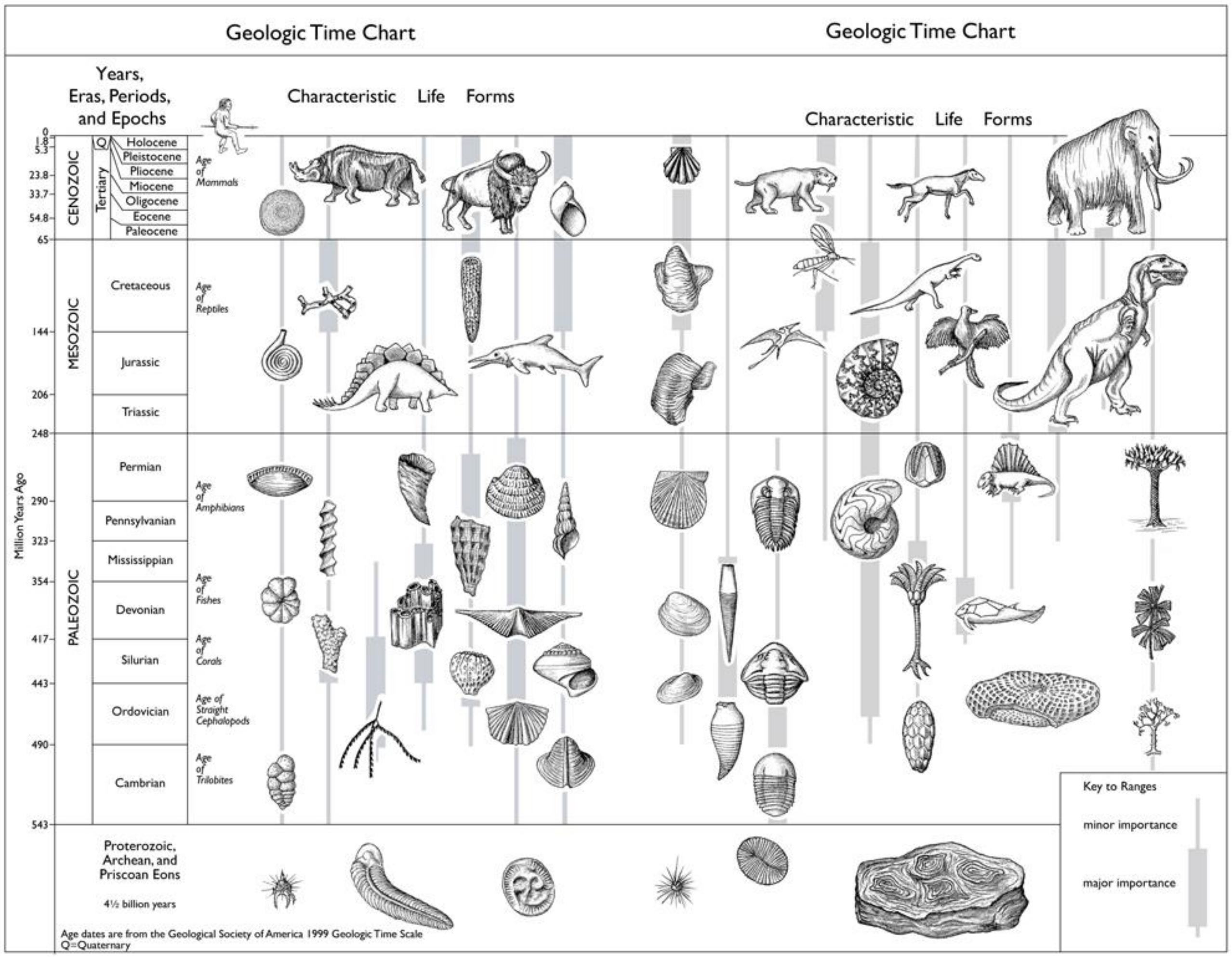
[See Bill Nye on origin of life and evolution]

Fossilized Skeleton of an Herbivore that Lived during the Cenozoic Era

Evidence for evolution came from several sources sources.

- Fossils provide evidence of evolution.
- Fossils in older layers are more primitive than those in the upper layers.


Life on Earth has Unity and Diversity descended from common ancestry

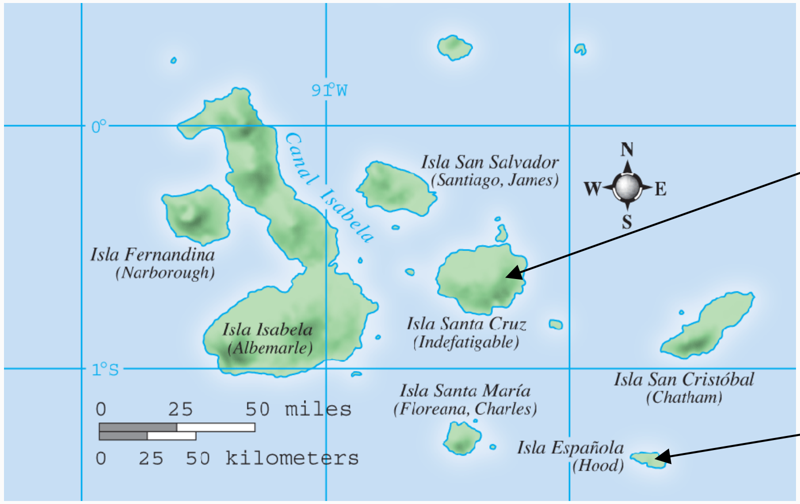


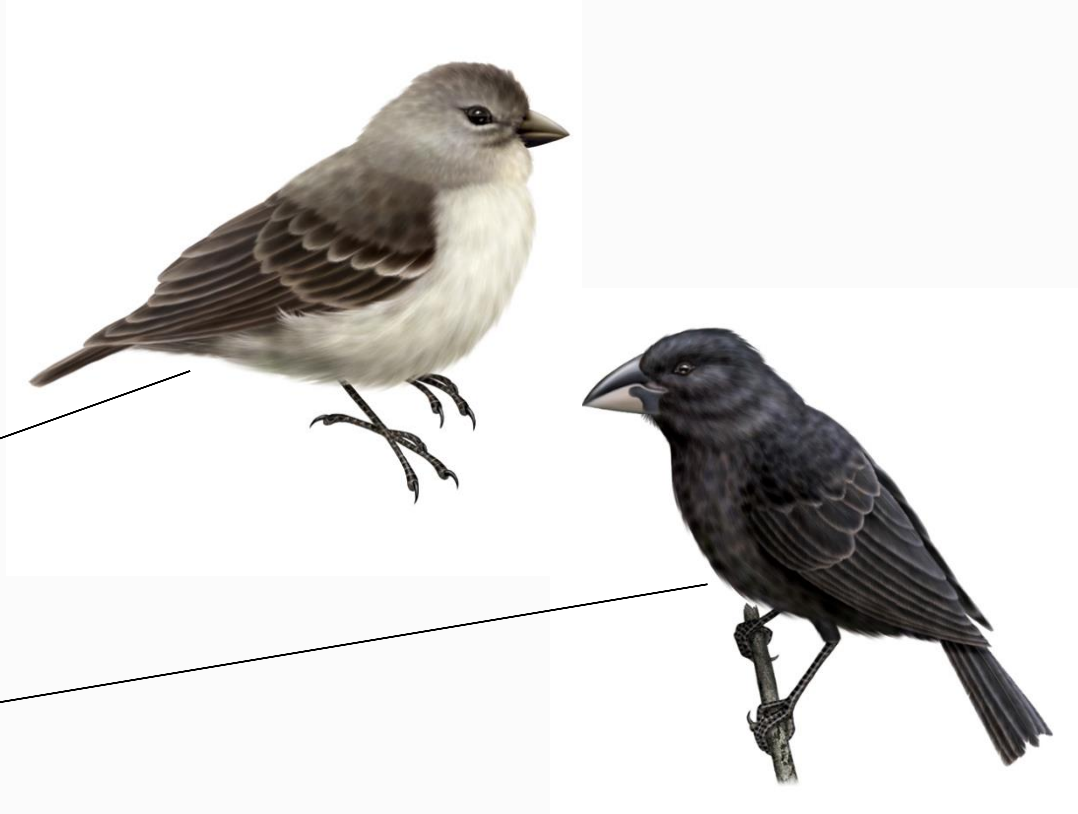
All of Earth's life forms are related and function universally the same way.

All species evolved from a single common ancestor at life’s origination 3.5 bya.

>200 million living species on Earth

- The study of geography provides evidence of evolution.
  - island species most closely resemble nearest mainland species
  - populations can show variation from one island to another



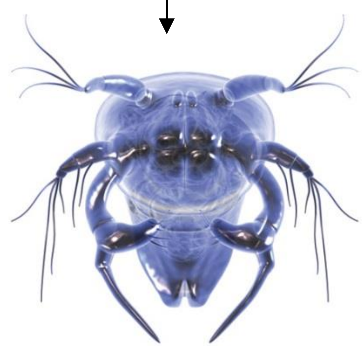


Embryology provides evidence of evolution.

- identical larvae, different adult body forms
- similar embryos, diverse organisms

Adult crab

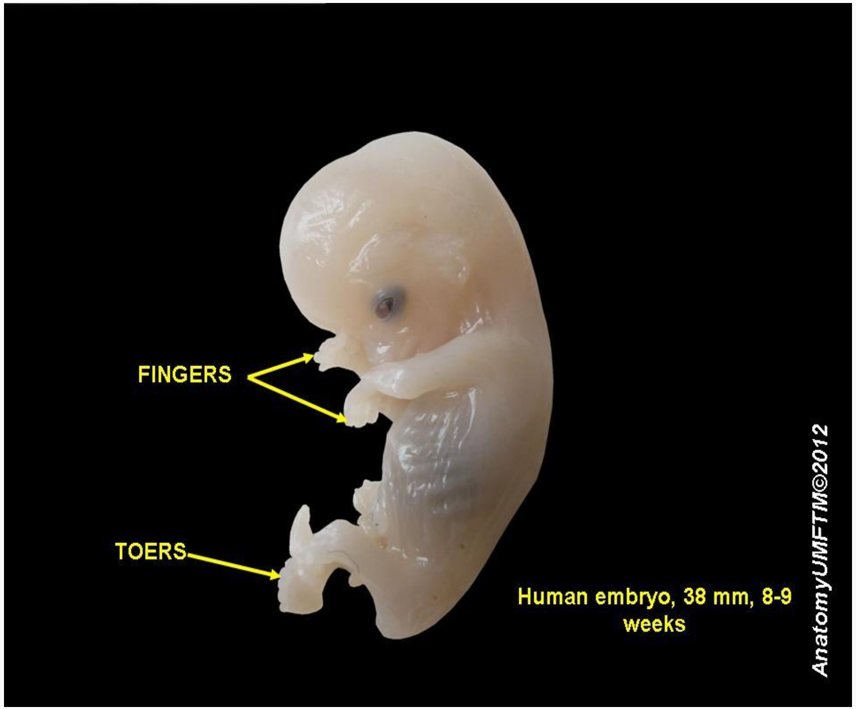
Larva

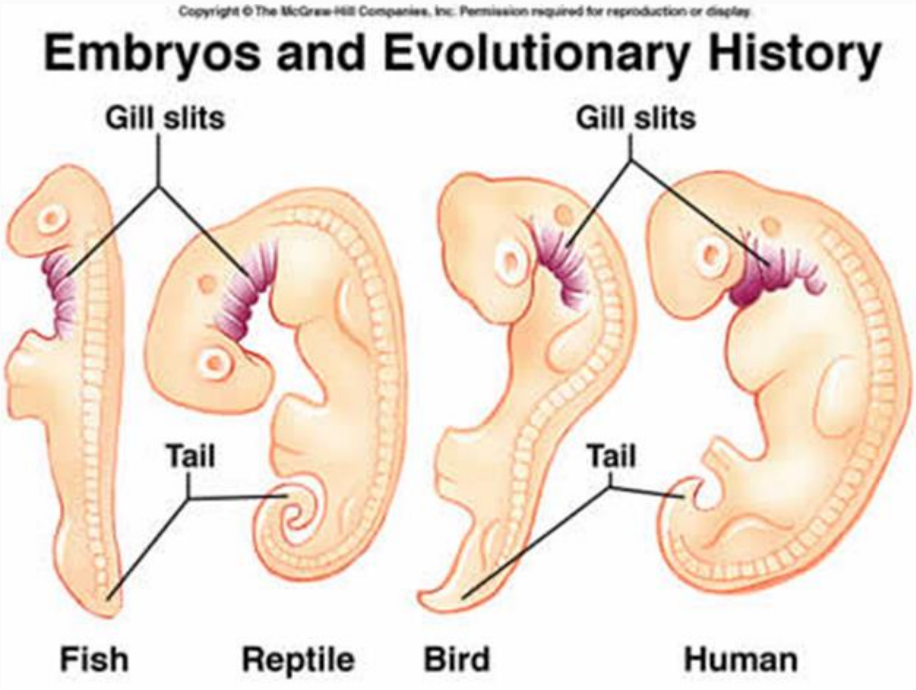


Adult barnacle

Embryology provides evidence of evolution.

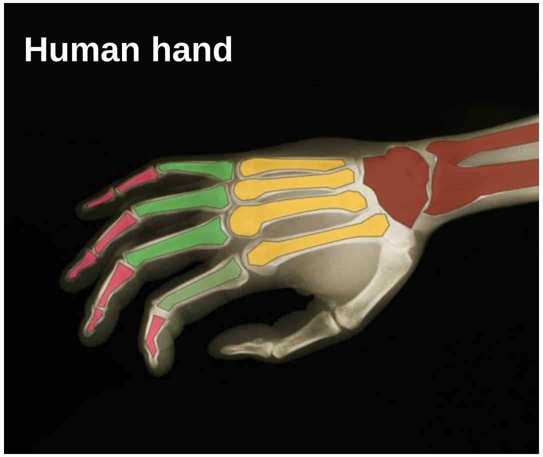
- identical larvae, different adult body forms
- similar embryos, diverse organisms

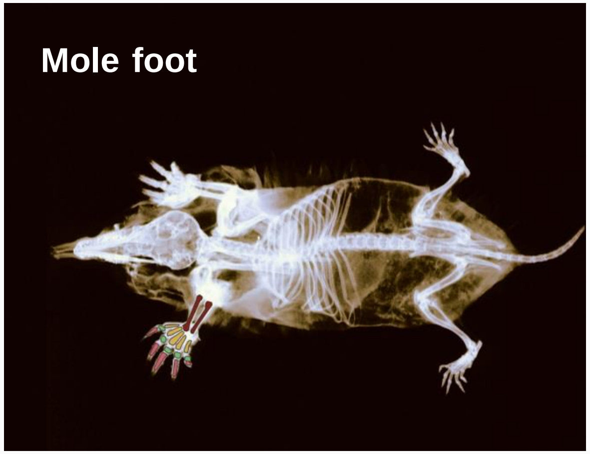




- The study of anatomy provides evidence of evolution from a common ancestor..

  - Homologous structures are similar in structure but different in function.
  - Homologous structures are evidence of a common ancestor modified by different environment.





- The study of anatomy provides evidence of evolution.

  – Analogous structures have a similar function.

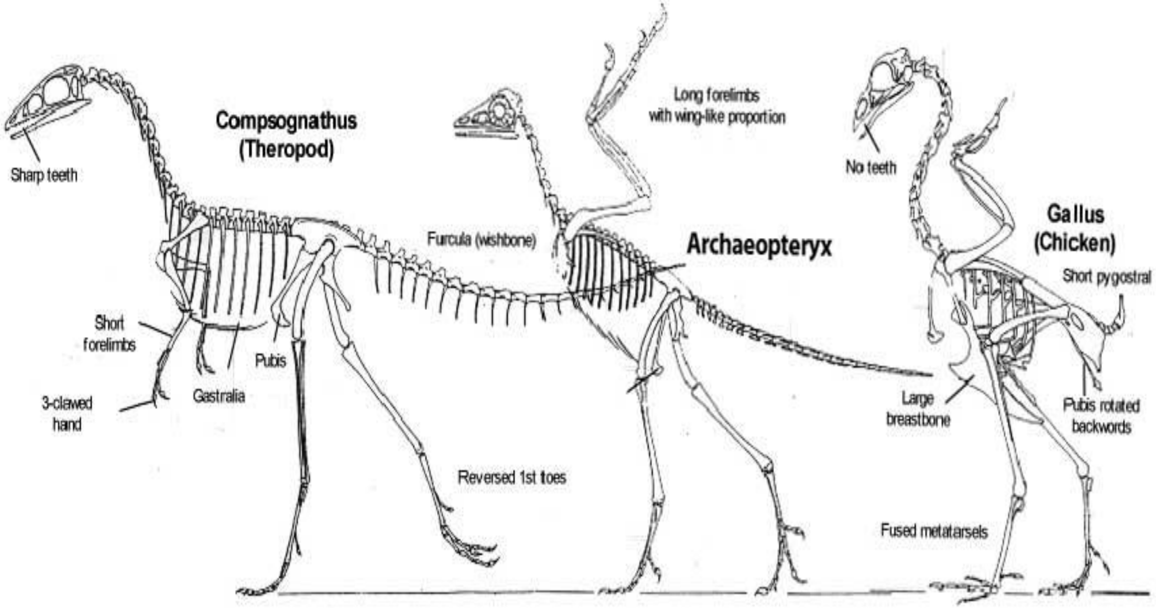
Human hand Mole foot

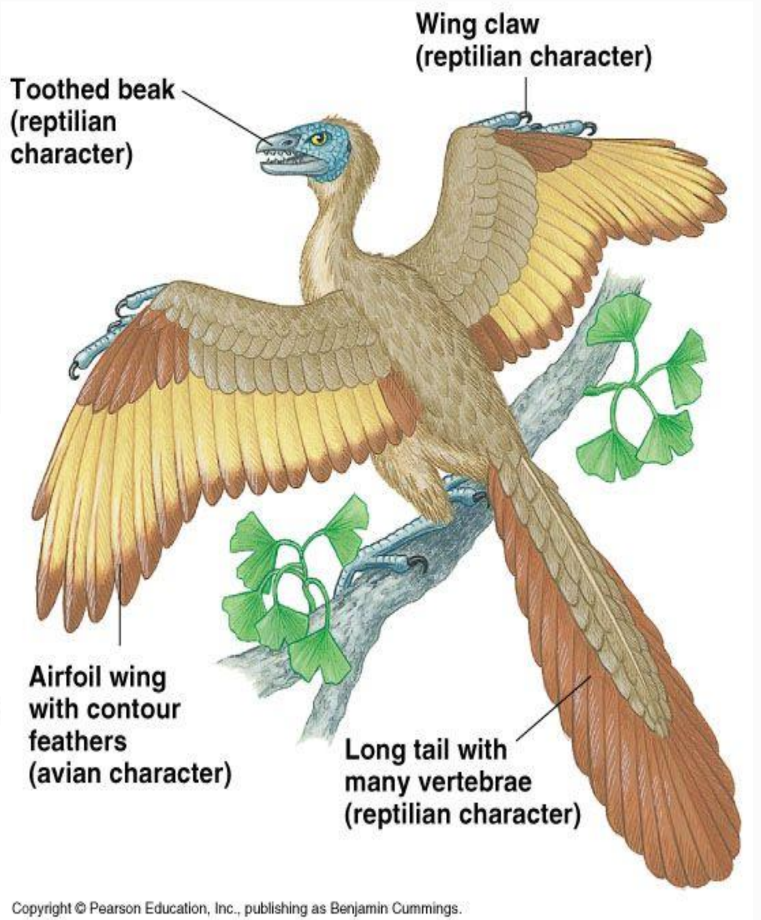
- Analogous structures are **not** evidence of a common ancestor.
- Provide evidence of **similar environments** shaping body forms

Structural patterns are clues to the history of a species.

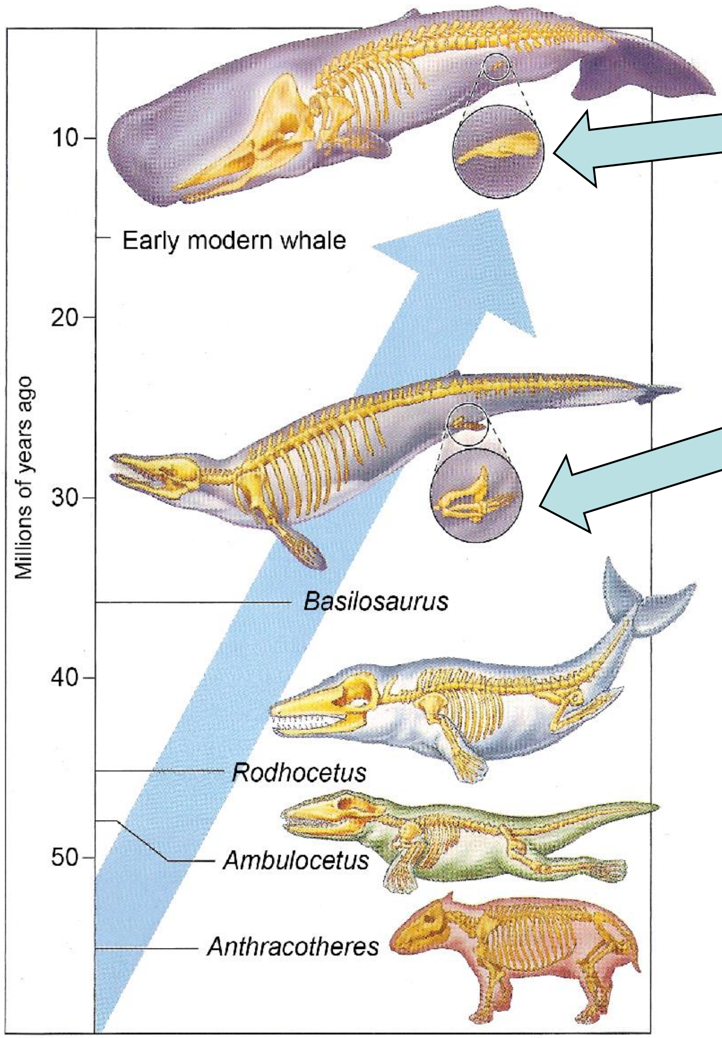
- Vestigial structures are remnants of organs or structures that had a function in an early ancestor.
- Ostrich wings are examples of vestigial structures.

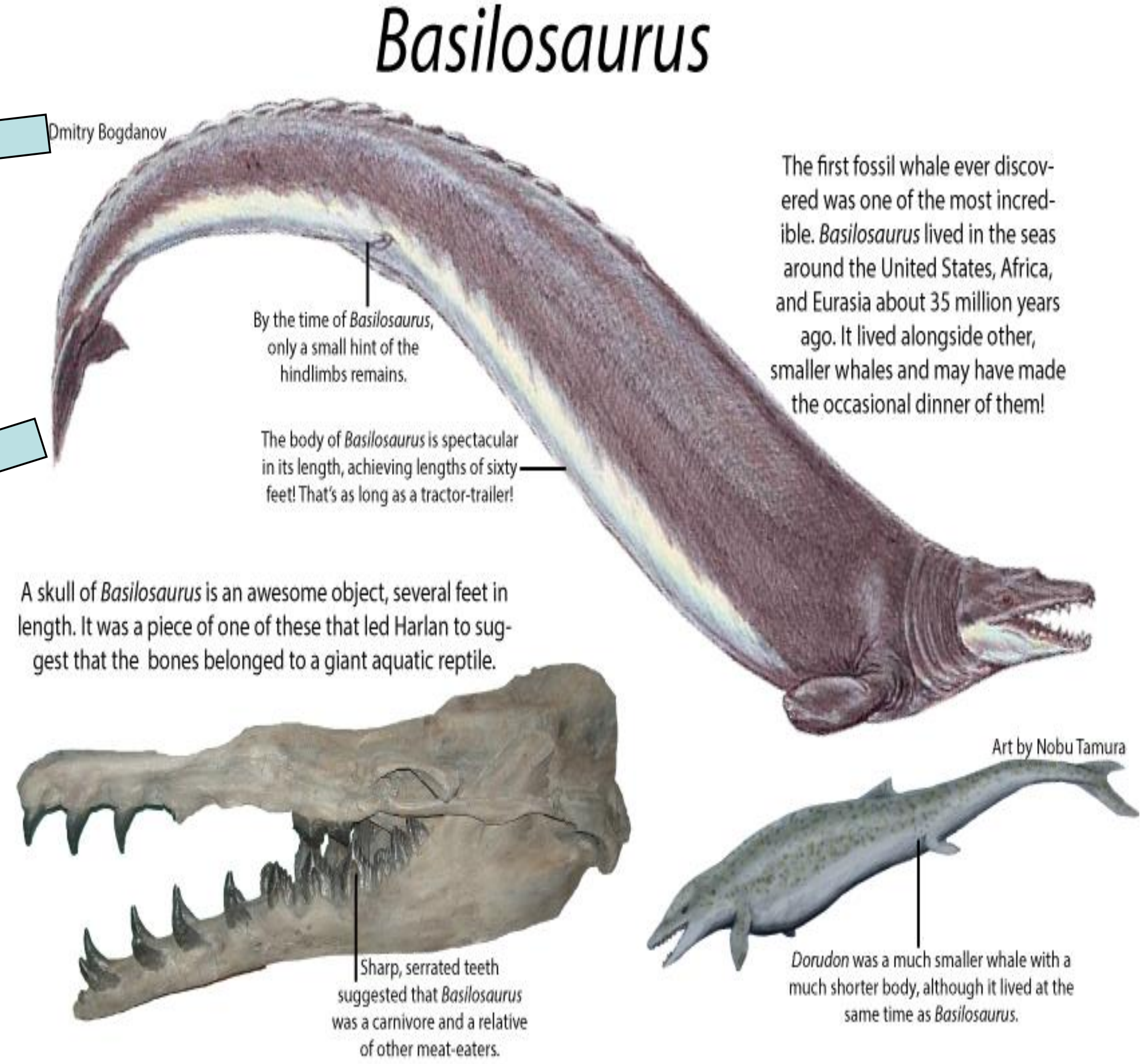
- Archaeopteryx fossils showed evidence of transition features from dinosaur reptiles to birds: Teeth and Winged claws





Vestigial or Remnant Structures: Evolution of the Modern Whale (Mysticetes)





“Living Fossils”

The Genetic Makeup of a Population Can Change

- **Populations evolve** by becoming genetically different over successive generations

- Genetic variations are:
  - First step in biological evolution, which occurs through **mutations** in **reproductive cells**
  - Random changes or exposure to **mutagens** such as radioactivity or chemicals (remember mercury)

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 (e.g., Fig. 4-5, bacteria resistant to antibiotics)
- When environmental conditions change, populations
  - Adapt
  - Migrate
  - Become extinct

Evolution by **Natural Selection**

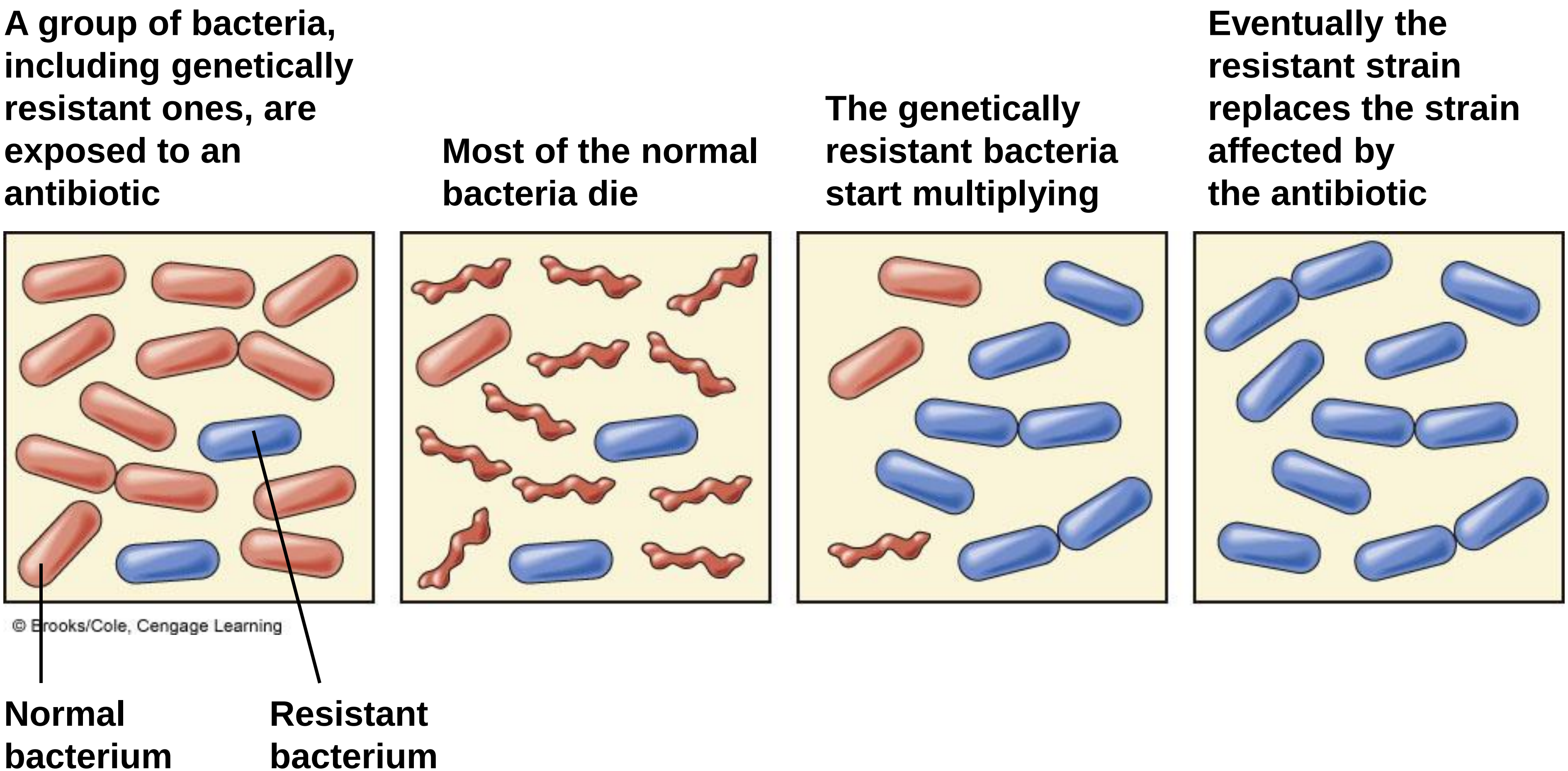


Fig. 4-5, p. 83

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
  - Traits must already be present!

- Reproductive capacity
  - Fast vs slow

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

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

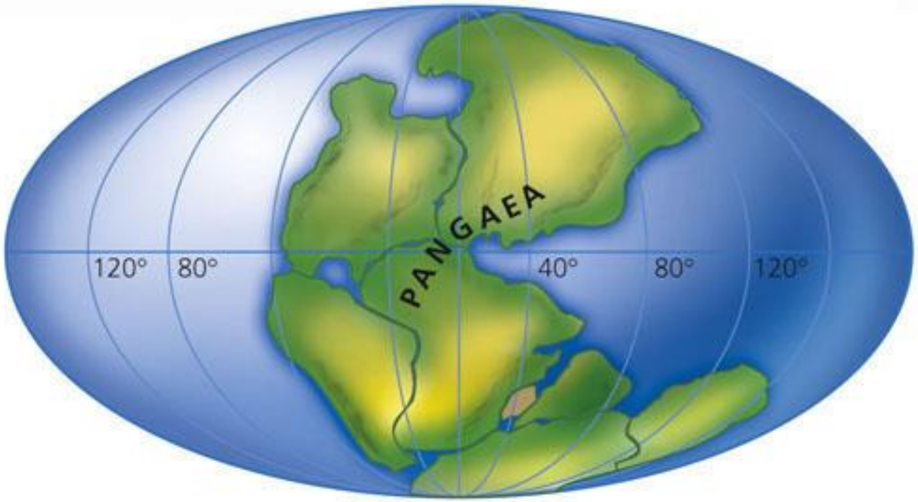
- Tectonic plates affect evolution and the location of life on earth
  - Location of continents and oceans
  - Species physically move, or adapt, or form new species through natural selection

- Earthquakes
  - Species isolation

- Volcanic eruptions
  - Habitat destruction

Animation: Continental drift

225 million years ago



135 million years ago

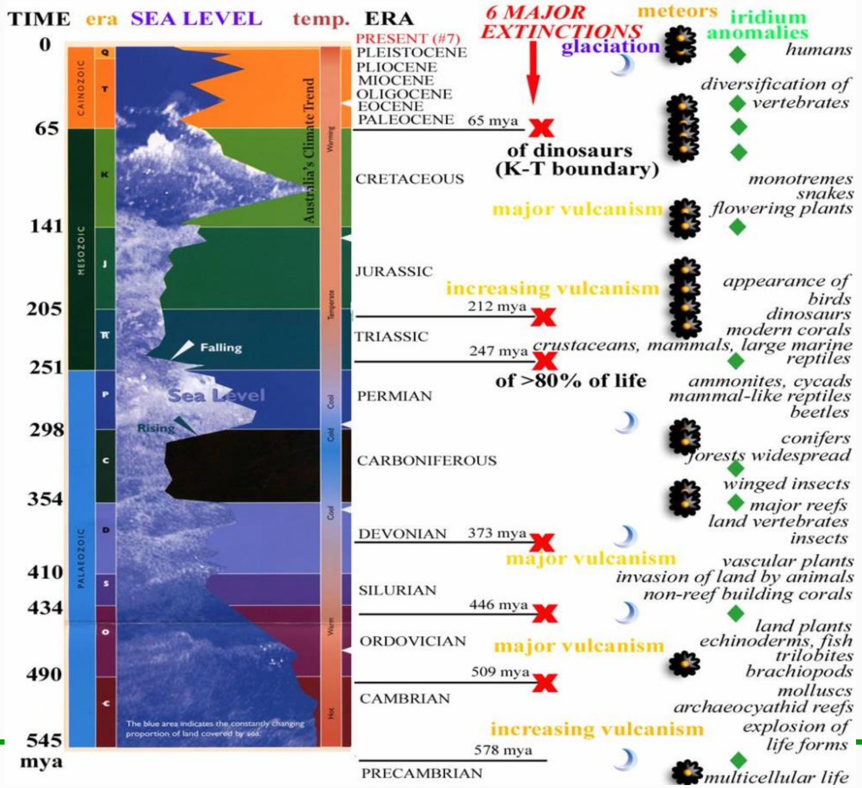
65 million years ago

Present

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 Cover in the Northern Hemisphere During the last 18,000 years

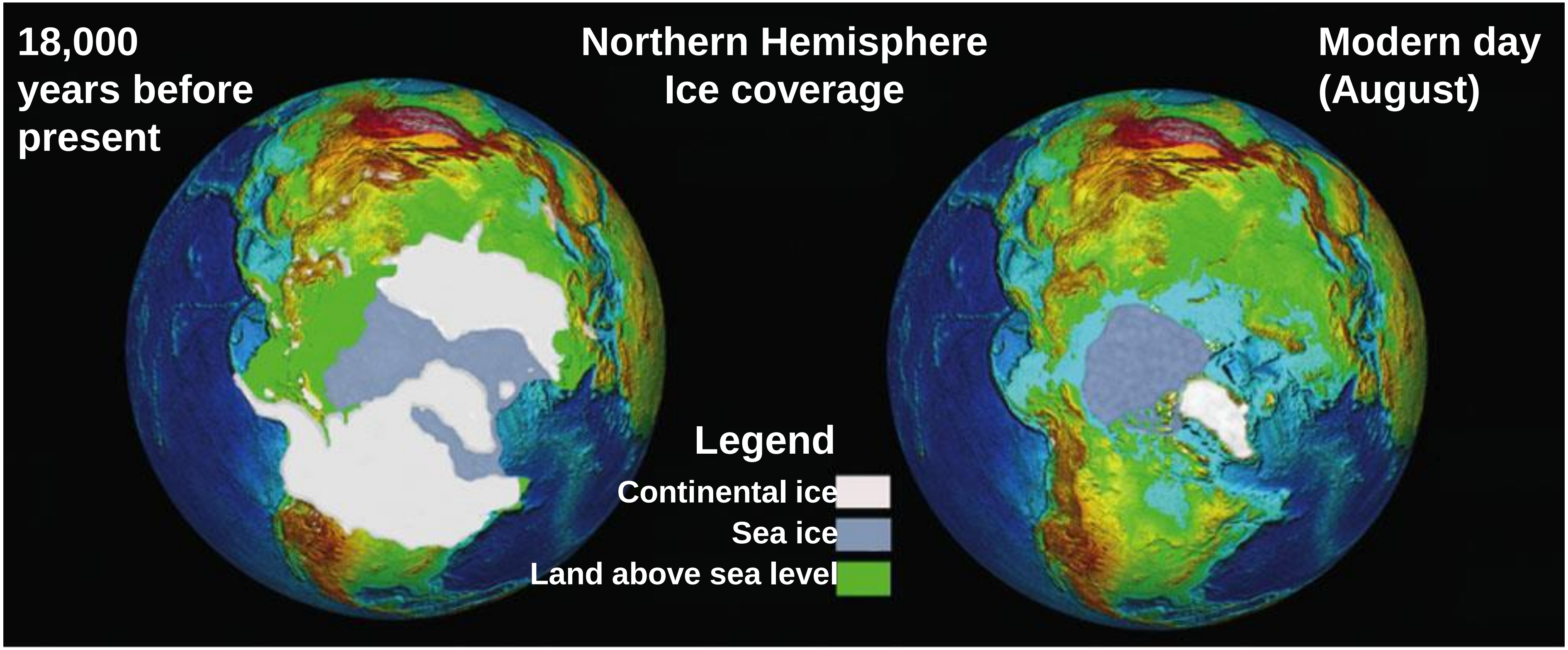
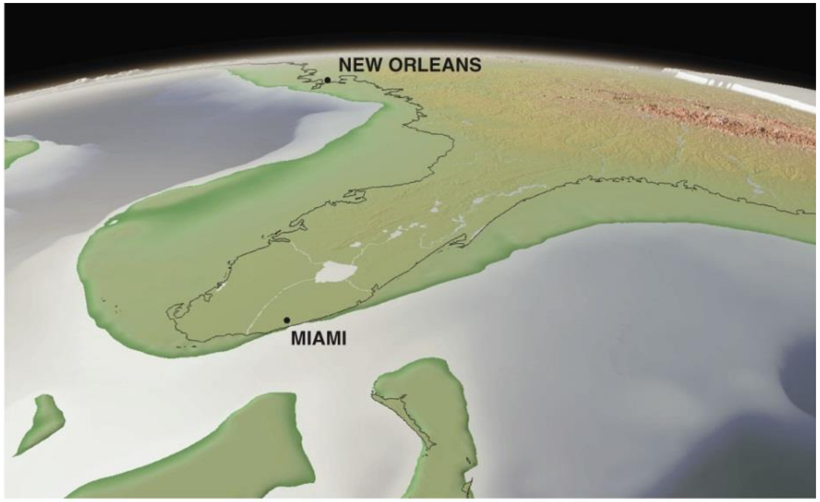
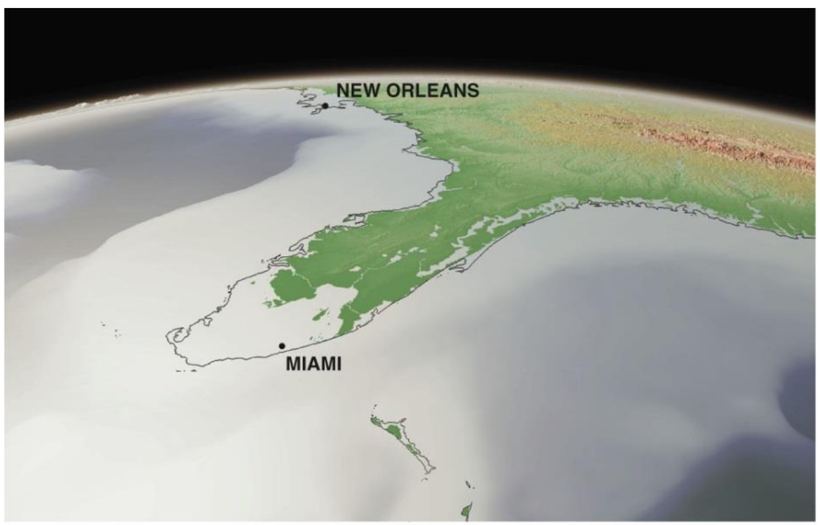


Fig. 4-7, p. 85



a

The southeastern coast of the U.S. during the last ice age (18,000 years ago).



b

If the ocean were to expand and polar ice caps were to melt, sea level could rise 5 meters

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

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
  - When different groups of the same population become physically isolated (physical barriers)

- Reproductive isolation
  - Occurs after geographic isolation, mutation and genetic drift may lead to new species (usually over thousands to millions of years)

Geographic Isolation Can Lead to Reproductive Isolation

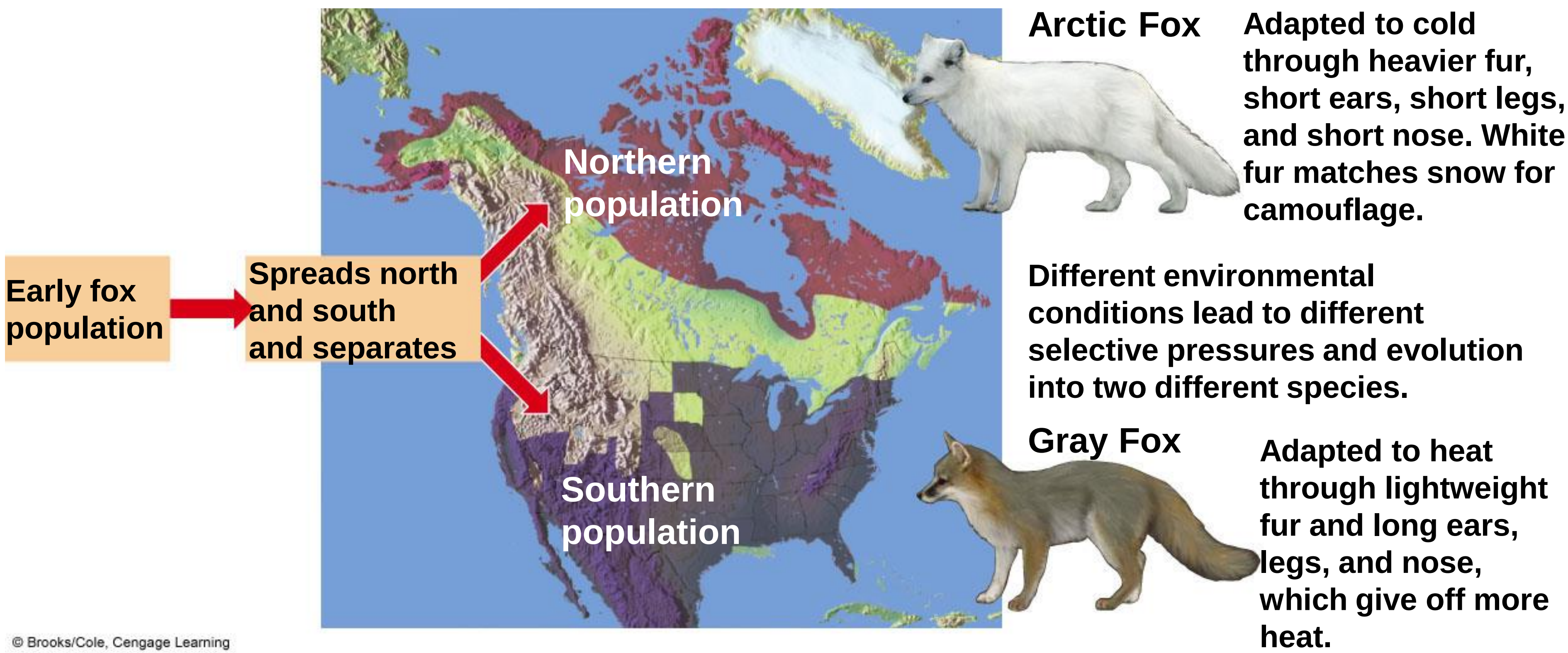
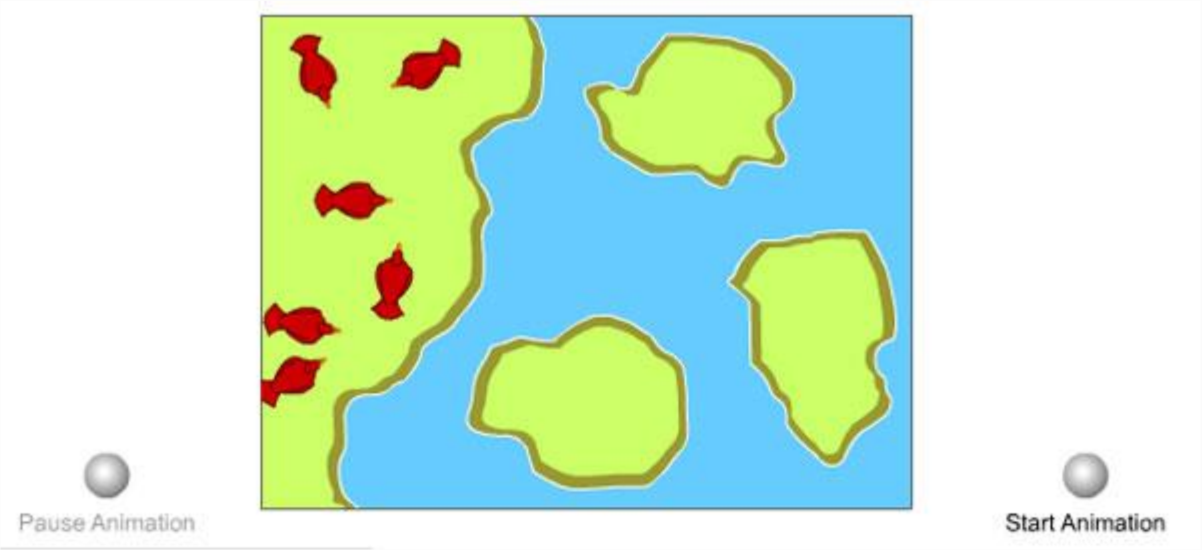


Fig. 4-8, p. 87

Animation: Speciation on an archipelago



Extinction is Forever

- **Extinction**
  - **An entire species ceases to exist**

- **Endemic species (found in only one area)**
  - Particularly vulnerable because they are generally highly specialized

Extinction Can Affect One Species or Many Species at a Time

- **Mass extinction**
  - How numbered is debated: 3–5 (5 is the generally accepted number)

Mass Extinction Event	Time Frame (mya)	Types of Life Effected
Late/End Ordovician	443 million years ago	Many species of Trilobites, Brachiopods, Graptolites, Echinoderms and Corals
Late/End Devonian	354 million years ago	Many marine families on tropical reefs, Corals, Brachiopods, Bivalves, Sponges
Late/End Permian	248 million years ago	57% of all marine families, Trilobites, Eurypterids, Mollusca devastated along with Brachiopods. Many vertebrates
Late/End Triassic	206 million years ago	Mollusca phyla, Sponges, marine vertebrates, large Amphibians, many Mammal-like Reptiles
Late/End Cretaceous	65 million years ago	Ammonites, Marine Reptiles, Dinosaurs, Pterosaurs, microscopic marine plankton, Brachiopods, Bivalves and Echinoderms

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 – number of species variety**
  - **Species evenness – relative abundance of each**

- 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

Species-Rich Ecosystems Tend to Be Productive and Sustainable

- Species richness seems to increase productivity and stability or sustainability

4-6 What Roles Do Species Play in Ecosystems?

- **Concept 4-6A** *Each species plays a specific ecological role called its* ***niche****. Species separate roles and don't overlap through niche partitioning.*

- **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 – species role**
  - Pattern of living, “a species way of life”
- **Generalist species**
  - Broad niche (e.g., racoon, Fig. 4-11)
- **Specialist species**
  - Narrow niche (e.g., panda, Fig. 4-11)

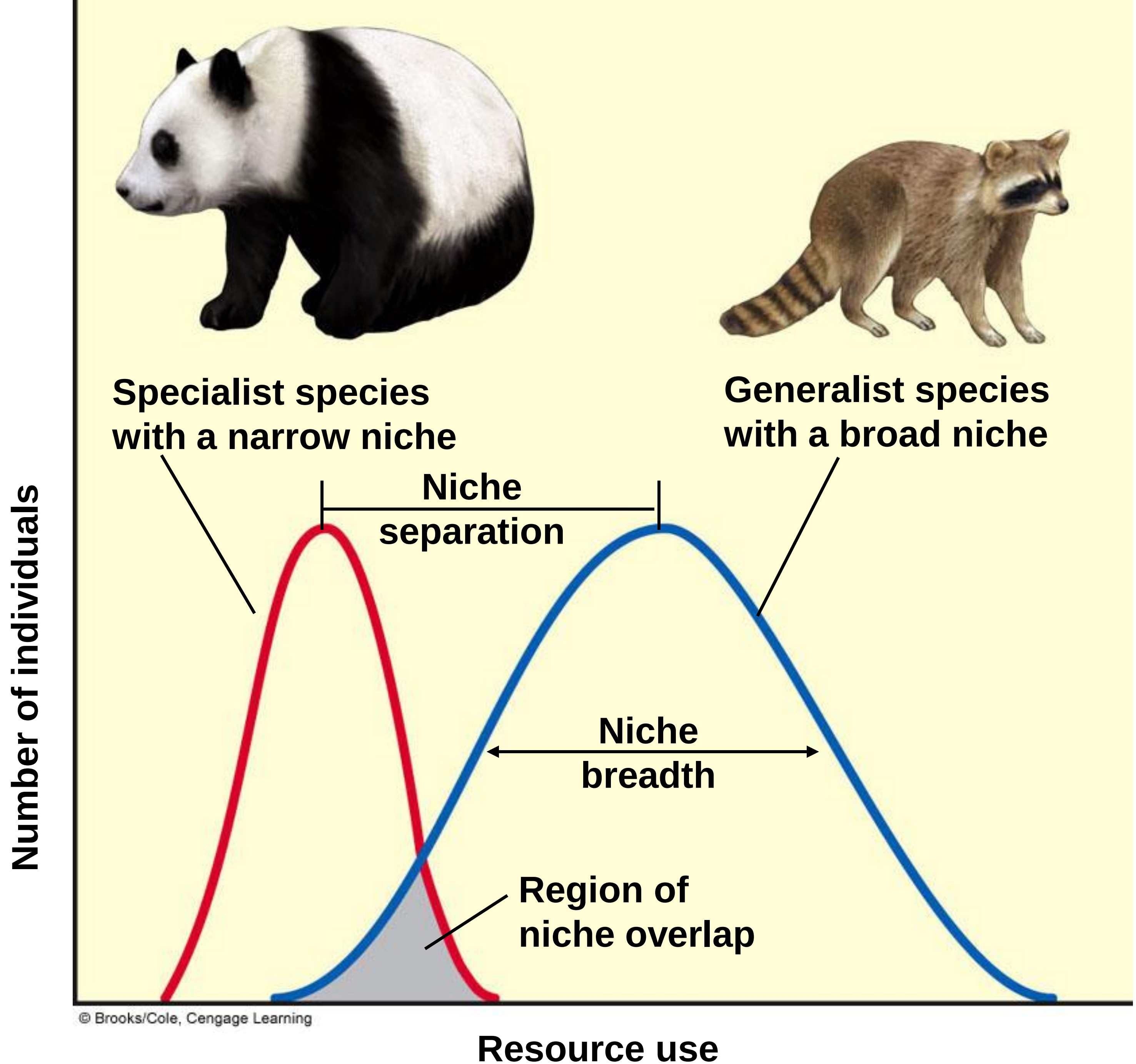

Specialist species
with a narrow niche
Generalist species
with a broad niche
Niche
separation
Niche
breadth
Region of
niche overlap
Number of individuals
Resource use
© Brooks/Cole, Cengage Learning

Fig. 4-11, p. 91

Specialized Feeding Niches of Various Bird Species in a Coastal Wetland (e.g., "resource or **niche partitioning**")

Black skimmer seizes small fish at water surface
Black skimmer seizes small fish at water surface

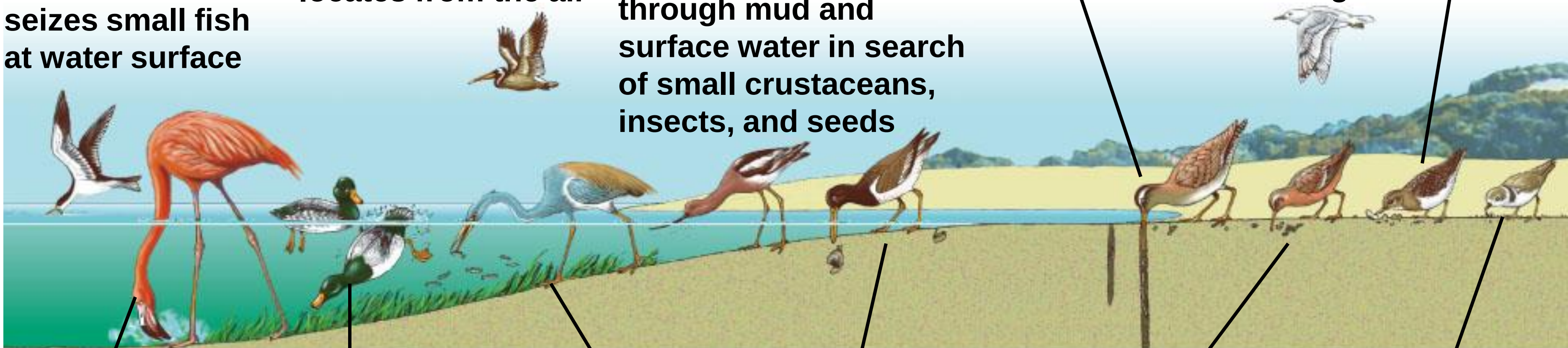
Brown pelican dives for fish, which it locates from the air

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



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

Case Study: Cockroaches: Nature's Ultimate Survivors

- Cockroaches
  - Generalists
  - High reproductive rates

- Giant panda and tiger salamanders
  - Specialists
  - Low reproductive rates

Cockroach

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

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

Keystone Species

Species whose influences on ecological communities are greater than would be expected on the basis of their abundance

- **Elephants** can alter the entire structure of the vegetation in those areas into which they migrate.

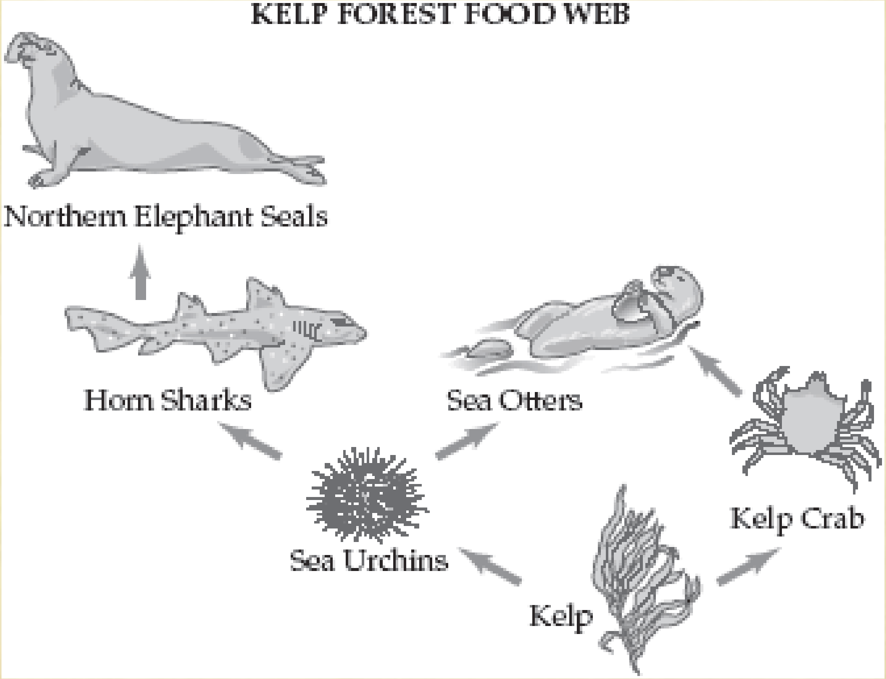
- By eating small trees, elephants preserve the grasslands, because the grasses need plenty of sun to survive. If they were not there, the savanna would convert to a forest or scrublands.

Elephants knock down and consume taller trees and shrubs...

… allowing lower growing species to predominate

Sea Otters as Keystone Species

The sea otter is another **example** of a **keystone species** in the Pacific Northwest. These mammals feed on sea urchins, controlling their population. If the otters didn't eat the urchins, the urchins would eat up the habitat's kelp. Kelp, or giant seaweed, is a major source of food and shelter for the ecosystem.



Other Examples

- **Wolves:** Being a top predator, wolves are important in many habitats. Wolves keep deer populations in check and too many deer will eat small trees, which leads to fewer trees. In turn, there would be fewer birds and beavers and the whole ecosystem would change. (think back to the Wolf FRQ)
- **American alligator**: Alligators use their tails to make burrows to stay warm and when they move on, these burrows fill with water which is used by other species. Alligators are also predators, keeping the numbers of other species in check.
- **Beavers**: Beavers are considered habitat engineers because they change the environment by building dams. This dam building provides still water in which many species flourish.

Case Study: Why Should We Protect Sharks?

- Keystone species
  - Sharks eat dead and dying fish in the ocean (top down population control of **prey** species)
  - Strong immune systems
    - Wounds do not get infected
    - Almost never get cancer
    - Could help humans if we understood their immune system