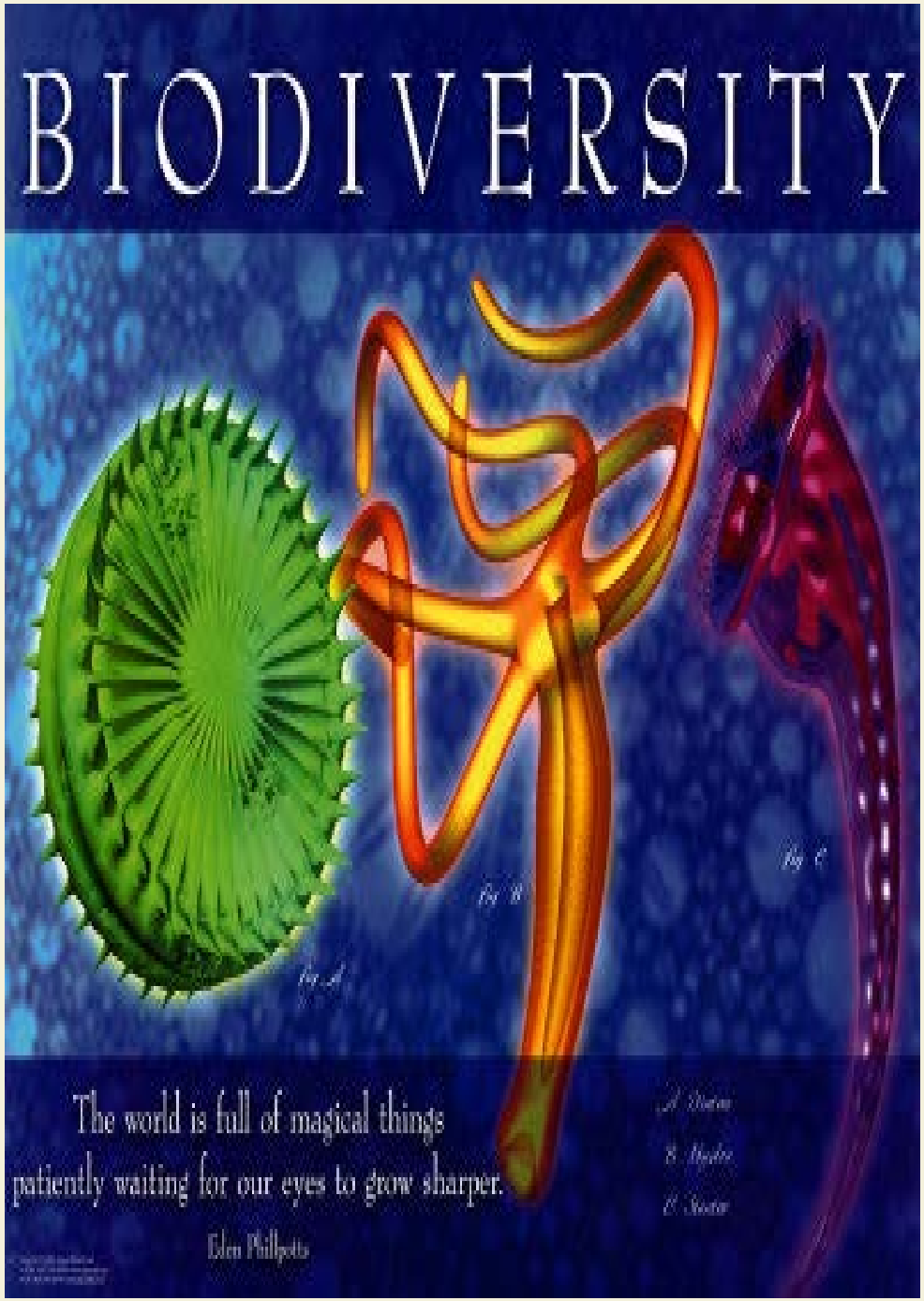


CHAPTER 4

Biodiversity and Evolution

There is grandeur to this view of life… that, whilst this planet has gone cycling on… endless forms most beautiful and most wonderful have been, and are being, evolved.
- Charles Darwin

Core Case Study: Why Should We Protect Sharks?

- 400 known species
- 6 deaths per year from shark attacks
- 79-97 million sharks killed every year
  - Fins
  - Organs, meat, hides
  - Fear
  - 32% shark species threatened with extinction
- Keystone species
- Cancer resistant

Threatened Sharks

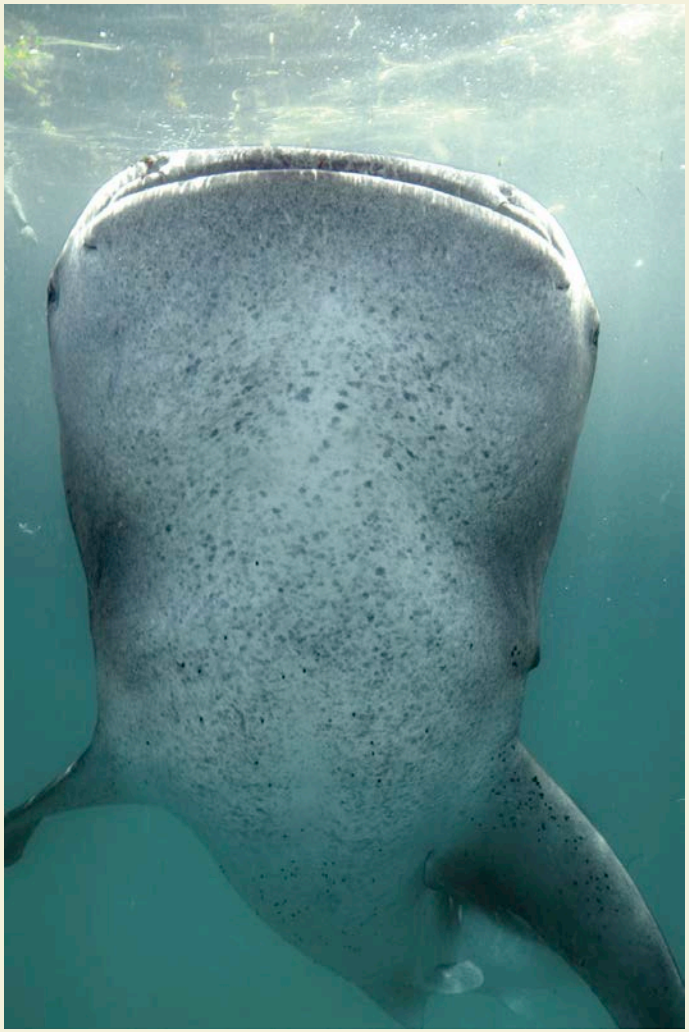
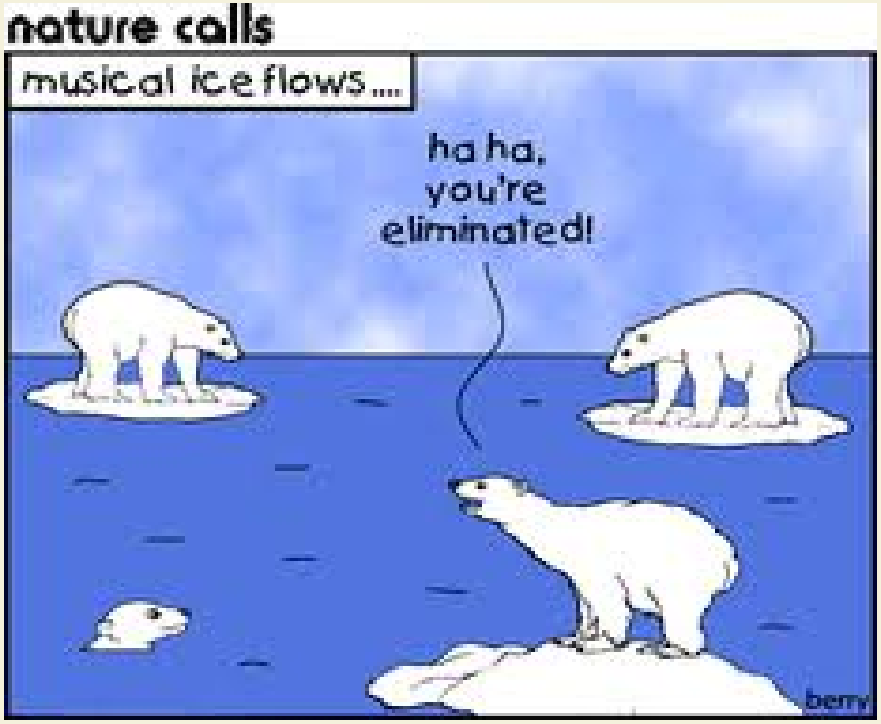


Fig. 4-1, p. 80

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

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

- **Species**: set of individuals who can mate and produce fertile offspring
- 8 million to 100 million species
- 1.9 million identified
- Unidentified are mostly in rain forests and oceans

Natural Capital: Major Components of the Earth's Biodiversity

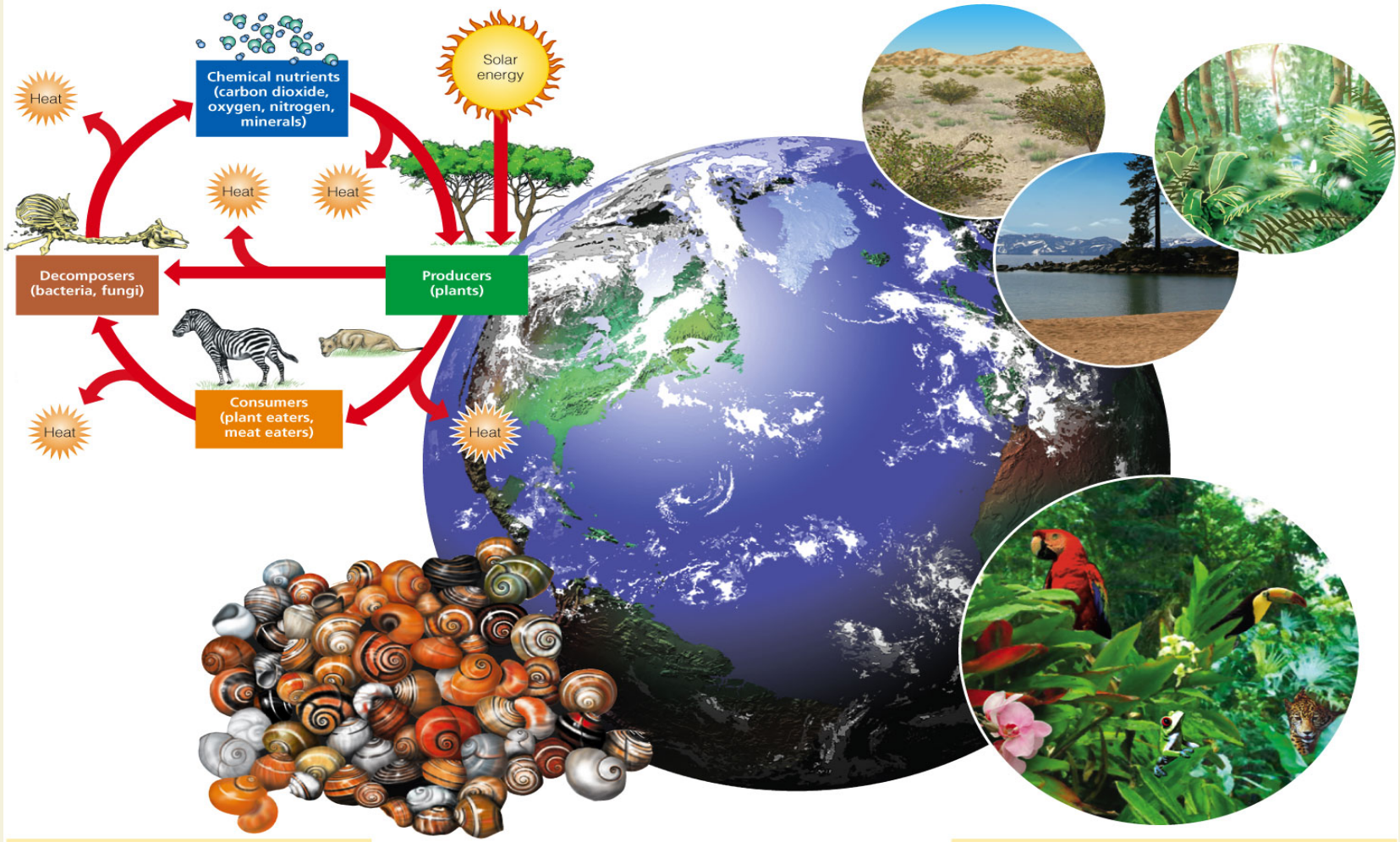


Fig. 4-2, p. 82

Two Species: Columbine Lily and Great Egret

Fig. 4-3, p. 82

Science Focus: Have You Thanked the Insects Today?

- **Bad rep: sting us, bite us, spread disease, eat our food, invade plants**
- **Pollination: lets flowering plants reproduce sexually**
- **Free pest control: insects eat other insects**
- **We need insects more than they need us**

Individuals Matter: Edward O. Wilson: A Champion of Biodiversity

- Loved bugs as a kid
- Specialized in ants
- Widened scope to earth's biodiversity
- Theory of island biogeography
- First to use "biodiversity" in a scientific paper

4-2 How Does the Earth's Life Change Over Time?

- ***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
FOSSILS

Fossils

- Physical evidence of ancient organisms
- Reveal what their external structures looked like

- Fossil record: entire body of fossil evidence

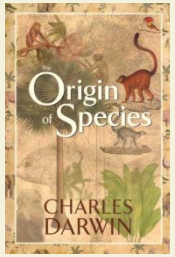
- Only have fossils of 1% of all species that lived on earth

Fossilized Skeleton of an Herbivore that Lived during the Cenozoic Era

Biological Evolution by Natural Selection Explains How Life Changes over Time

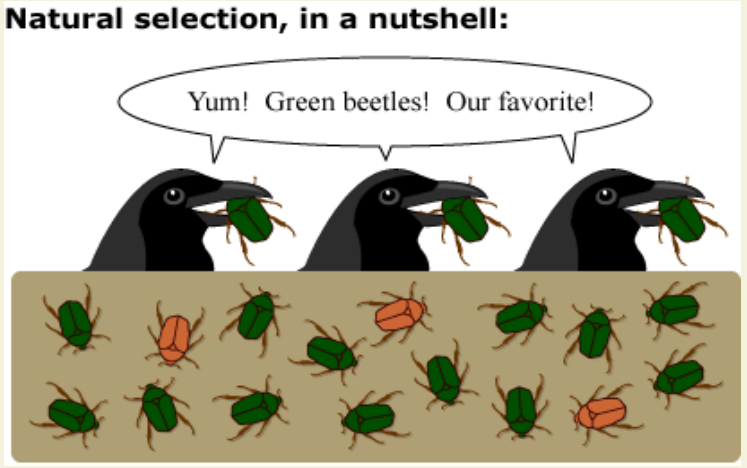
Biological evolution: how earth's life changes over time through changes in the genetic characteristics of populations

- Darwin: *Origin of Species*

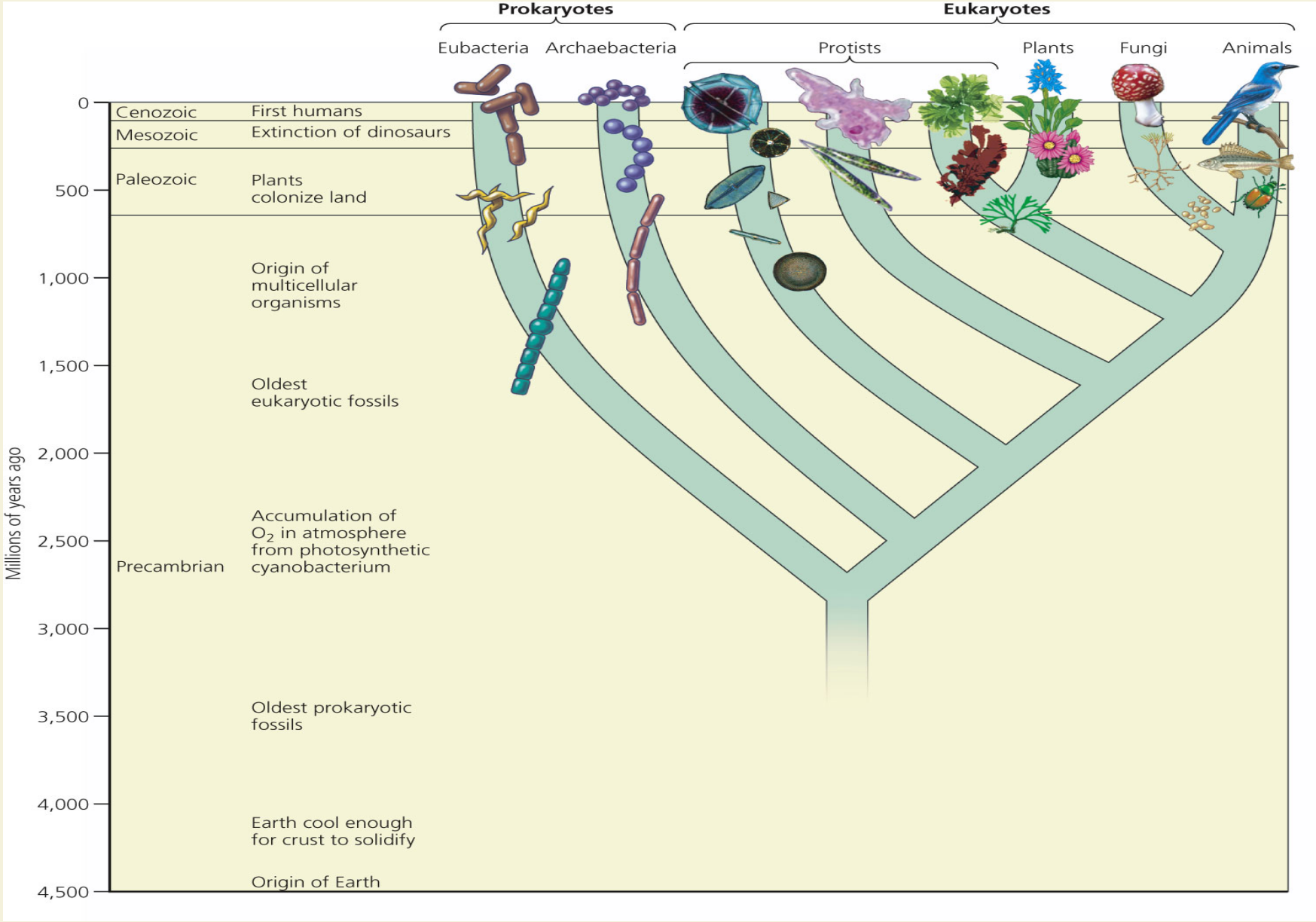


- **Natural selection**: individuals with certain traits are more likely to survive and reproduce under a certain set of environmental conditions

Huge body of evidence

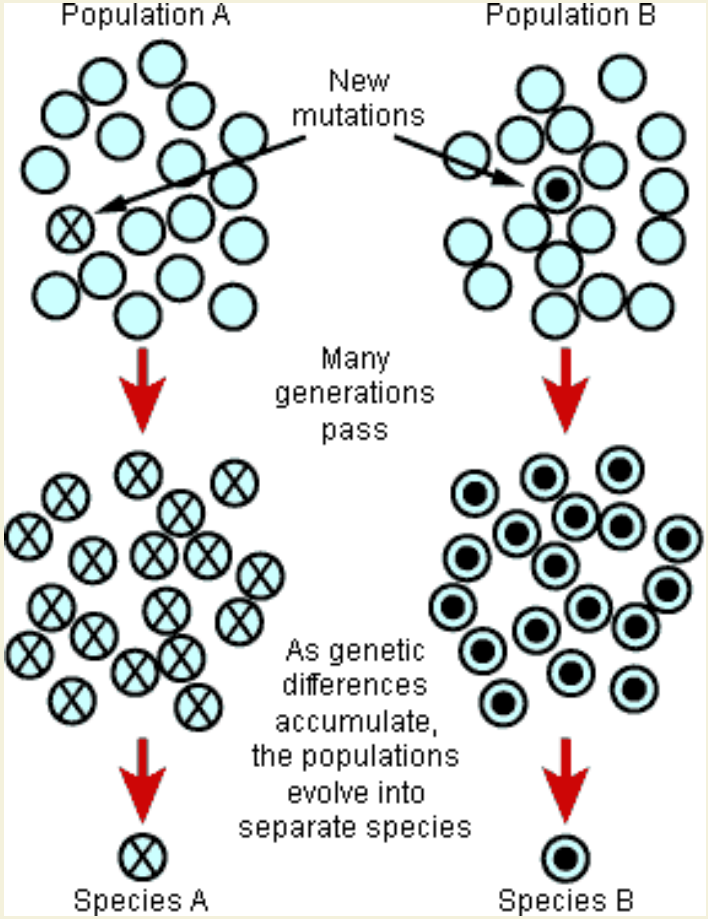


Evolution of Life on Earth



Supplement 5, Fig. 2, p. S18

Evolution by Natural Selection Works
MUTATIONS & VARIATIONS



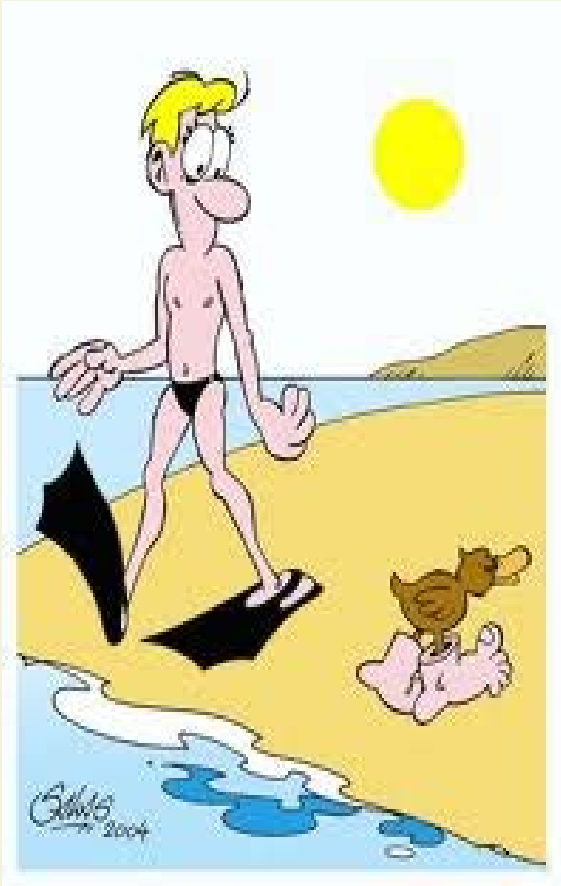
- Populations evolve by becoming genetically different

<u>Genetic variations</u>

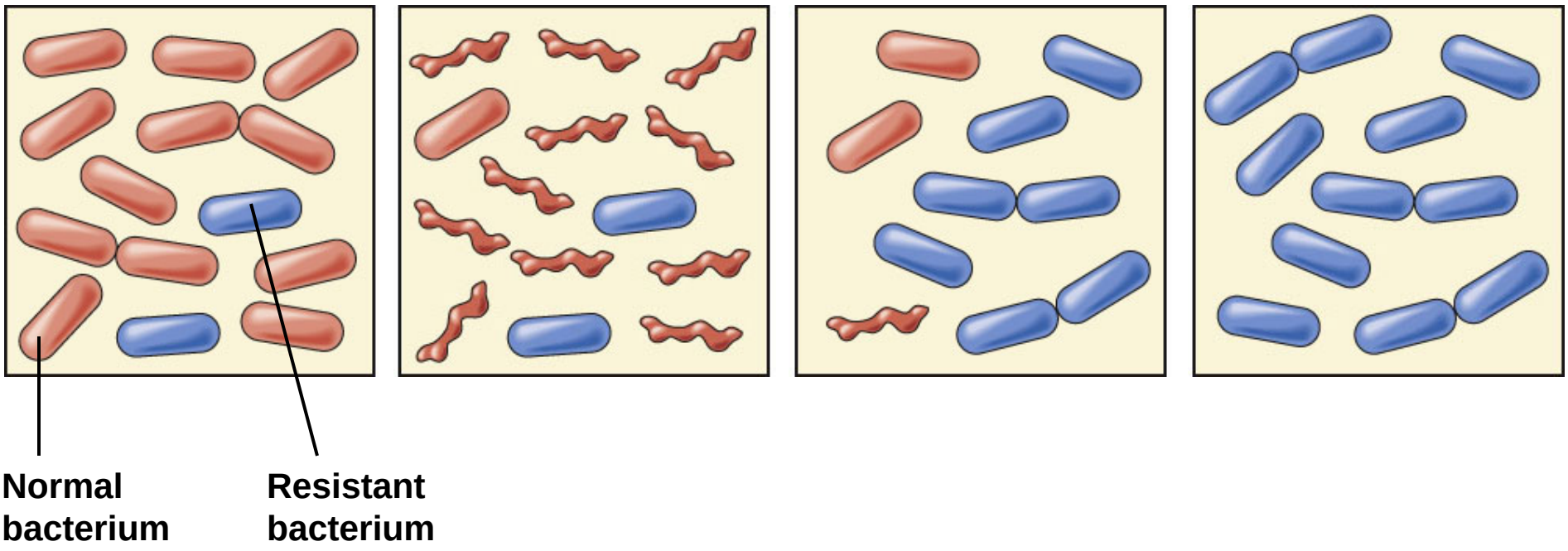
- First step in biological evolution
- Occurs through mutations in reproductive cells
- **Mutations**: random changes in DNA molecules

Evolution by Natural Selection Works
ADAPTATIONS

- **Natural selection**: acts on individuals
  - Second step in biological evolution
  - **Adaptation** may lead to **differential reproduction**
  - Genetic resistance: ability of one or more members of a population to resist a chemical designed to kill it



Evolution by Natural Selection

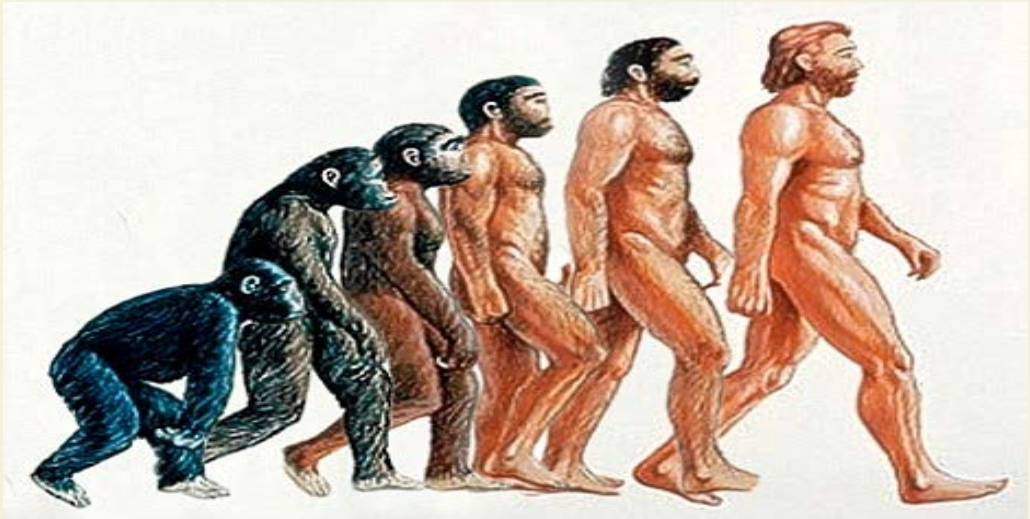


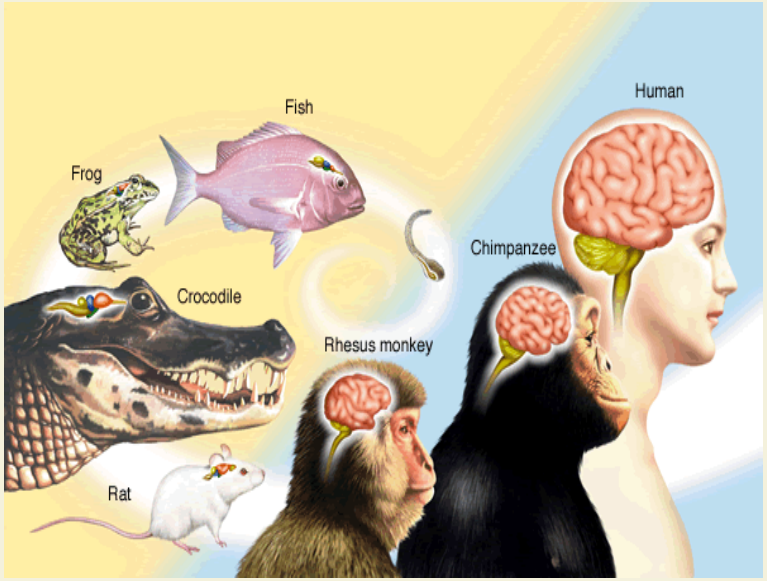
Stepped Art

Fig. 4-7, p. 87

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

- Strong opposable thumbs
- Walk upright
- Complex brain





Adaptation through Natural Selection Has Limits

- Adaptive genetic traits must precede change in the environmental conditions

- Reproductive capacity
  - Species that reproduce rapidly and in large numbers are better able to adapt

Three Common Myths about Evolution through Natural Selection

1. “Survival of the fittest” is not “survival of the strongest”

2. Organisms do not develop traits out of need or want

3. 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
  - Locations of continents and oceans have shifted
  - Species physically move, or adapt, or form new species through natural selection
- Earthquakes: shifting of tectonic plates
- Volcanic eruptions: occur near plate boundaries

Movement of the Earth's Continents over Millions of Years

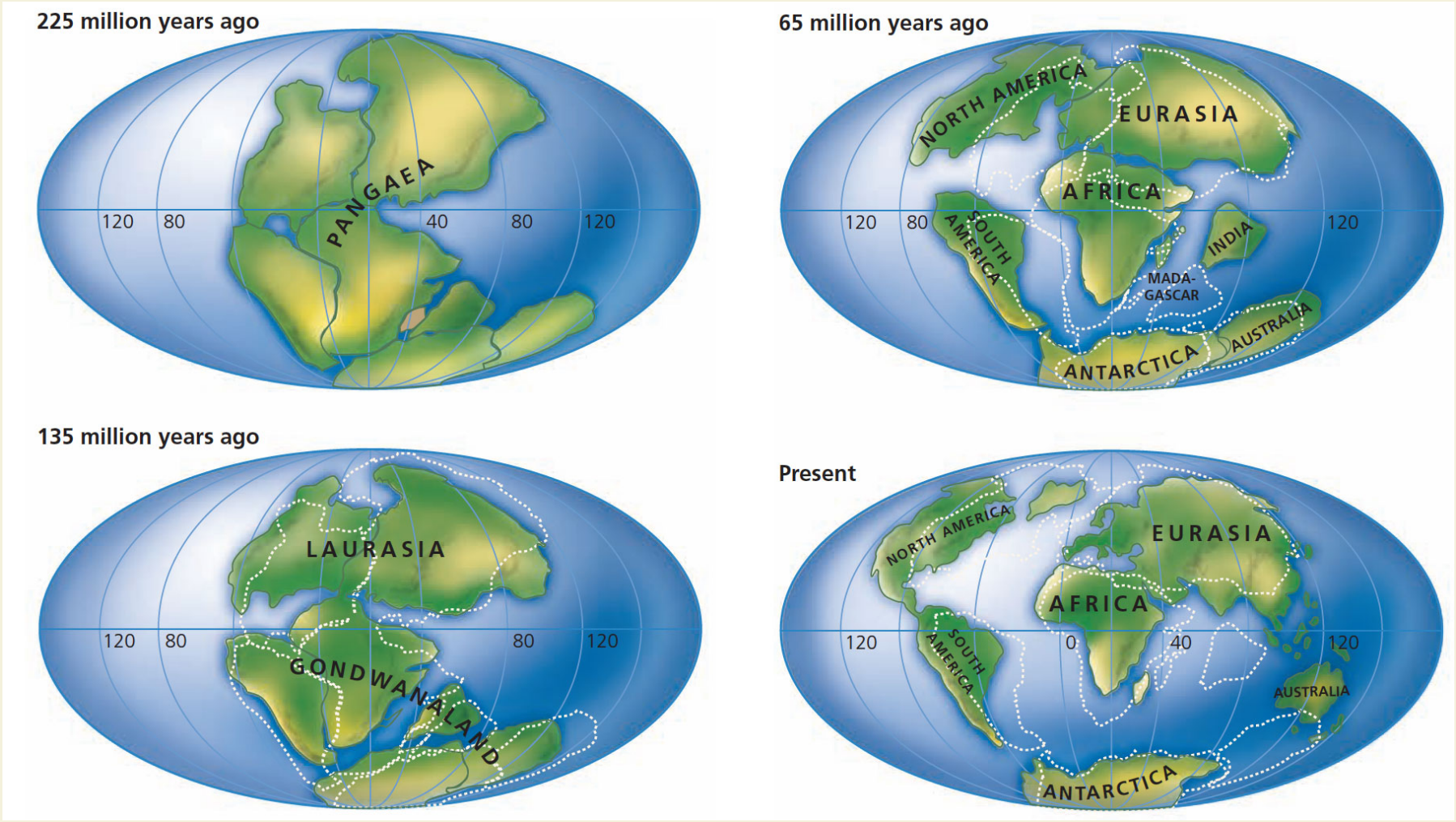
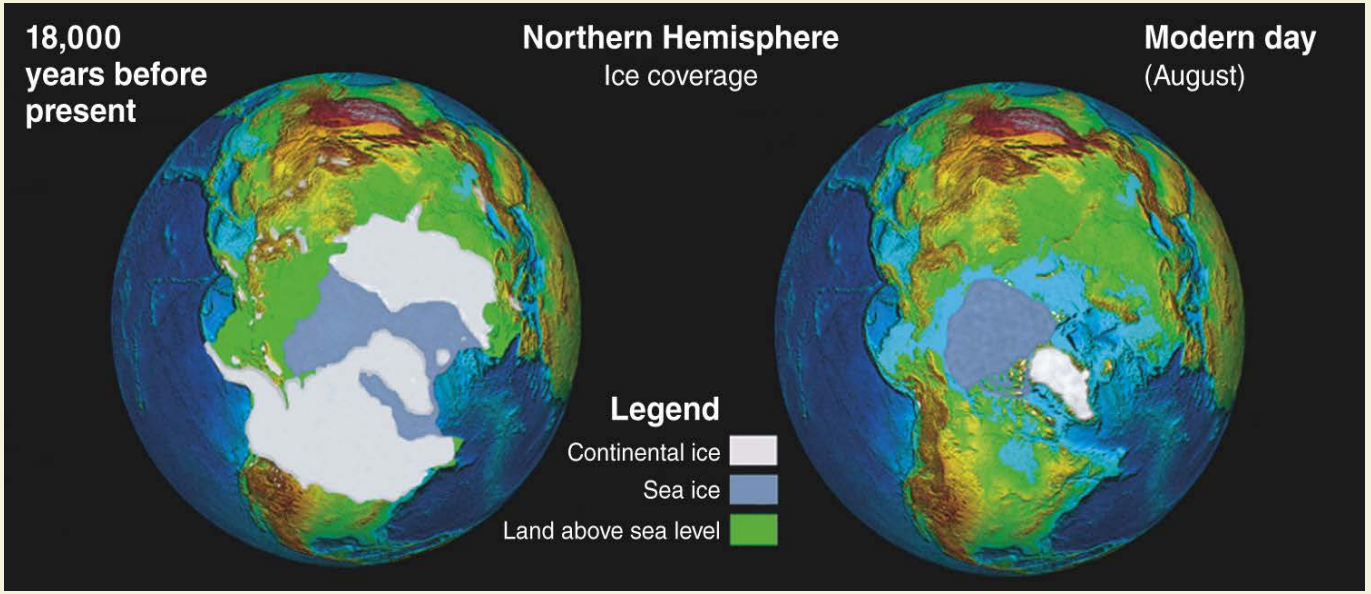


Fig. 4-8, p. 89

Climate Change Affect Natural Selection
Changes in Ice Coverage in the Northern Hemisphere During the last 18,000 Years

- Ice ages followed by warming temperatures

- Collisions between the earth and large asteroids
  - New species
  - Extinctions



VIDEO: Many Planets, One Earth

The early Earth was a much different planet than the one we know today. Ancient rocks provide evidence to the emergence of oxygen in the atmosphere and the deep freeze of a Snowball Earth. Can these clues help explain the rise of complex animal life?

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.*

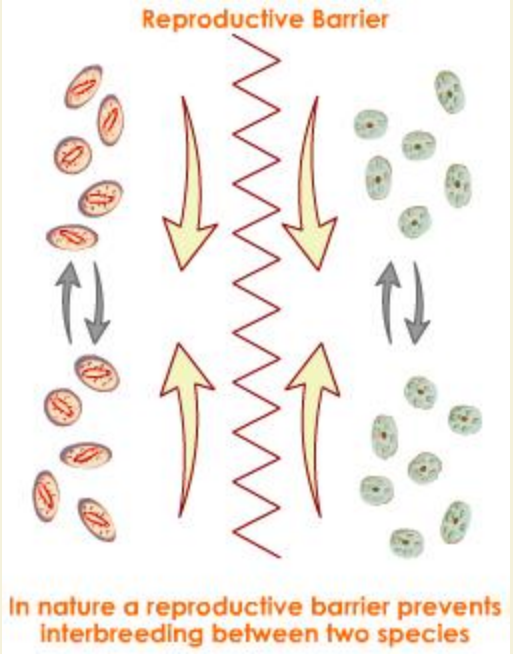
- ***Concept 4-4B*** *Human activities can decrease biodiversity by causing the extinction of many species and by destroying or degrading habitats needed for the development of new species.*

How Do New Species Evolve?

- **Speciation**: one species splits into two or more species

- **Geographic isolation**: happens first; physical isolation of populations for a long period

- **Reproductive isolation**: mutations and natural selection in geographically isolated populations lead to inability to produce viable offspring when members of two different populations mate



Geographic Isolation Can Lead to Reproductive Isolation

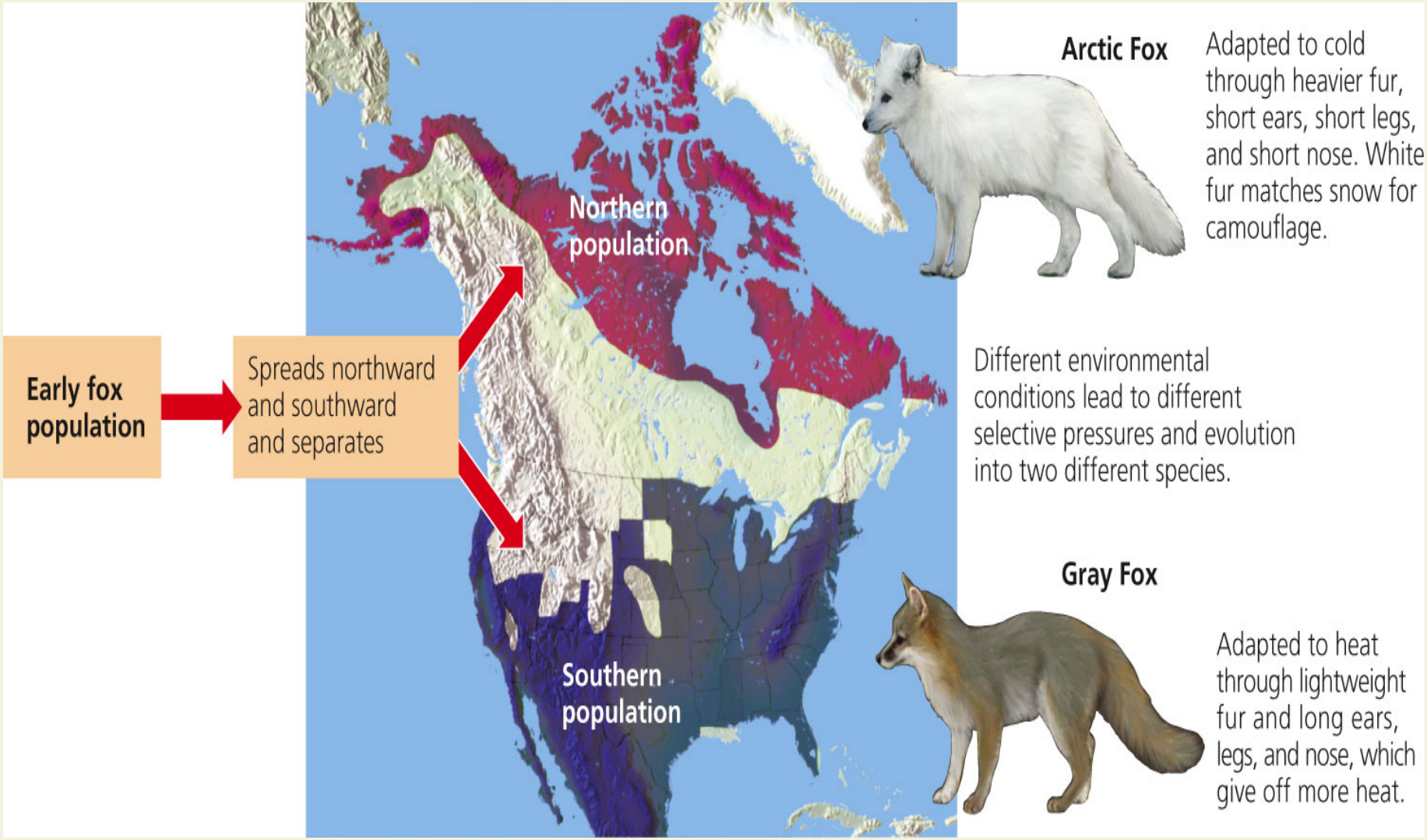


Fig. 4-10, p. 91

Extinction is Forever

- **Extinction**
  - Biological extinction
  - Local extinction
- **Endemic species**
  - Found only in one area
  - Particularly vulnerable

- **Background extinction**: typical low rate of extinction
- **Mass extinction**: 3-5 over 500 million years

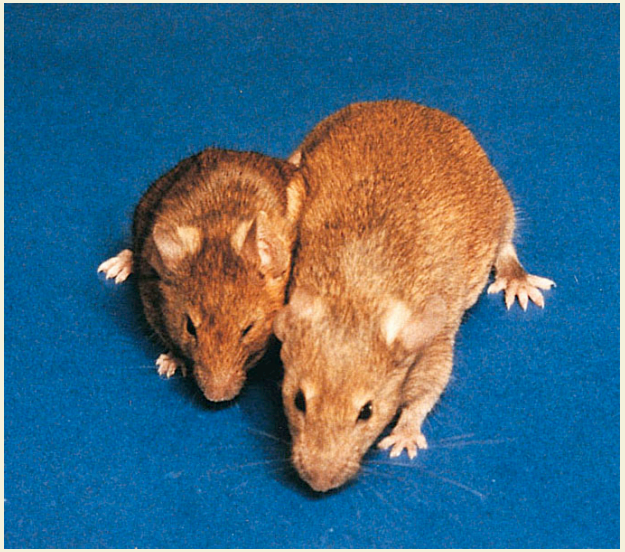
Golden Toad of Costa Rica, Extinct

Fig. 4-11, p. 92

Science Focus: Changing the Genetic Traits of Populations

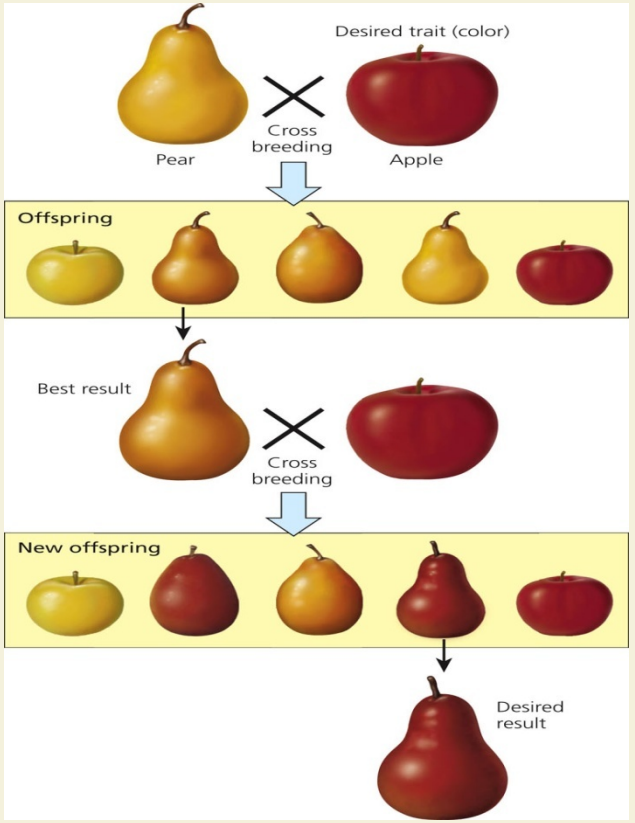
Genetic engineering

gene splicing



Artificial selection

Use selective breeding/crossbreeding



Things to Consider

- Ethics
- Morals
- Privacy issues
- Harmful effects

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.*

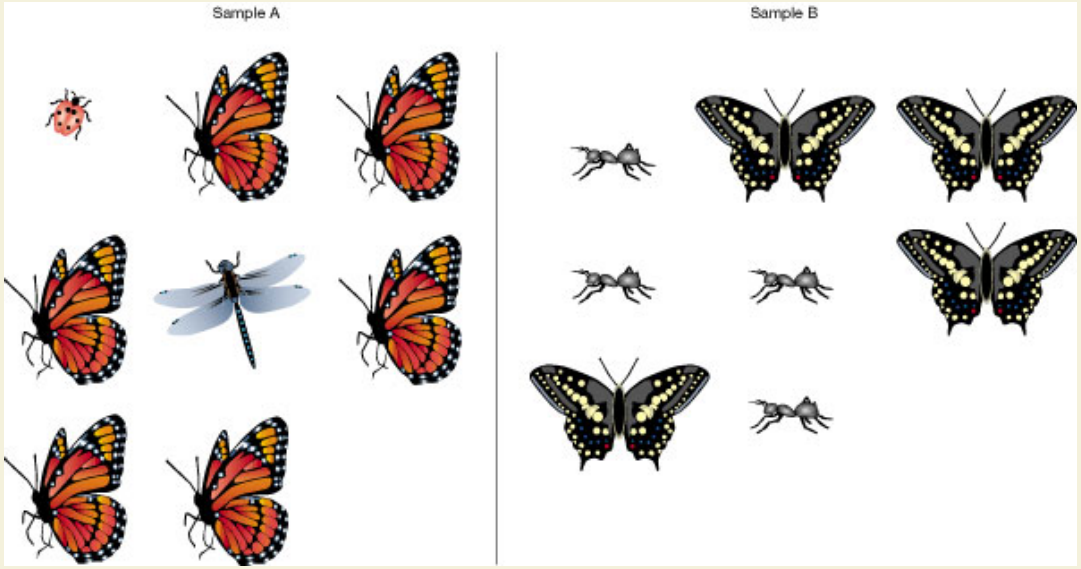
Species Diversity: Variety, Abundance of Species in a Particular Place

Species richness:

- The number of different species in a given area

Species evenness:

- Comparative number of individuals



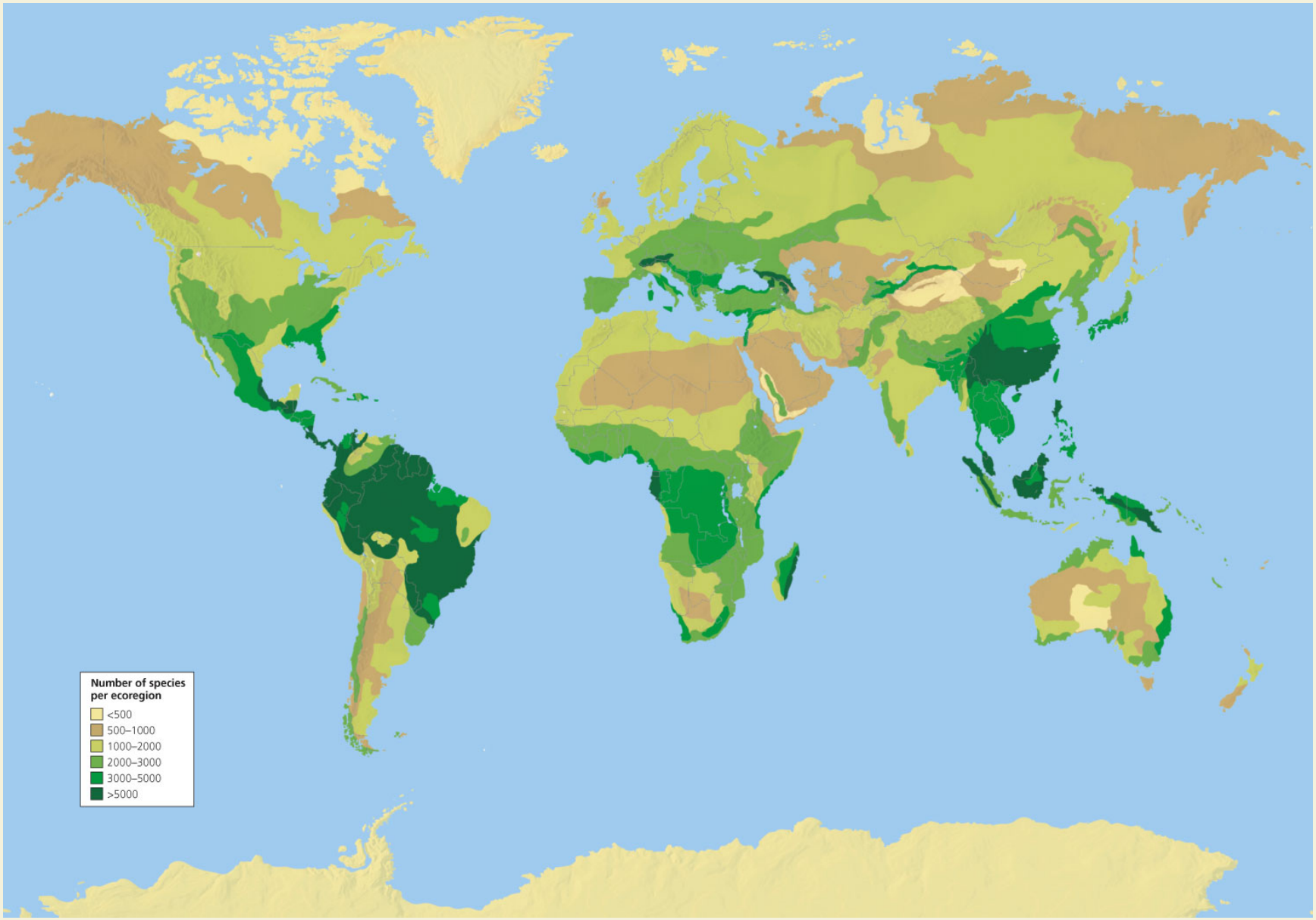
Sample A could be described as being the more diverse as it contains three species to sample B's two. But there is less chance in sample B than in sample A that two randomly chosen individuals will be of the same species.

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

- Diversity varies with geographical location

- The most species-rich communities
  - Tropical rain forests
  - Coral reefs
  - Ocean bottom zone
  - Large tropical lakes

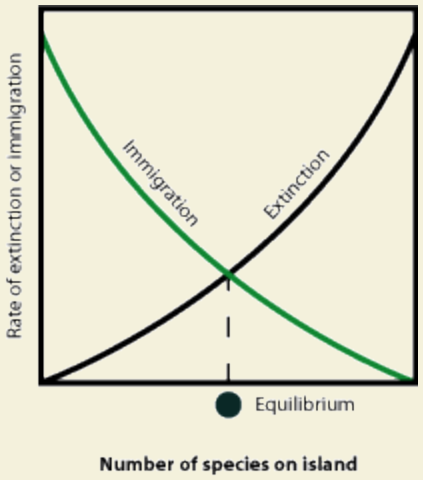
Global Map of Plant Biodiversity

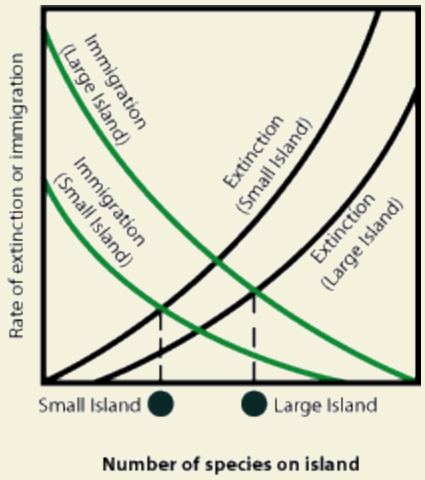


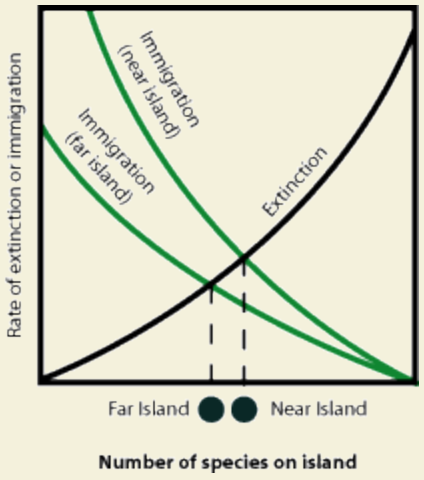
Supplement 8, Fig. 6, p. S36

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, and provide insurance against catastrophe

- How much species richness is needed is debatable

4-6 What Roles Do Species Play in an Ecosystem?

- ***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—in a particular ecosystem.*

What is a Species?

- **Definition**: A group of organisms which can interbreed to form fertile young
- A class of individuals having some common characteristics or qualities; distinct sort or kind

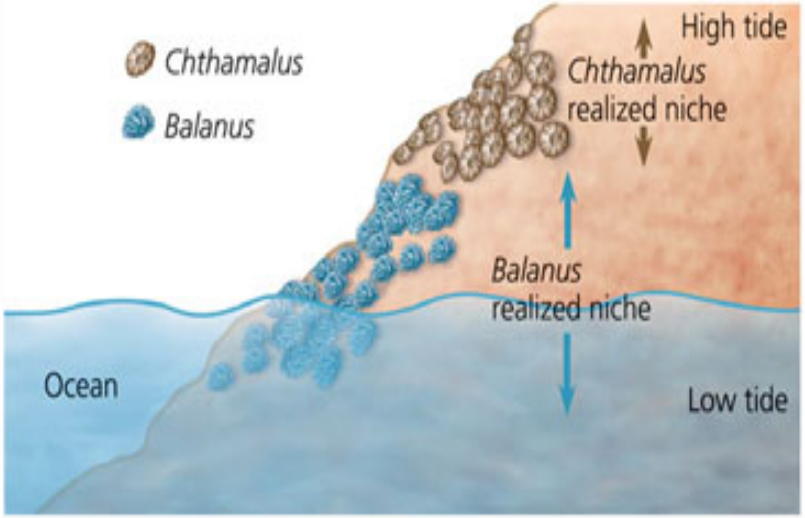
←Different Species of Plants

Each Species Plays a Unique Role in Its Ecosystem

- **Ecological niche, niche**
  - Pattern of living: everything that affects survival and reproduction
  - Water, space, sunlight, food, temperatures
- **Generalist species**
  - Broad niche: wide range of tolerance
- **Specialist species**
  - Narrow niche: narrow range of tolerance

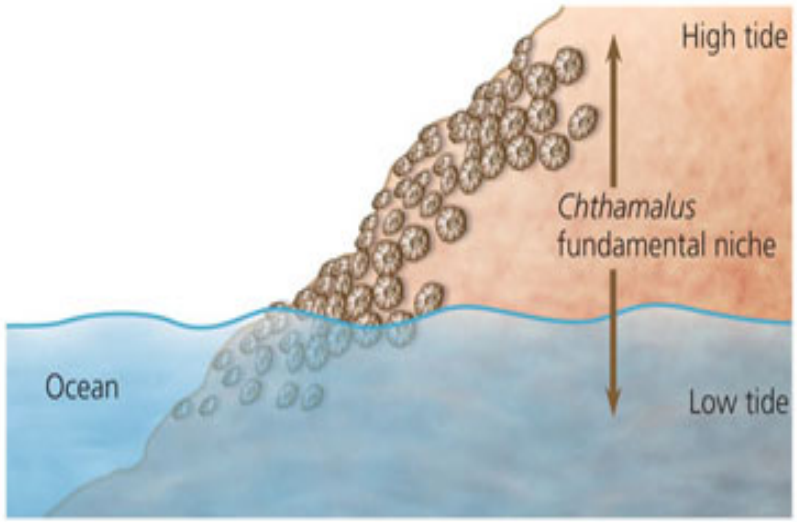
Competitive Exclusion Principle
Fundamental vs. Realized Niche

EXPERIMENT Ecologist Joseph Connell studied two barnacle species—*Balanus balanoides* and *Chthamalus stellatus*—that have a stratified distribution on rocks along the coast of Scotland.



In nature, *Balanus* fails to survive high on the rocks because it is unable to resist desiccation (drying out) during low tides. Its realized niche is therefore similar to its fundamental niche. In contrast, *Chthamalus* is usually concentrated on the upper strata of rocks. To determine the fundamental niche of *Chthamalus*, Connell removed *Balanus* from the lower strata.

RESULTS When Connell removed *Balanus* from the lower strata, the *Chthamalus* population spread into that area.



CONCLUSION The spread of *Chthamalus* when *Balanus* was removed indicates that competitive exclusion makes the realized niche of *Chthamalus* much smaller than its fundamental niche.

Specialist Species and Generalist Species Niches

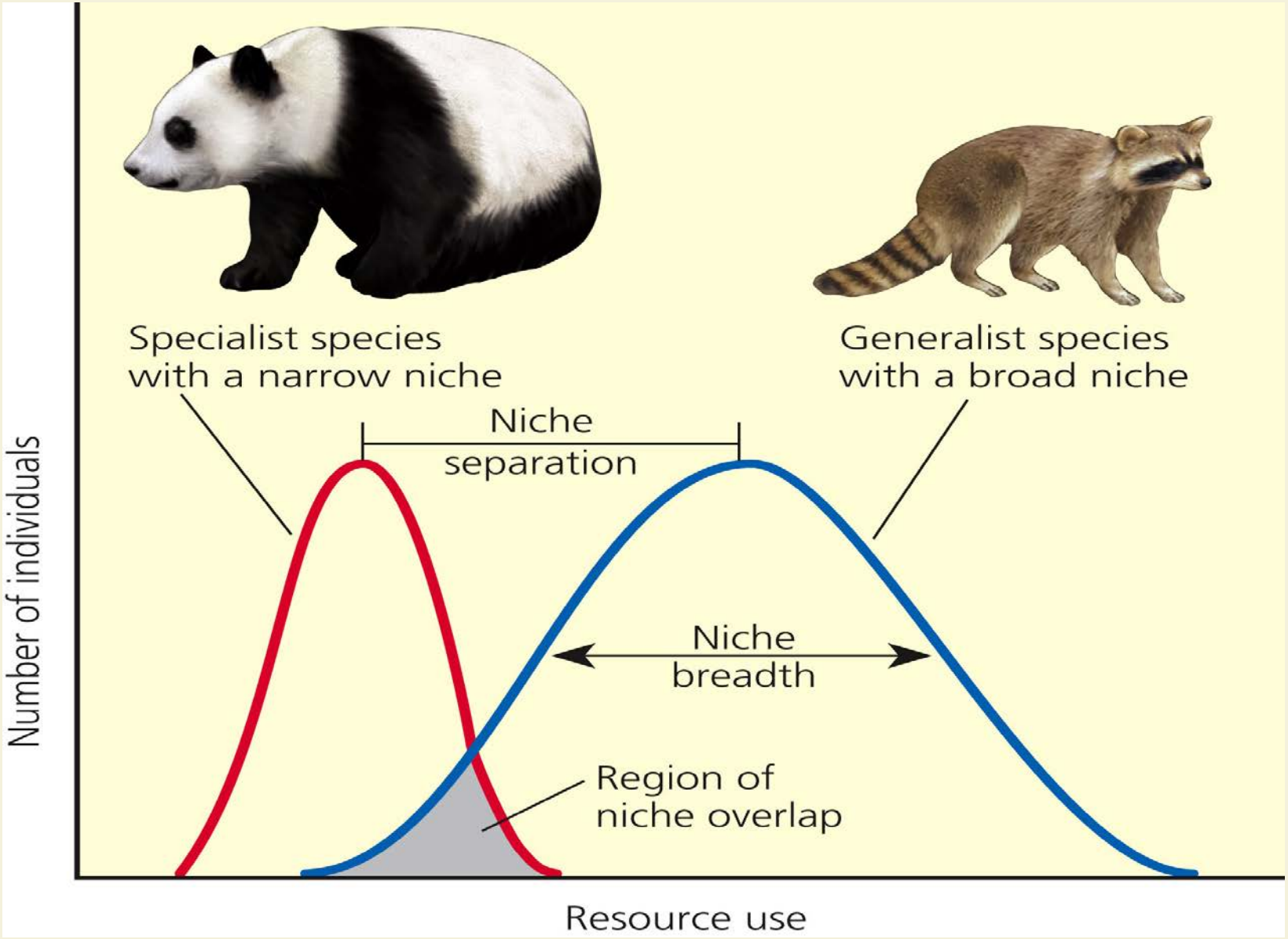


Fig. 4-13, p. 95

Specialized Feeding Niches of Various Bird Species in a Coastal Wetland

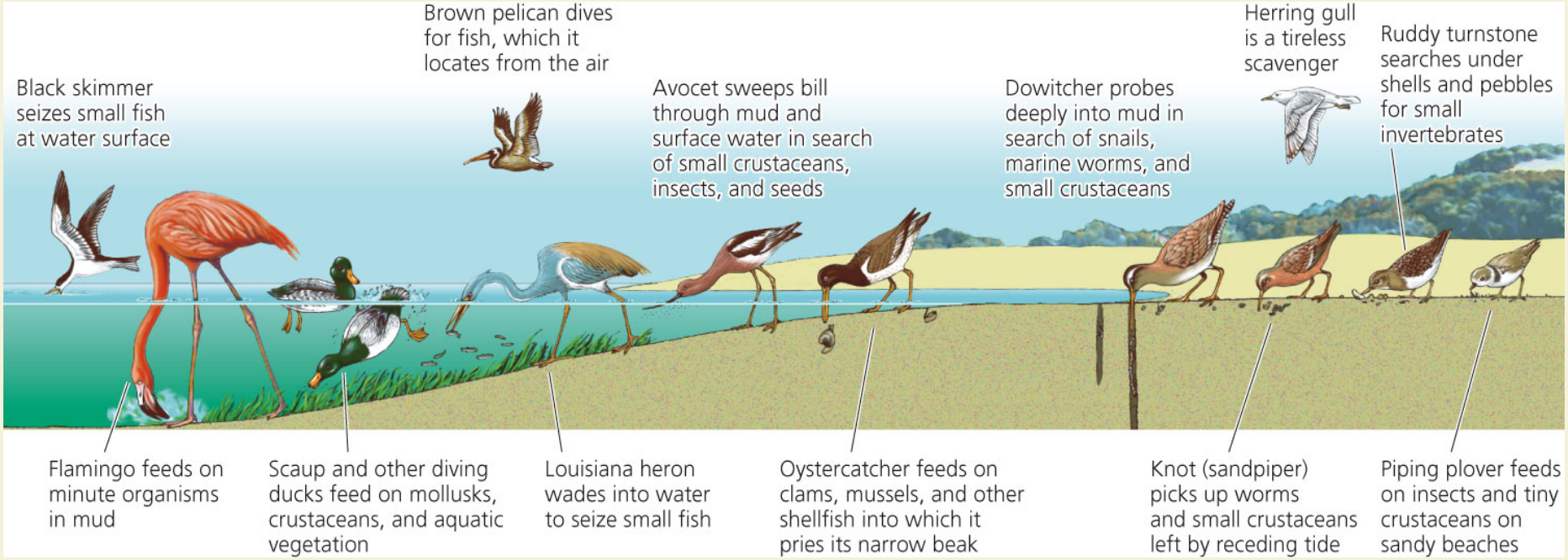


Fig. 4-14, p. 96

Case Study: Cockroaches: Nature's Ultimate Survivors

- 3500 species
- Generalists
  - Eat almost anything
  - Live in almost any climate
- High reproductive rates

Species Can Play Five Major Roles within Ecosystems

- **Native species:** normally live & thrive in particular ecosystem
- **Nonnative species:** migrate (deliberately or accidentally) into an ecosystem
- **Indicator species:** early warnings of damage to ecosystem
- **Keystone species:** role have a large effect on the types & abudance of other species in an ecosystem
- **Foundation species:** play a major role in shaping their communities by creating & enhancing their habitats to benefit other species

What is The Importance of Native Species?

- It is important to remember that every species in an ecosystem is there for a reason
- Native species are a vital part of the food web
- Plants and animals native to the same area have adapted to one another so that animals can eat the plants, but plants can defend themselves enough to be able to reproduce successfully

Non-Native Species - Invasive Species

- **species considered to be alien or non-native to an ecosystem**
- **can cause environmental harm or harm to human health**

Problems They May Cause:

- **Economic harm**
- **Environmental harm**
- **Harm to human health**

Invasive Organisms

- **50,000 species introduced into US in past 500 years**
- **Not all invasive**
- **Out of 4200 “weed” species, 630 cause excessive harm**

Deliberately Introduced Species

Purple looselife

European starling

African honeybee
("Killer bee")

Nutria

Salt cedar
(Tamarisk)

Marine toad

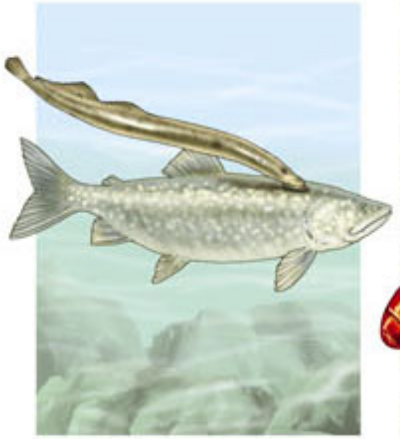
Water hyacinth

Japanese beetle

Hydrilla

European wild boar
(Feral pig)

Accidentally Introduced



Sea lamprey
(attached to lake trout)

Argentina fire ant

Brown tree snake

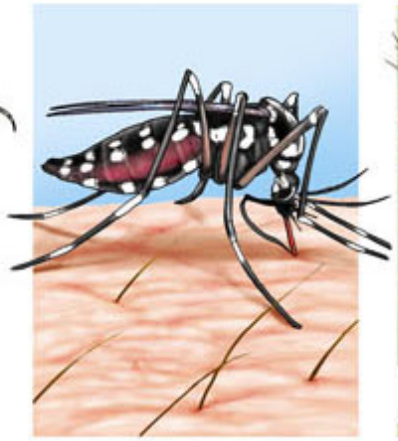
Eurasian muffle

Common pigeon
(Rock dove)

Formosan termite

Zebra mussel

Asian long-horned
beetle

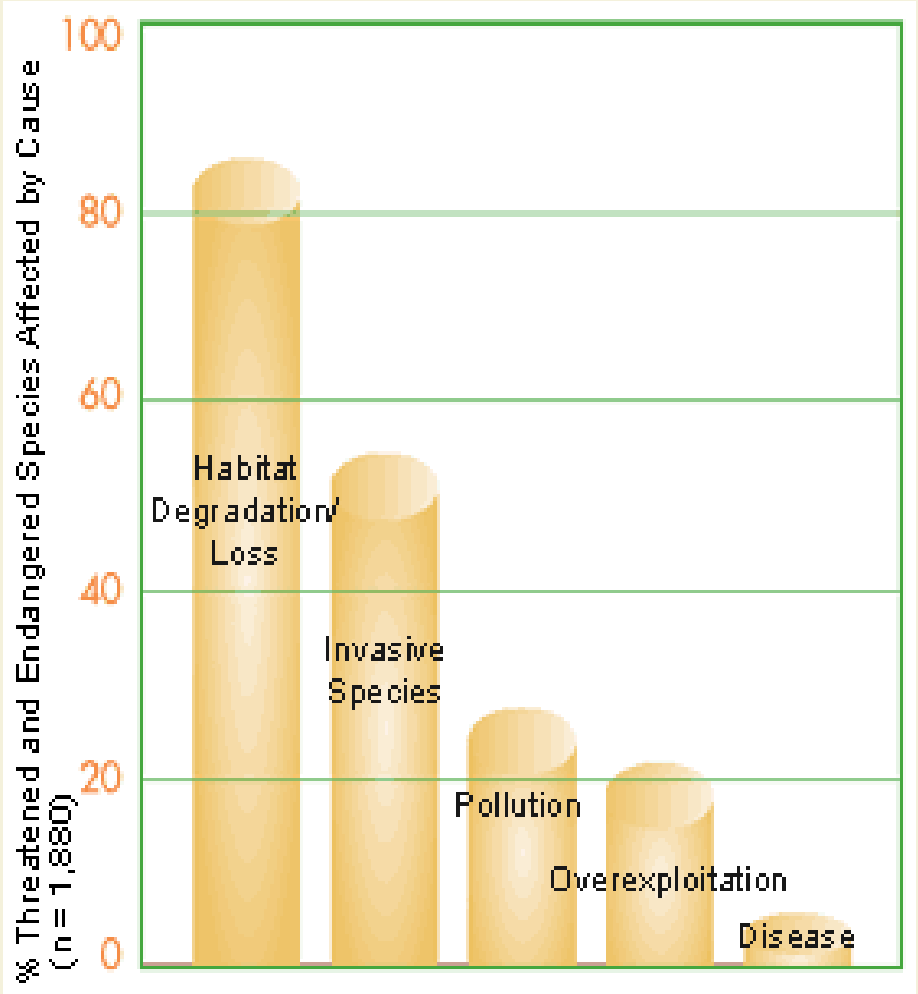


Asian tiger mosquito

Gypsy moth larvae

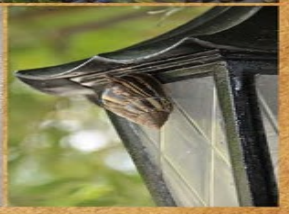
Ecological Effects of Invasive Species

- **Outcompete native and endangered species**
- **Less survival of native species**
- **Lower diversity of native species**
- **Reduce hunting and fishing potential**
- **Habitat aesthetics diminished**



WANTED

GIANT AFRICAN SNAIL



LOOK FOR THEM! REPORT THEM!

888-397-1517

A major landscape and agricultural pest, even eats stucco on homes

Public health threat - known to carry rat lungworm that may cause meningitis in humans

Able to reproduce rapidly - one snail can lay 1,200 eggs in a year
Can grow to up to 8 inches in length - no natural enemies

We need your help to stop this pest!

www.freshfromflorida.com/pi

USDA

Fresh from Florida

Division of PLANT INDUSTRY

Protection through Detection

Florida Department of Agriculture and Consumer Services

Adam H. Putnam, Commissioner

Indicator Species

- **plants and animals that, by their presence, abundance, or chemical composition, are able to reveal something about the environment**
- **used as measures of habitat or ecosystem quality**

- **Examples: canary in the coal mine, global death of amphibians, spotted owl in old growth forests, butterflies, frogs**

Case Study: Why Are Amphibians Vanishing?

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

Red-Eyed Tree Frog

Poison Dart Frog

Why Are Amphibians Important?

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

Keystone Species Play Critical Roles in Their Ecosystems

Keystone species: roles have a large effect on the types and abundances of other species

- Pollinators
- Top predators

Keystone Species: SALMON

- critical fall food source for the grizzly bear, wolves, eagles and otters, but they also act as fertilizer for the trees

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: a keystone species**
- **1967: endangered species**
- **1977: comeback, threatened species**

Foundation Species Help to Form the Bases of Ecosystems

- Create or enhance their habitats, which benefit others
- Examples: Elephants (break/uproot trees giving space for grasses); Beavers (ecological engineers – build dams)

CHAPTER 4: Three Big Ideas

1. **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).**
2. **Human activities are decreasing the earth's vital biodiversity by causing the extinction of species and by disrupting habitats needed for the development of new species.**
3. **Each species plays a specific ecological role (ecological niche) in the ecosystem where it is found.**