Chapter 5
Evolution of Biodiversity

Dung of the Devil ……..Rosy Periwinkle
Strong antiviral……..fights childhood
(against H1N1 flu)…….leukemia/Hodgkin's .

ter 5 Opener
nmental Science
W. H. Freeman and Company

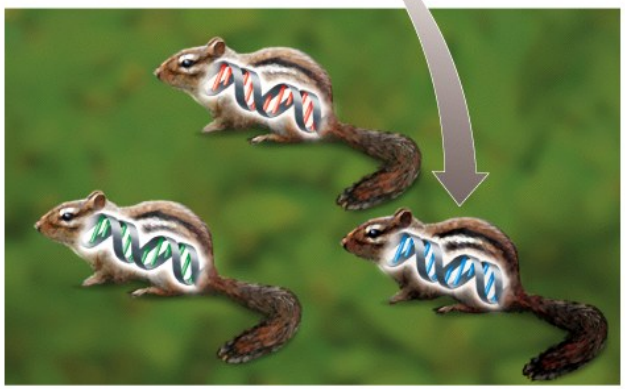
npany

Earth is home to a tremendous diversity of species

- **Genetic diversity**- the variety of genes within a given species.
- **Species diversity**- the variety of species in a given ecosystem.
- **Ecosystem diversity**- the variety of ecosystems within a given region.
- **Cultural diversity** – variety of customs, norms, racial groups, philosophies

(a) Ecosystem diversity

(b) Species diversity



(c) Genetic diversity

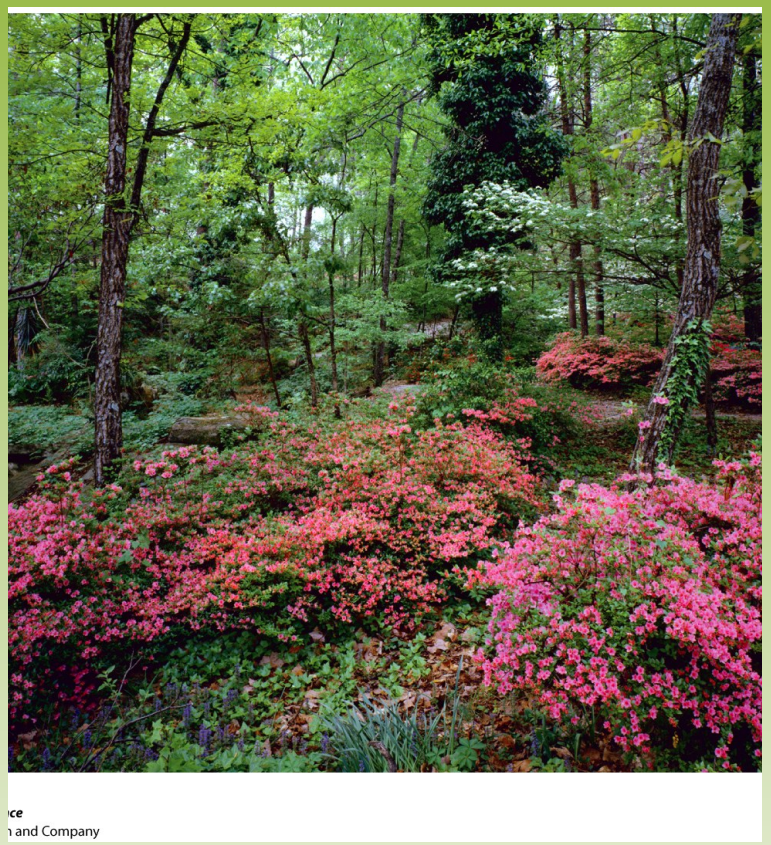
Figure 5.2
Environmental Science

Genetic Diversity with Species

Measuring Species Diverstiy

Figure 5.3b
Environmental Science

Species diversity varies among ecosystems



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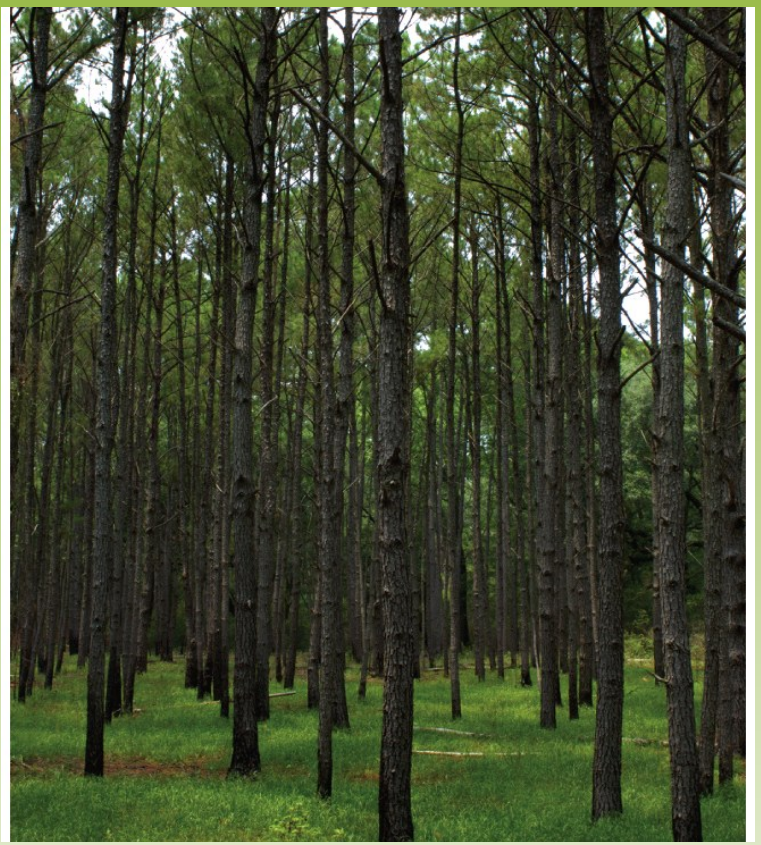
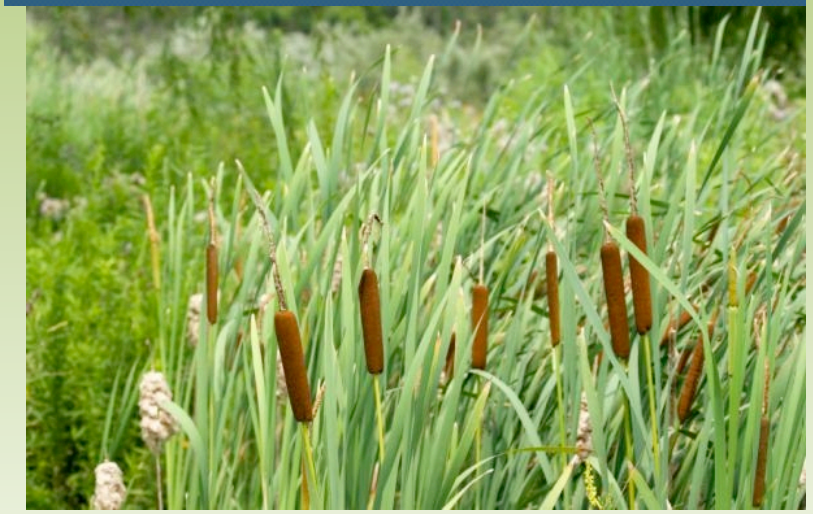
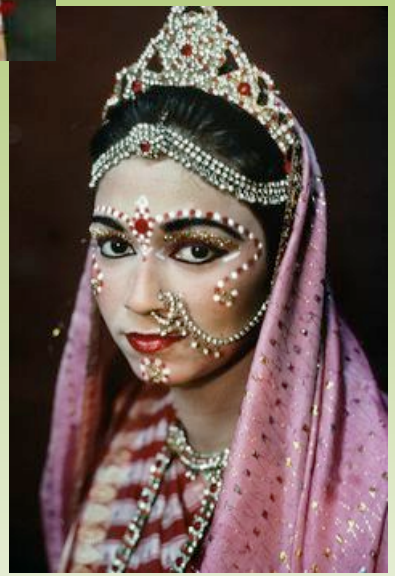
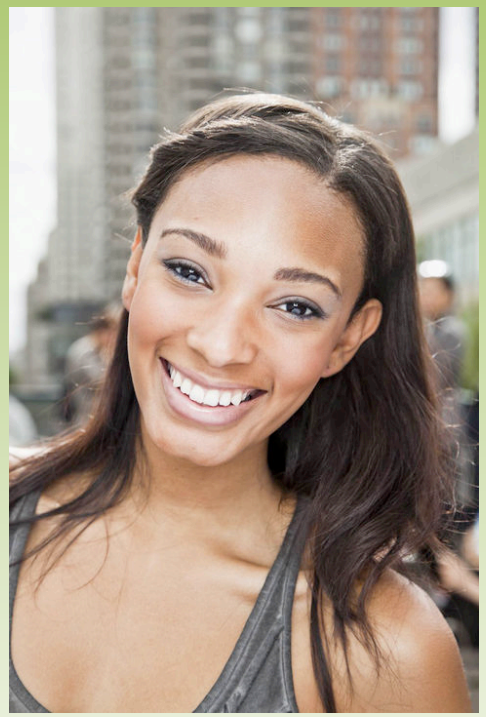


Ecosystem Diversity

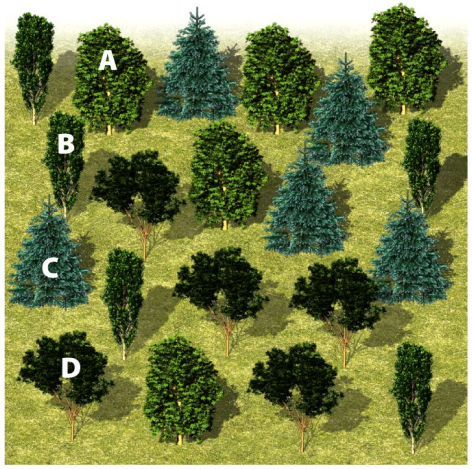


Cultural diversity

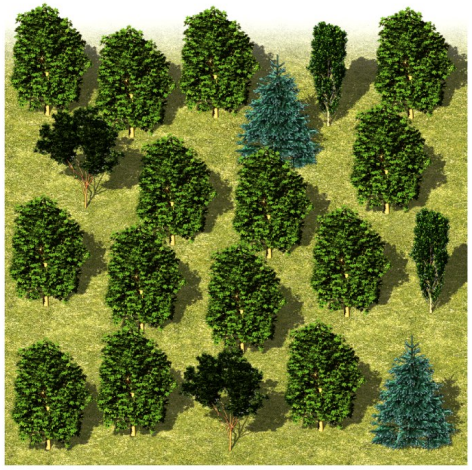




- **Species richness**- the number of species in a given area…a.k.a species diversity.
- **Species evenness**- the measure of whether a particular ecosystem is numerically dominated by one species or are all represented by similar numbers of individuals.



Community 1
A: 25% B: 25% C: 25% D: 25%



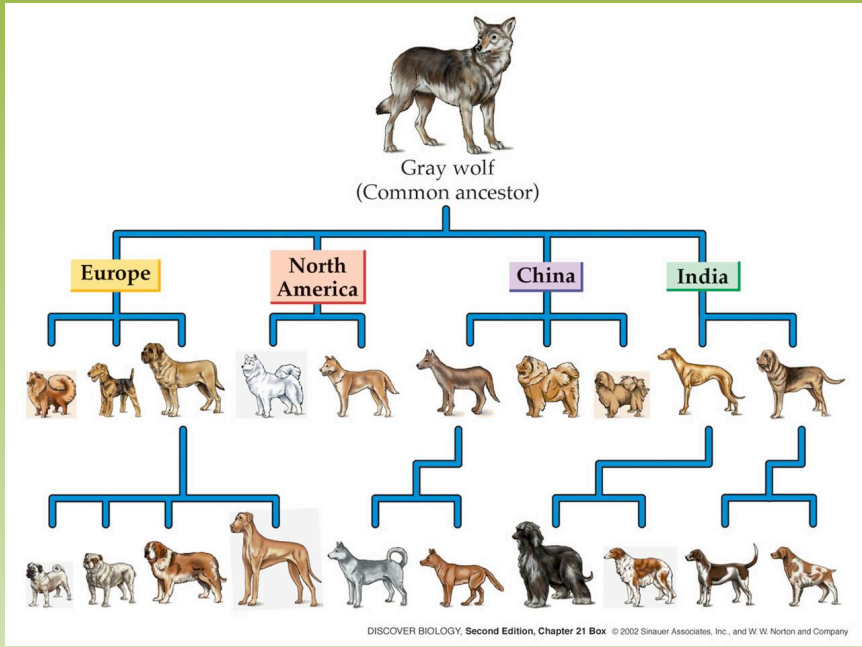
Community 2
A: 70% B: 10% C: 10% D: 10%

Figure 5.4
Environmental Science

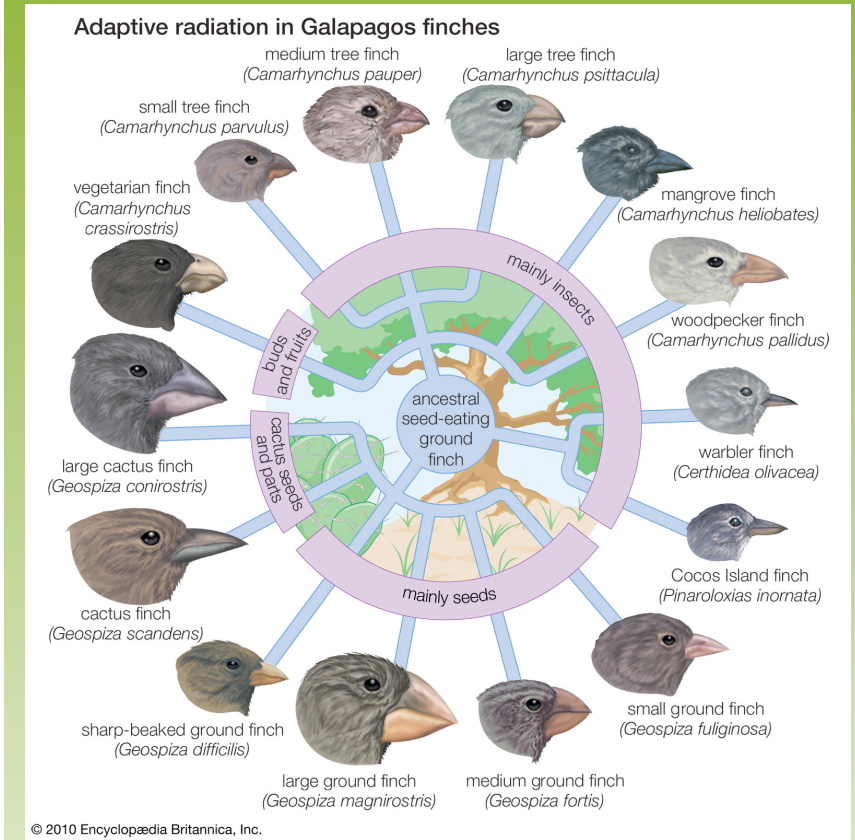
Evolution is the mechanism underlying biodiversity

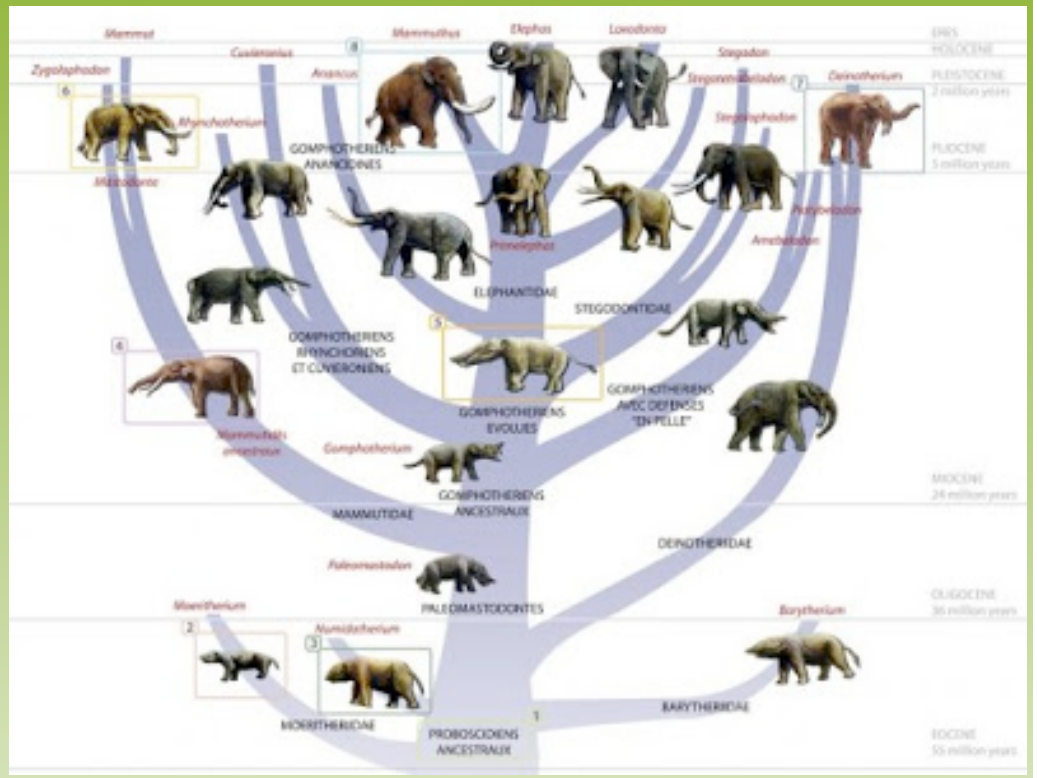
- **Evolution-** a change in the genetic composition of a population over time.
- **Microevolution**- evolution below the species level.
- **Macroevolution**- Evolution which gives rise to new species or new genera, family, class or phyla.

Microevolution



Macroevolution





Phylogenic tree
shows evolutionary relationships among related groups.

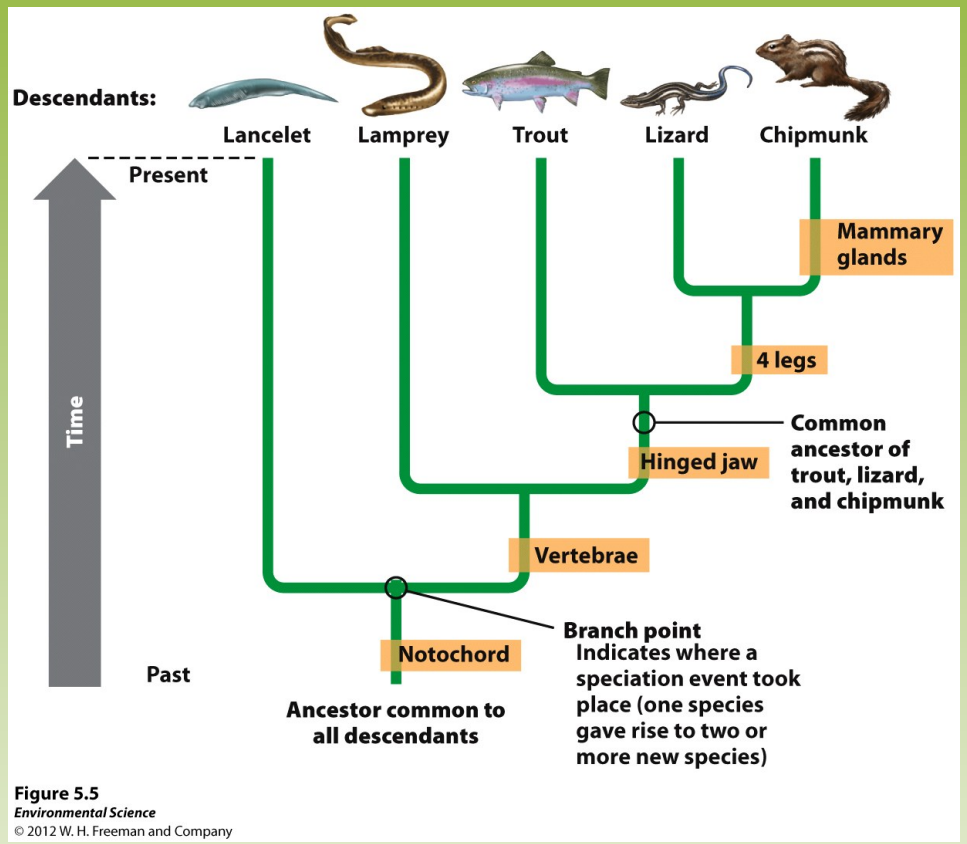


Figure 5.5
Environmental Science

Creating Genetic Diversity

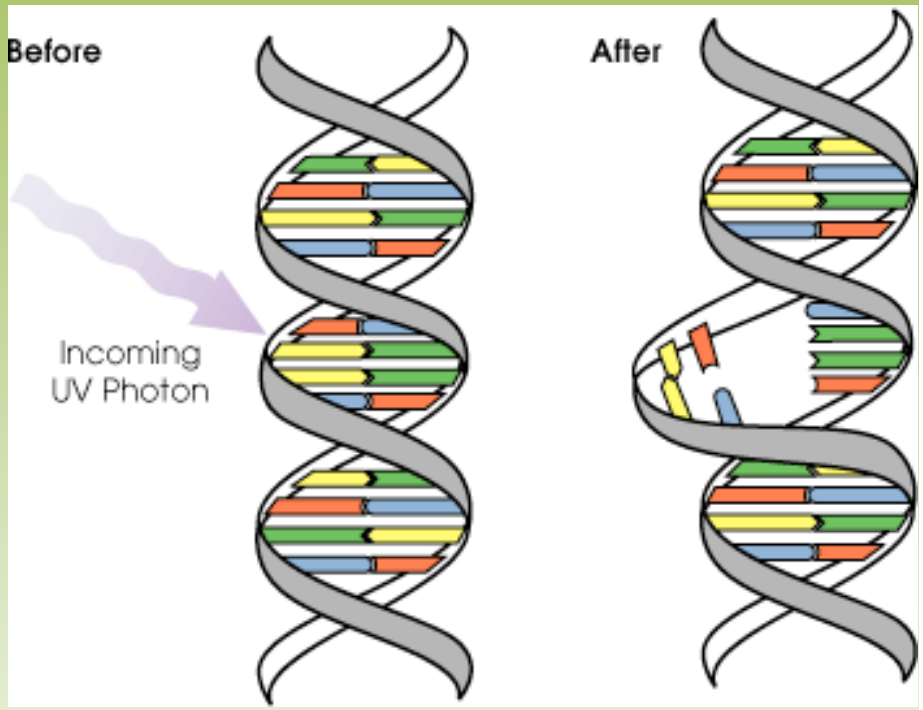
- **Genes-** physical locations on chromosomes within each cell of an organism.
- **Genotype**- the complete set of genes in an individual.
- **Mutation**- a random change in the genetic code.
- **Phenotype**- the actual set of traits expressed in an individual.

Mutation…the bad

bright blue colors for a forest-dwelling bird might not be a good thing for survival.

So, a change in the genes changes the genotype, which changes the phenotype.

Figure 5.6
Environmental Science



…and the good!

In the water flea, the presence of a predator means that the larger "sword" is favored.

Figure 5.7
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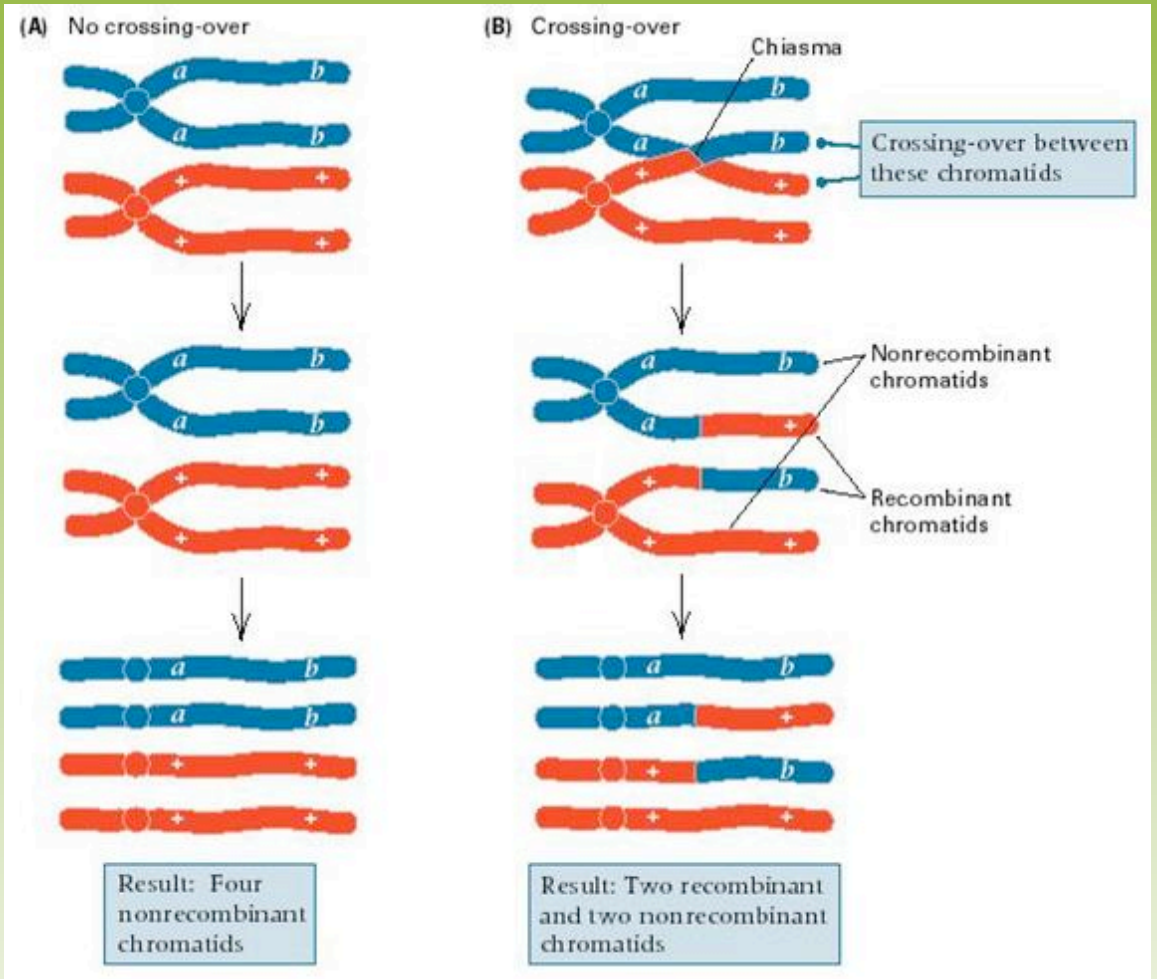
Recombination…something new in the genome



Evolution by artificial and natural selection

- **Evolution by artificial selection**- when humans determine which individuals breed.
- **Evolution by natural selection**- the environment determines which individuals are most likely to survive and reproduce.

Artificial Selection in Dog Breeding

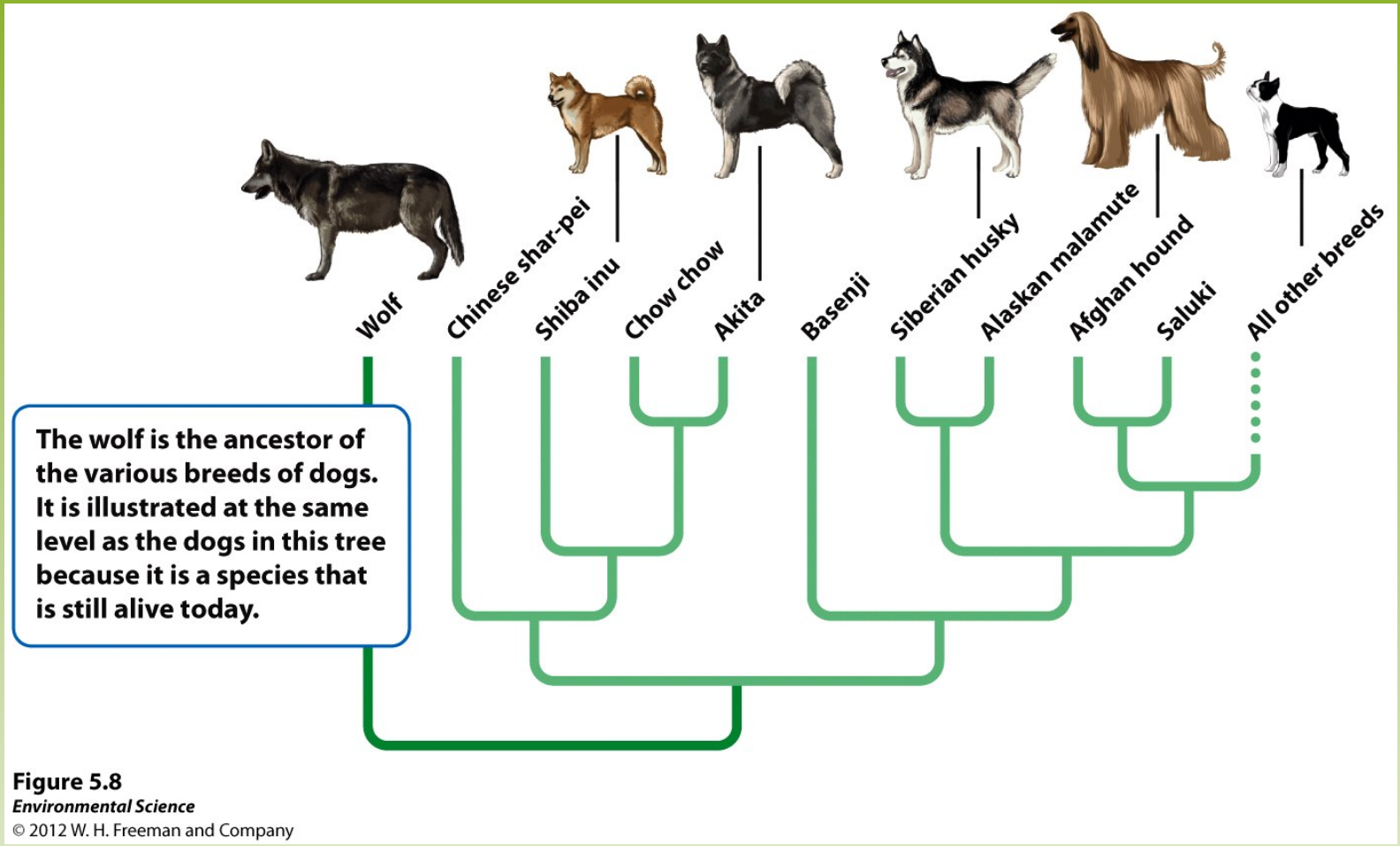


Figure 5.8
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Artificial Selection in Plants…
all of these different vegetables are the same species!

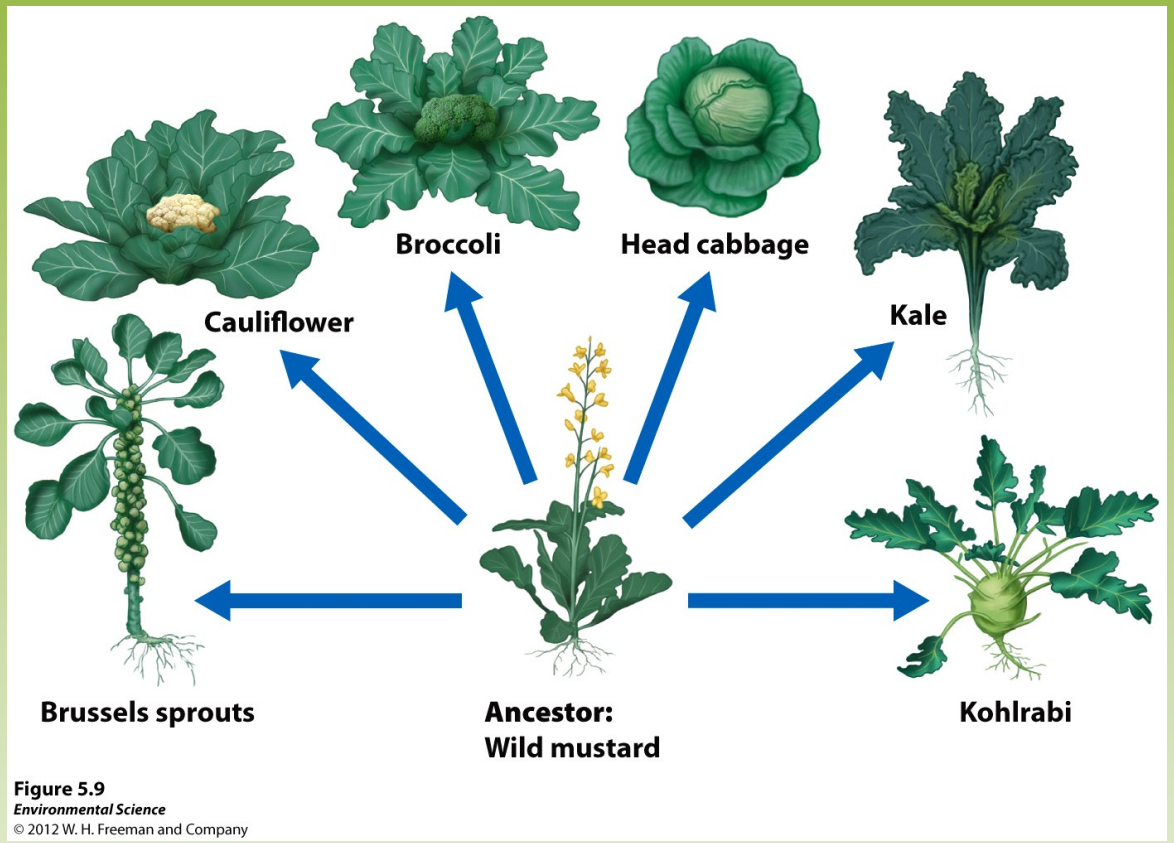

Figure 5.9
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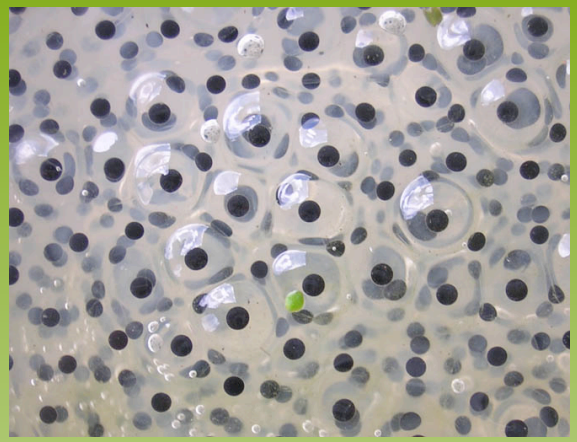
Darwin's theory of evolution by natural selection

- Individuals produce an excess of offspring.
- Not all offspring can survive.
- Individuals differ in their traits.
- Differences in traits can be passed on from parents to offspring.
- Differences in traits are associated with differences in the ability to survive and reproduce.



Natural Selection

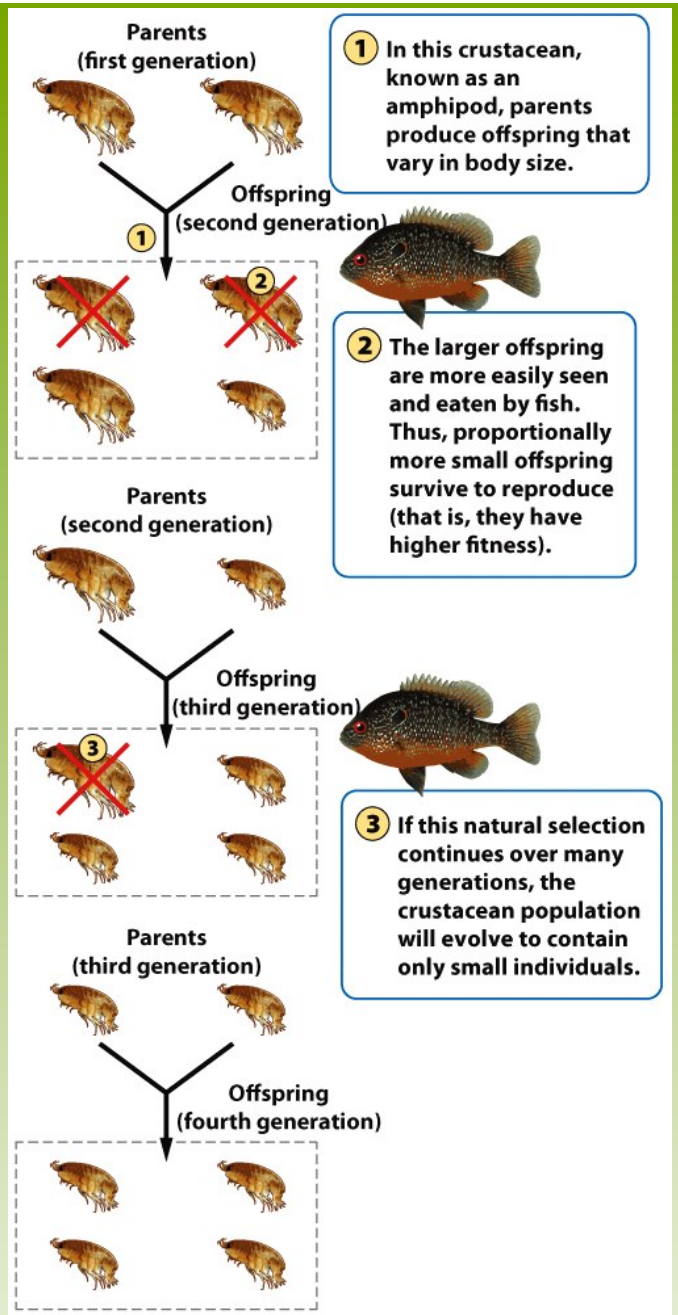


Figure 5.10
Environmental Science

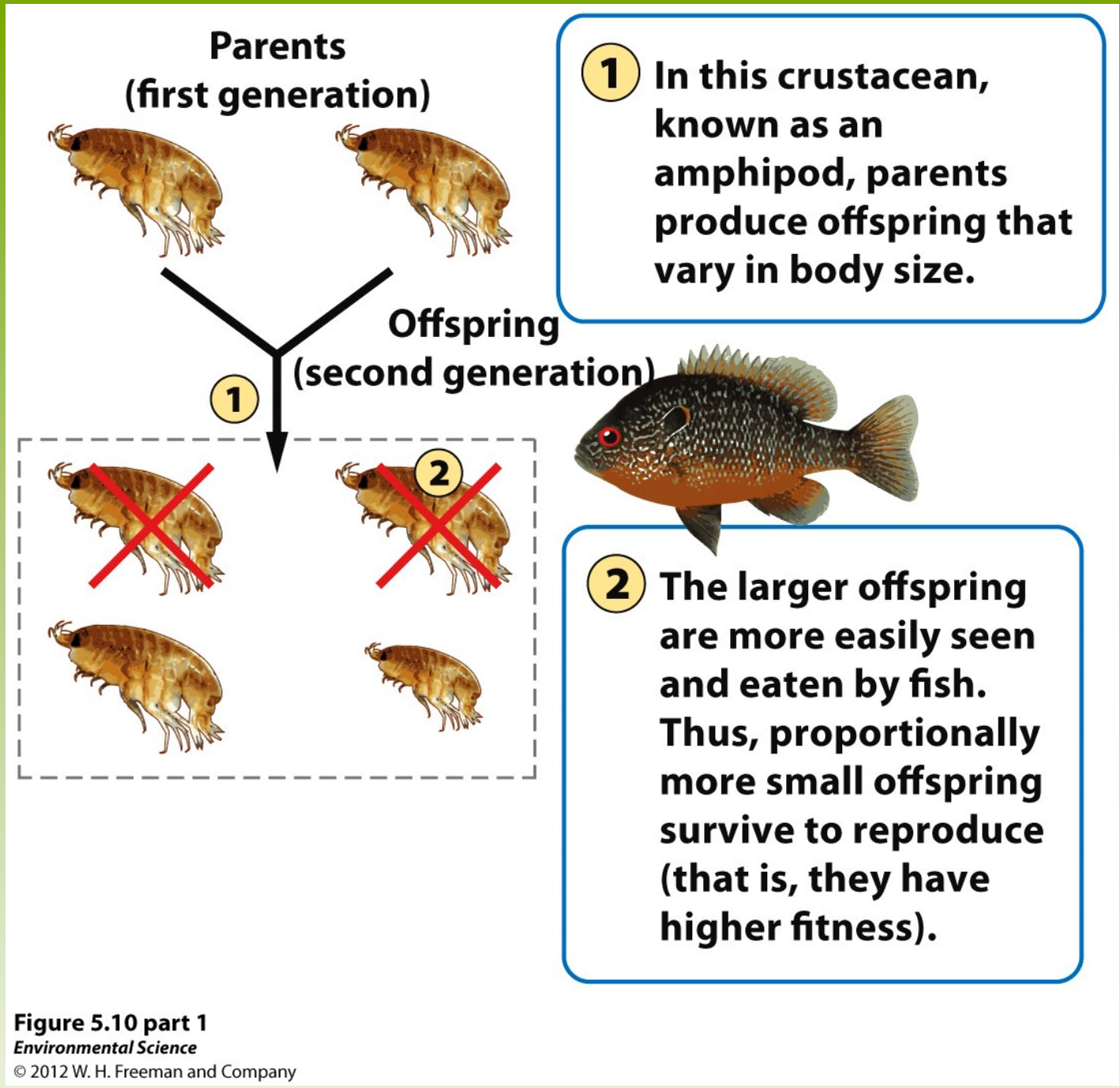


Figure 5.10 part 1
Environmental Science

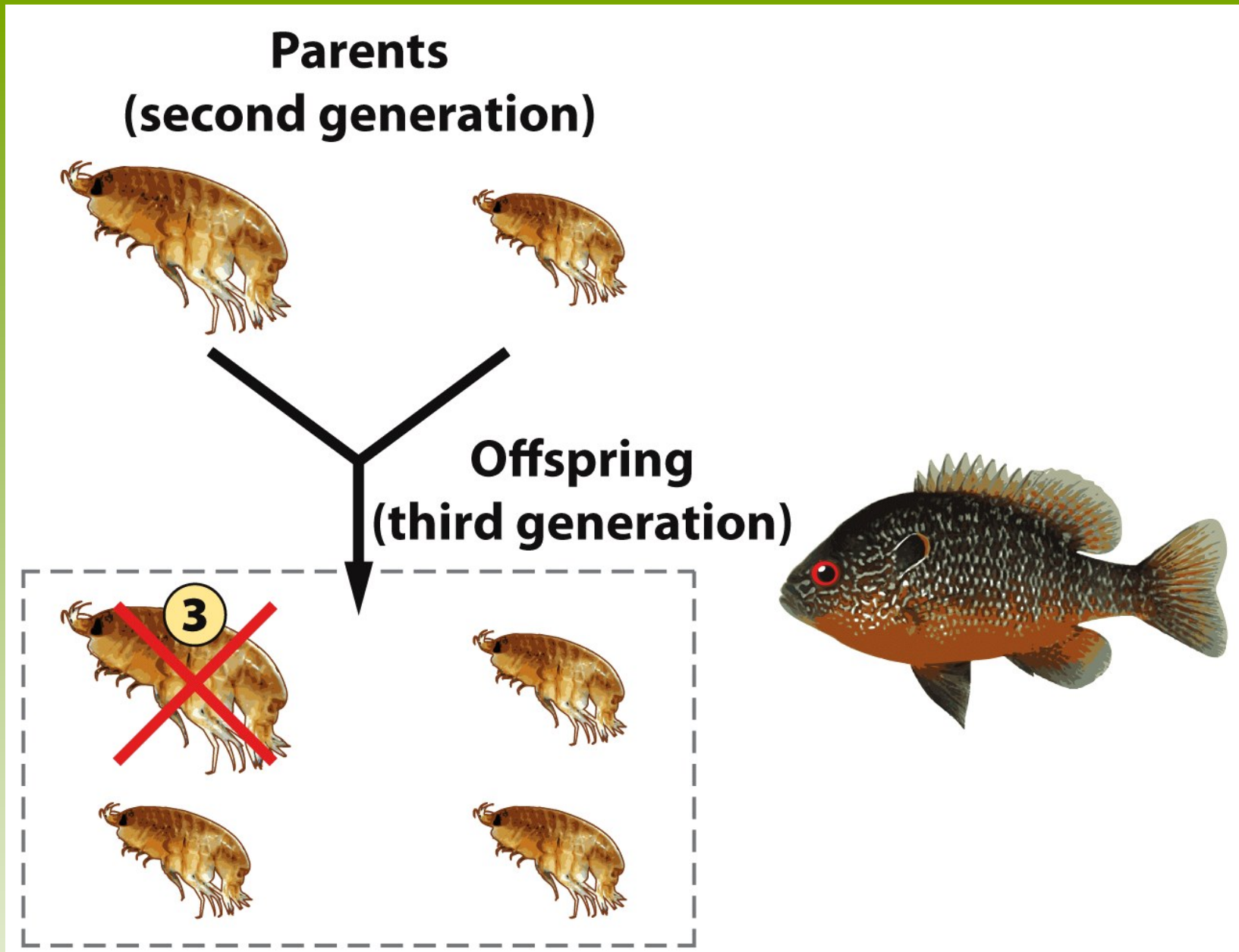
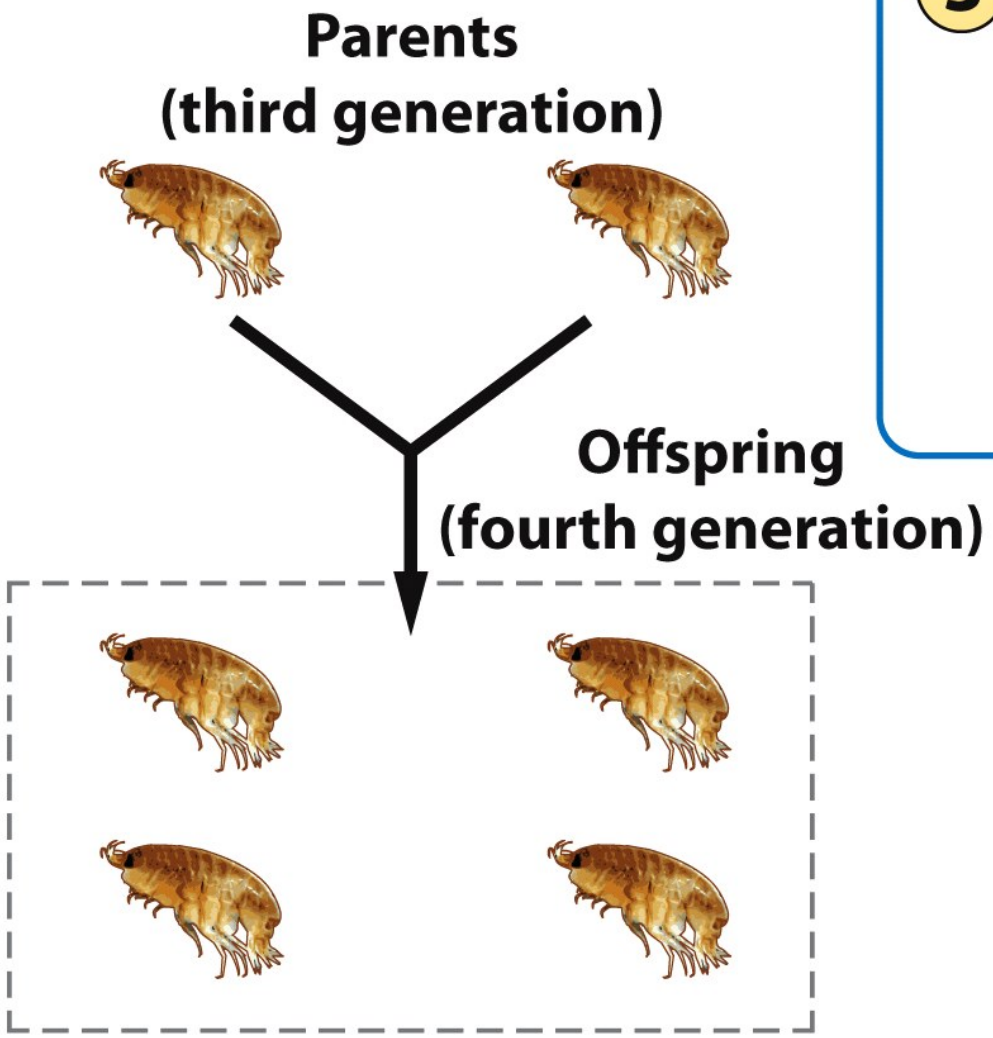


Figure 5.10 part 2
Environmental Science

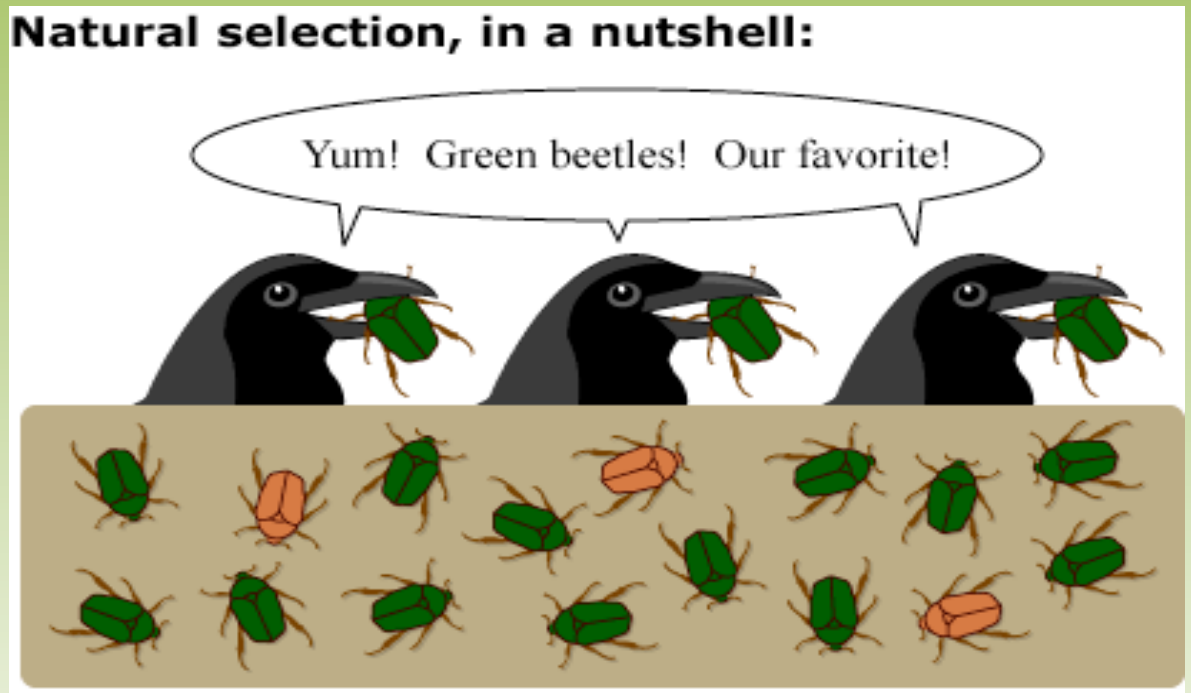


3 If this natural selection continues over many generations, the crustacean population will evolve to contain only small individuals.

Figure 5.10 part 3
Environmental Science

Darwinian "Fitness"

the ability to survive and reproduce…to have one's genes appear in the next generation.



Adaptations

Ex: for life in the desert

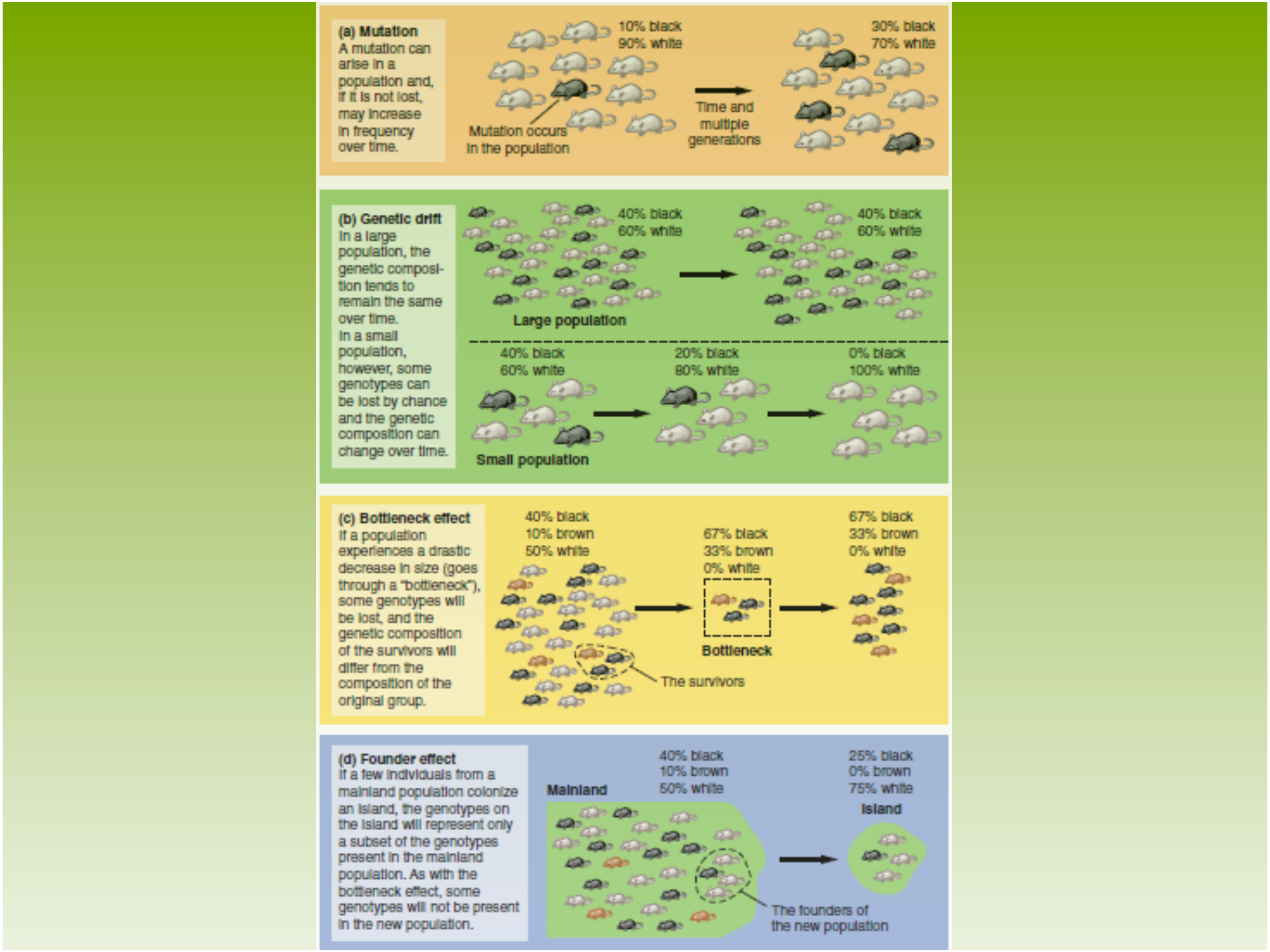
Figure 5.11a
Environmental Science

Figure 5.11b
Environmental Science

Figure 5.11c
Environmental Science

Evolution by Random Processes

- **Mutation**- occur randomly and can add to the genetic variation of a population.
- **Genetic drift**- change in the genetic composition of a population over time as a result of random mating.
- **Bottleneck effect**- a reduction in the genetic diversity of a population caused by a reduction in its size.
- **Founder effect**- a change in a population descended from a small number of colonizing individuals.


(a) Mutation
A mutation can arise in a population and, if it is not lost, may increase in frequency over time.
10% black
90% white
Mutation occurs in the population
Time and multiple generations
30% black
70% white
(b) Genetic drift
In a large population, the genetic composition tends to remain the same over time.
In a small population, however, some genotypes can be lost by chance and the genetic composition can change over time.
40% black
60% white
Large population
40% black
60% white
40% black
60% white
Small population
20% black
80% white
0% black
100% white
(c) Bottleneck effect
If a population experiences a drastic decrease in size (goes through a "bottleneck"), some genotypes will be lost, and the genetic composition of the survivors will differ from the composition of the original group.
40% black
10% brown
50% white
The survivors
67% black
33% brown
0% white
Bottleneck
67% black
33% brown
0% white
(d) Founder effect
If a few individuals from a mainland population colonize an island, the genotypes on the island will represent only a subset of the genotypes present in the mainland population. As with the bottleneck effect, some genotypes will not be present in the new population.
Mainland
40% black
10% brown
50% white
The founders of the new population
25% black
0% brown
75% white
Island

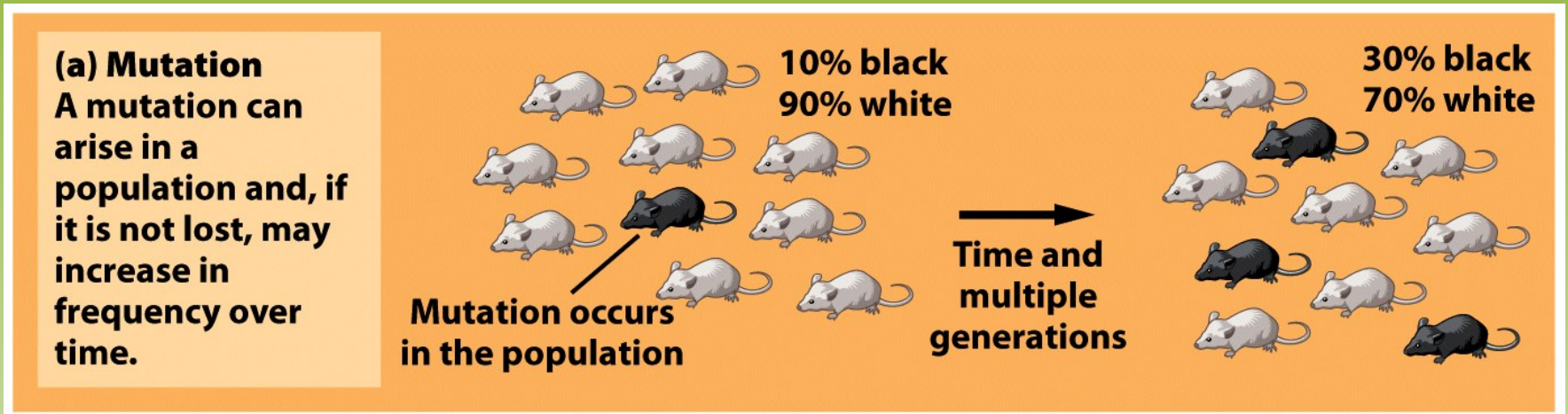


Figure 5.12 part 1
Environmental Science

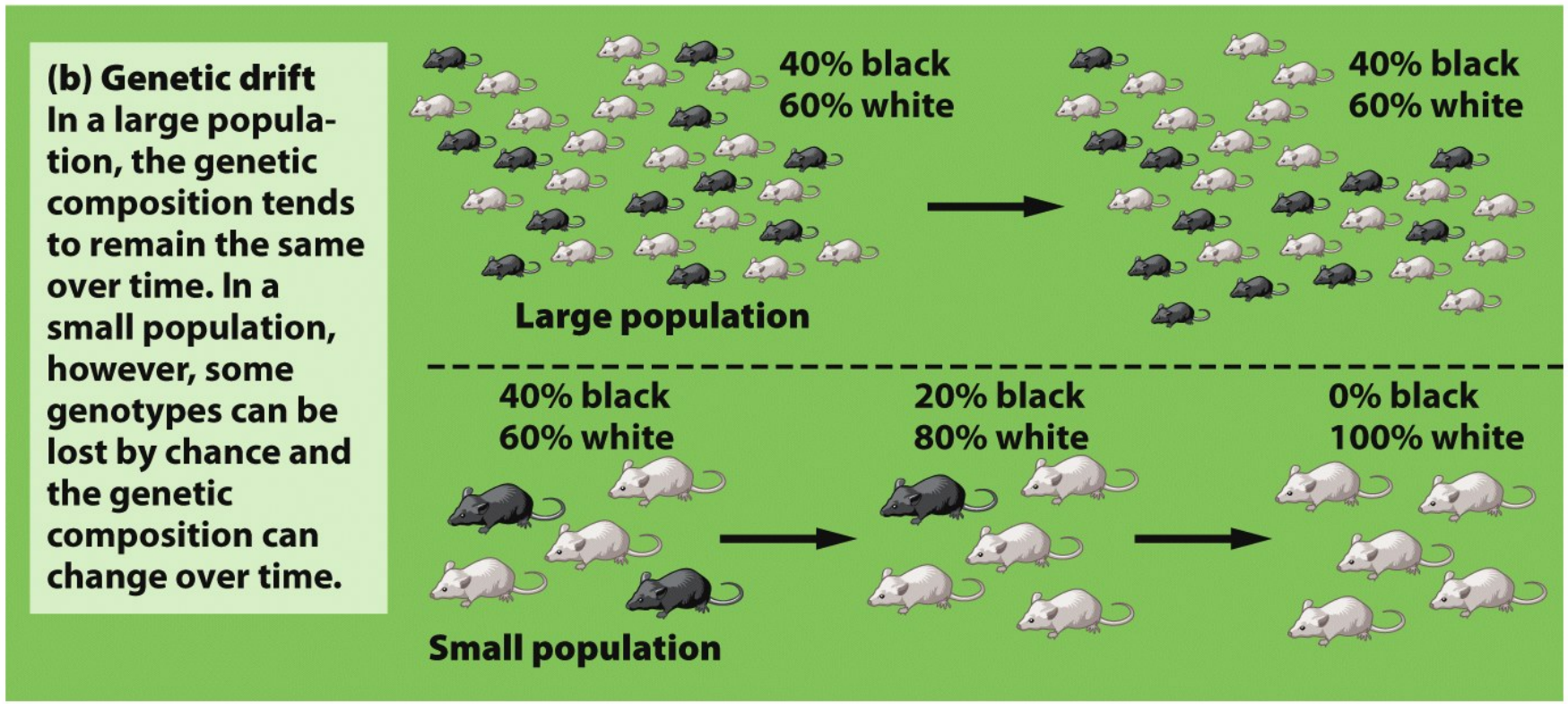


Figure 5.12 part 2
Environmental Science

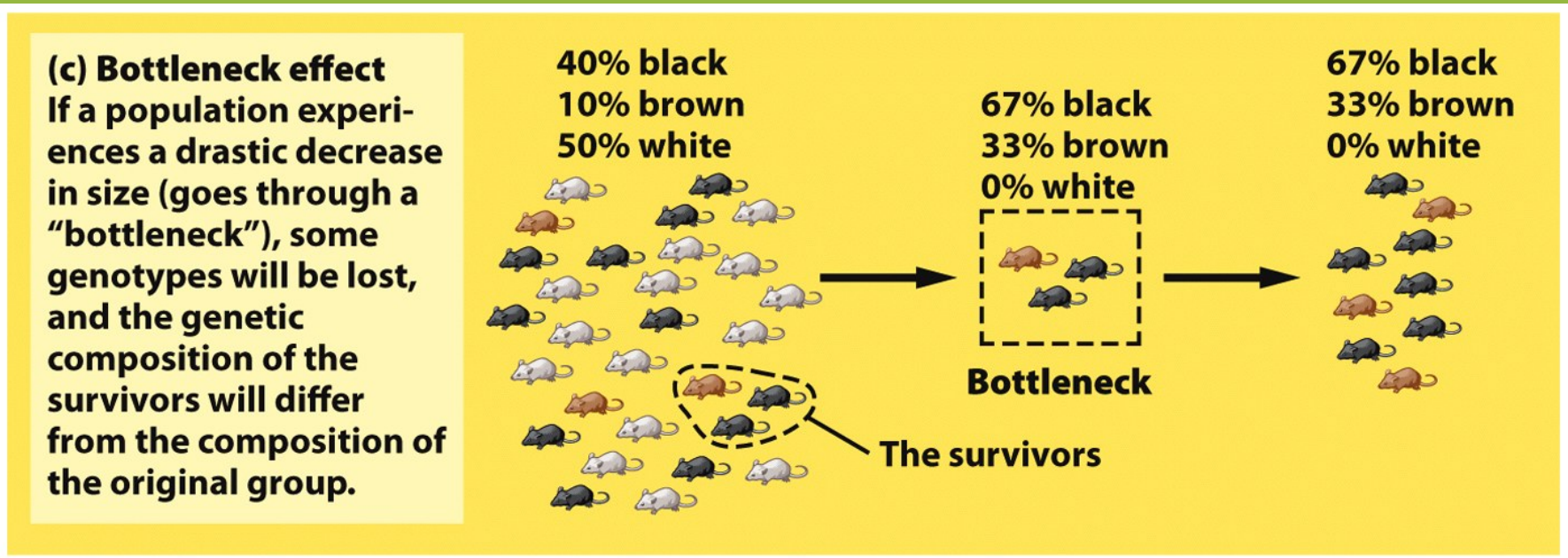


Figure 5.12 part 3
Environmental Science

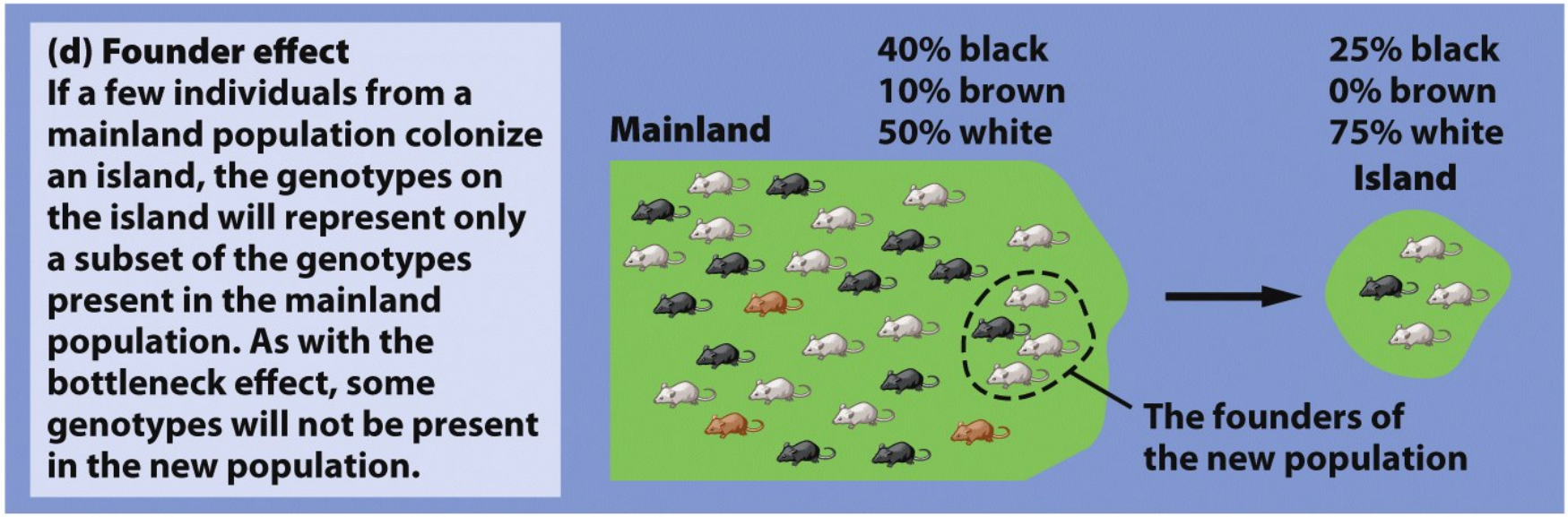


Figure 5.12 part 4
Environmental Science

Speciation and extinction determine biodiversity

- Allopatric speciation- when new species are created by geographic or reproductive isolation.

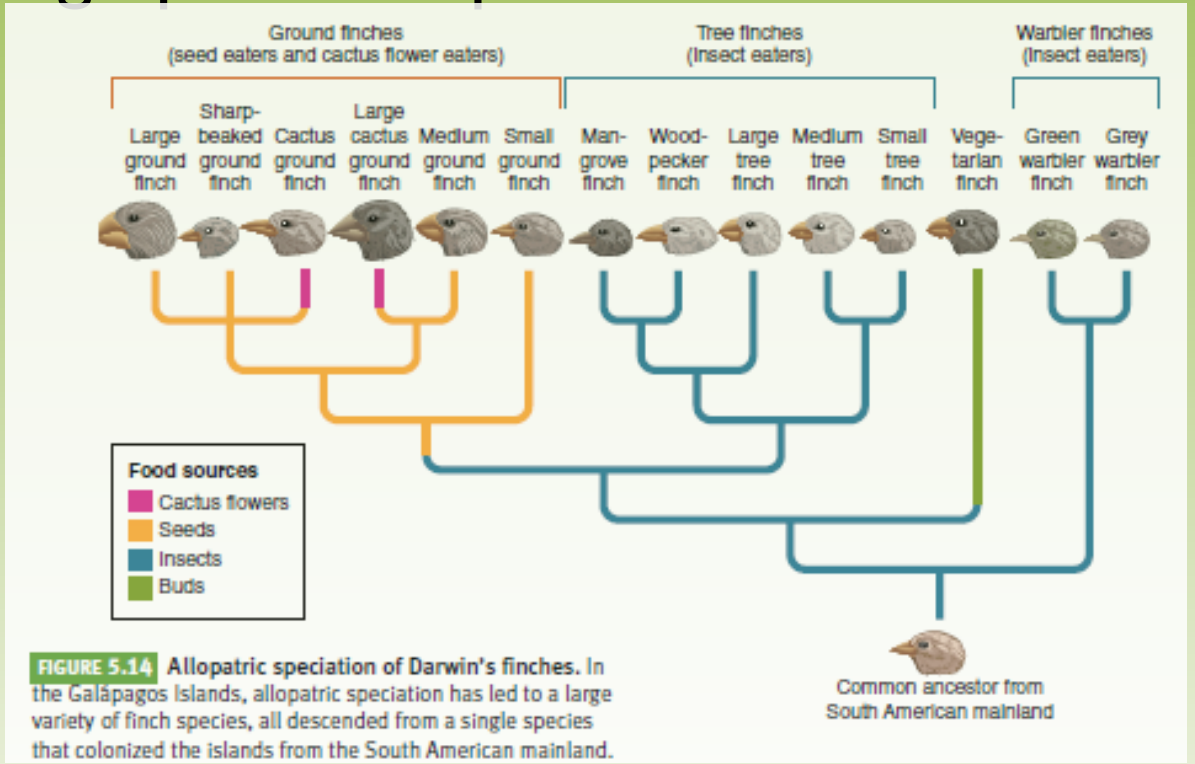


FIGURE 5.14 Allopatric speciation of Darwin's finches. In the Galápagos Islands, allopatric speciation has led to a large variety of finch species, all descended from a single species that colonized the islands from the South American mainland.

Allopatric Speciation

Geographic isolation leads to Reproductive isolation

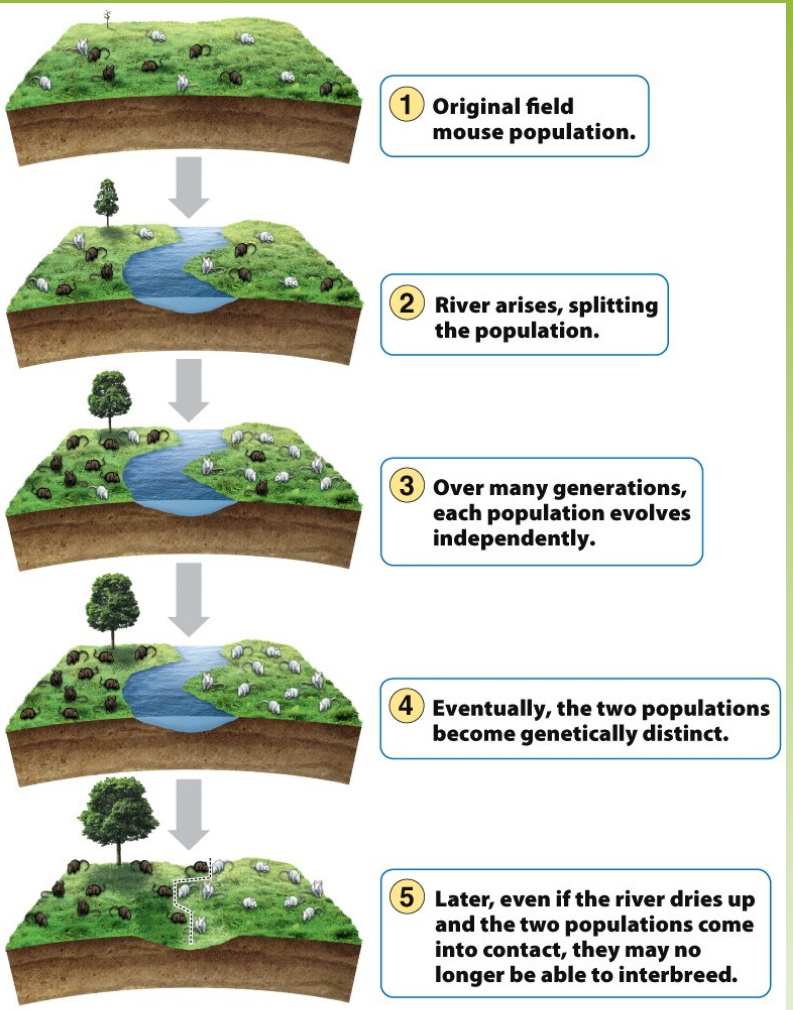
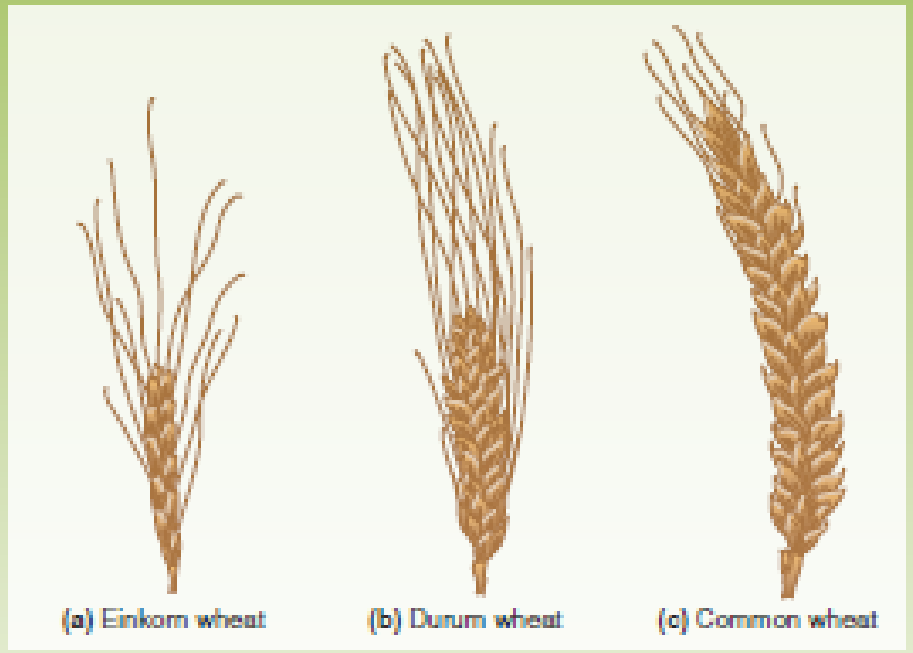


Figure 5.13
Environmental Science

- Sympatric speciation- the evolution of one species into two species in the absence of geographic isolation, usually through the process of polyploidy, an increase in the number of sets of chromosomes.



The pace of evolution

Figure 5.16
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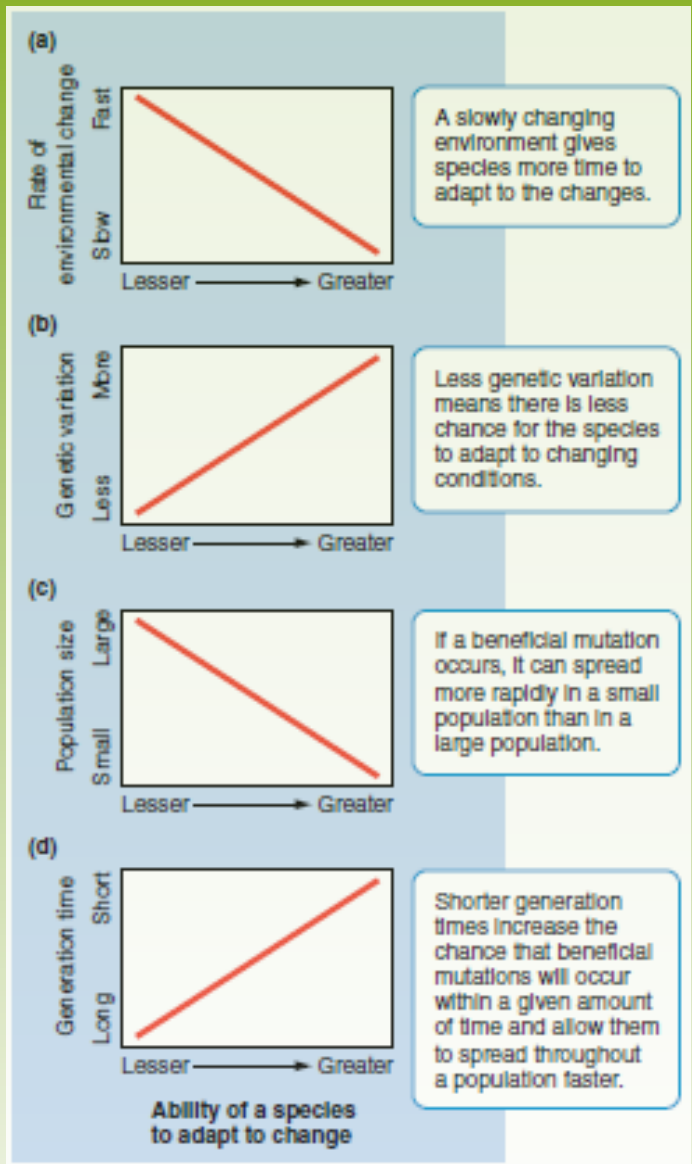


Evolution shapes ecological niches and determines species distributions

- **Range of tolerance**- all species have an optimal environment in which it performs well. The limit to the abiotic conditions they can tolerate is known as the range of tolerance.
- **Fundamental niche**- the ideal conditions for a species.

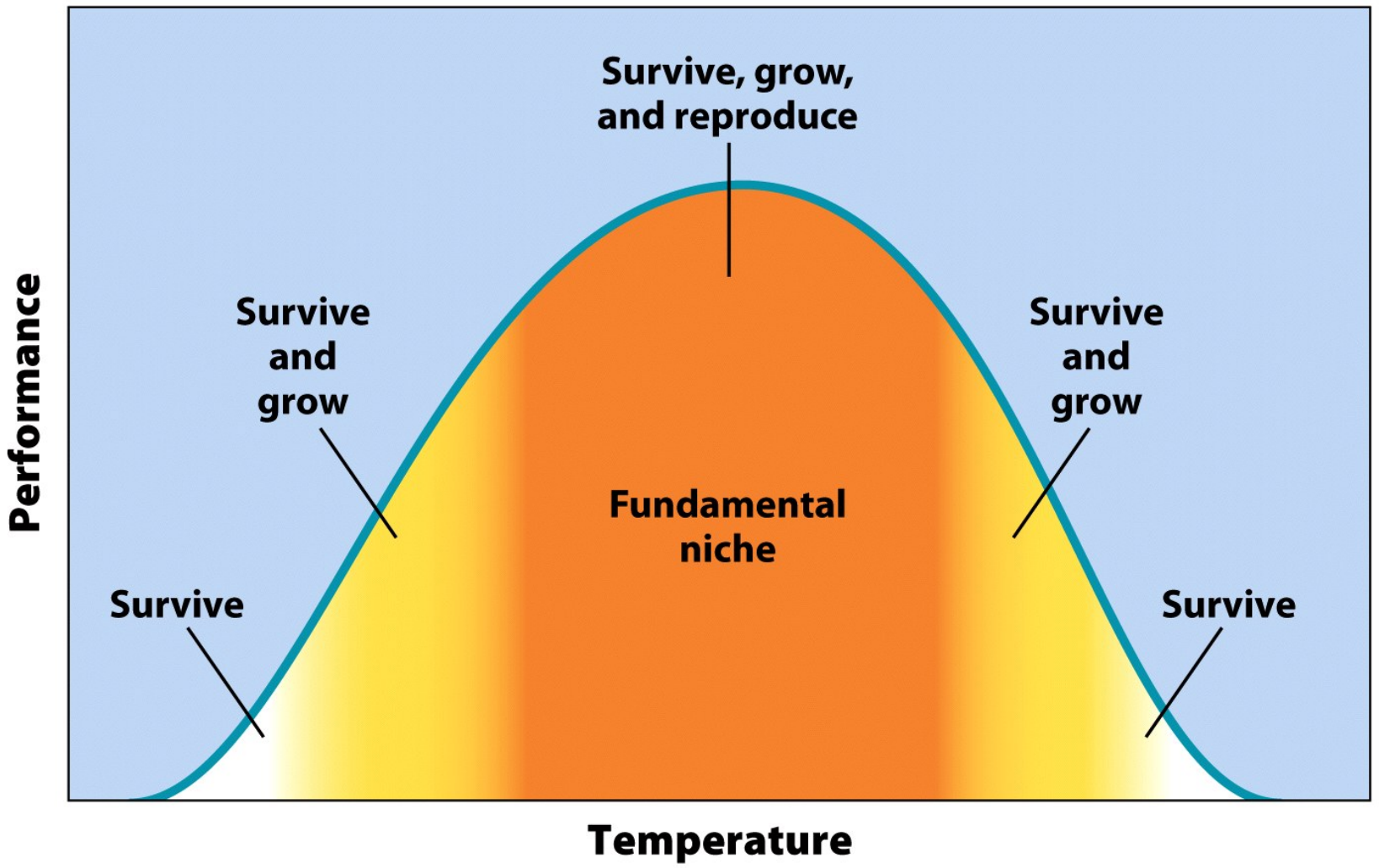


Figure 5.18
Environmental Science

Niches

Realized niche- the range of abiotic and biotic conditions under which a species lives. This determines the species distribution, or areas of the world where it lives.

- **Niche GENERALIST**- species that live under a wide range of conditions…variable diet, tolerant of wide variety of contions.
- **Niche SPECIALIST**- species that live only in specific habitats…specific diet, requires specific conditions.

Generalist

Figure 5.19a
Environmental Science

Specialist

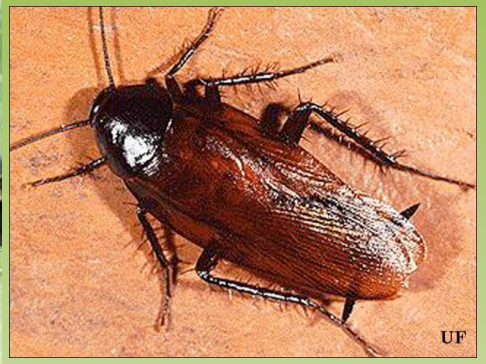
Figure 5.19b
Environmental Science

Spittlebug

Skeletonizing Leaf Beetle

How wide is your niche?

Generalists



Specialists

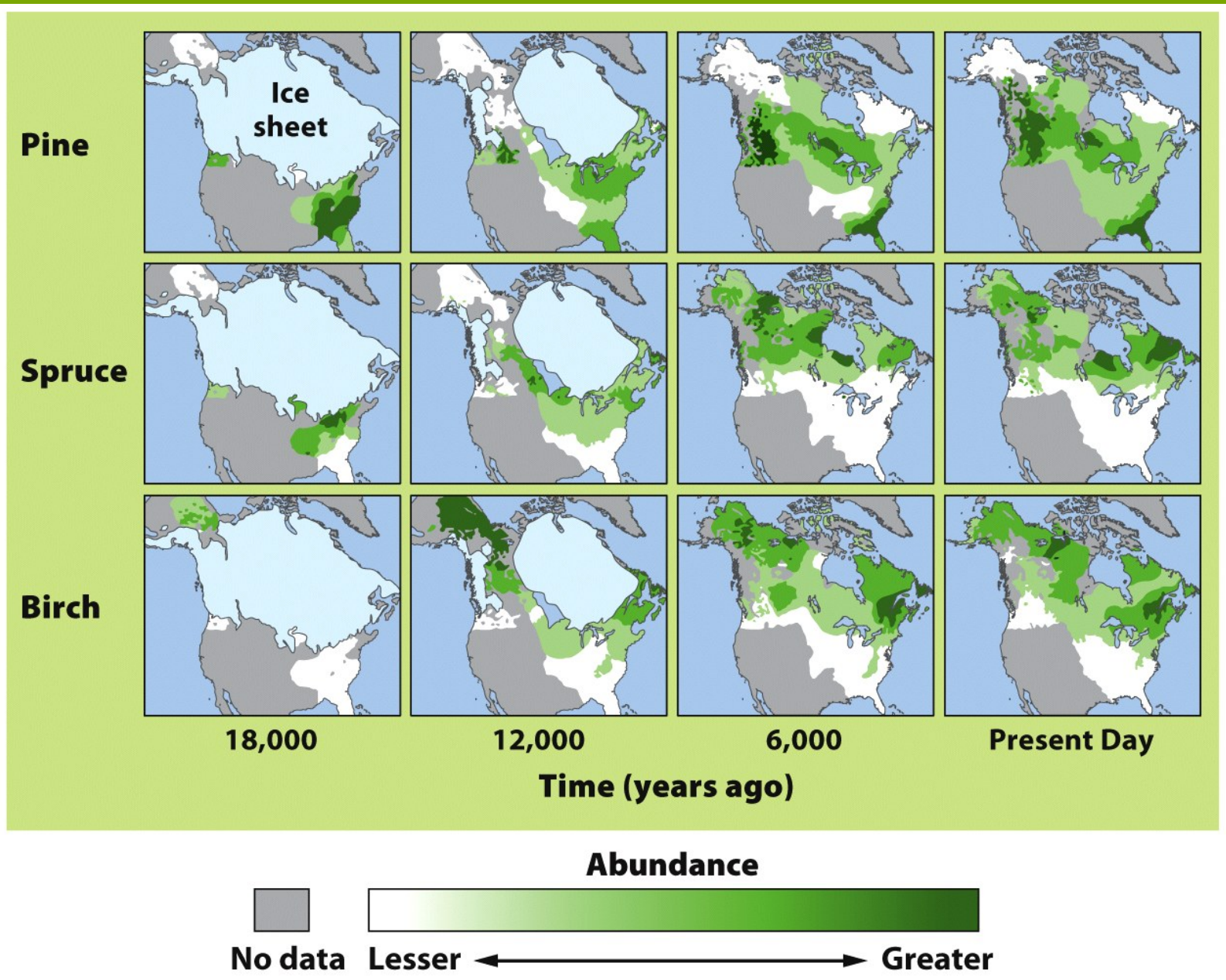


Figure 5.20
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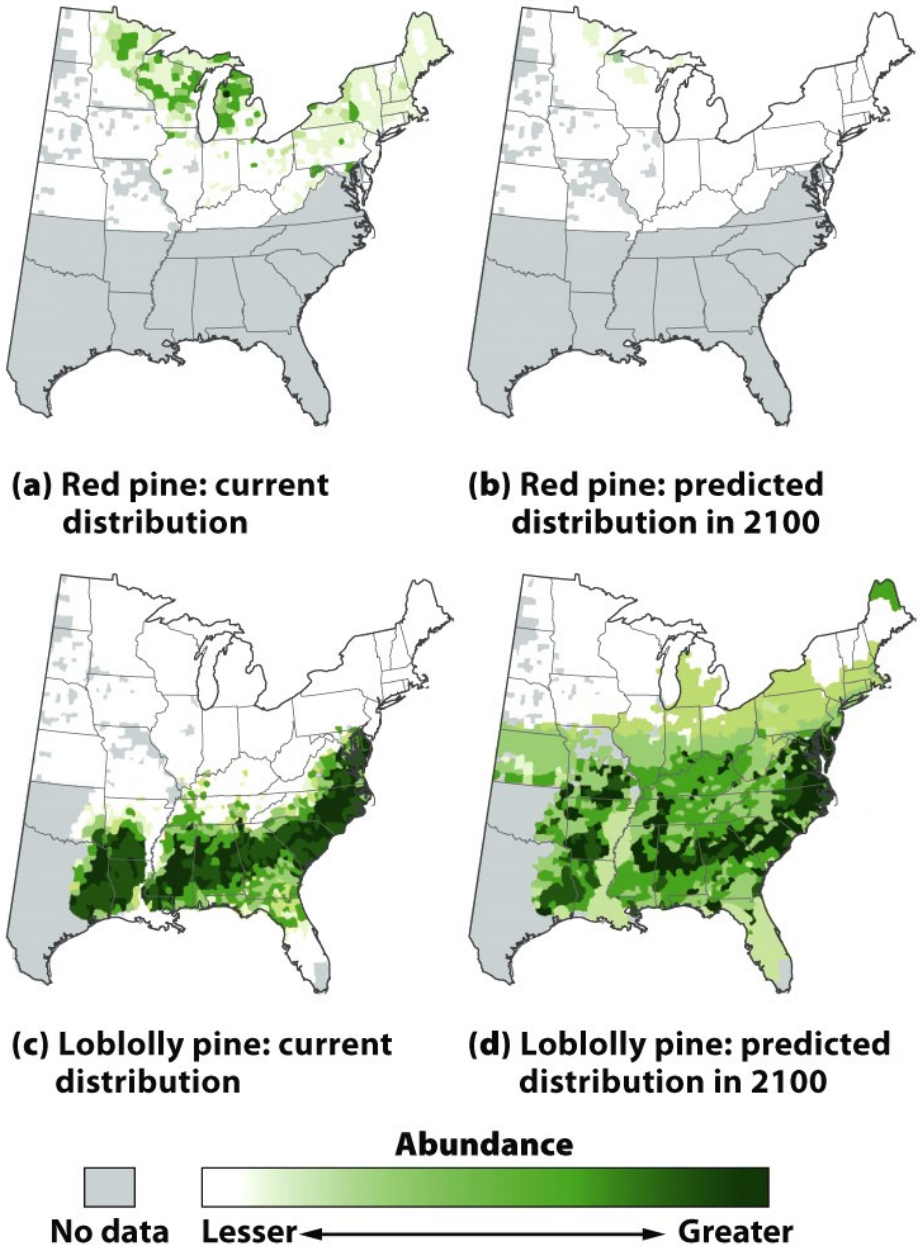


Figure 5.21
Environmental Science

The Fossil Record

- Fossils- remains of organisms that have been preserved in rock. Much of what we know about evolution comes from the fossil record.

Figure 5.22
Environmental Science

The Five Global Mass Extinctions

- Mass extinction- when large numbers of species went extinct over a relatively short period of time.

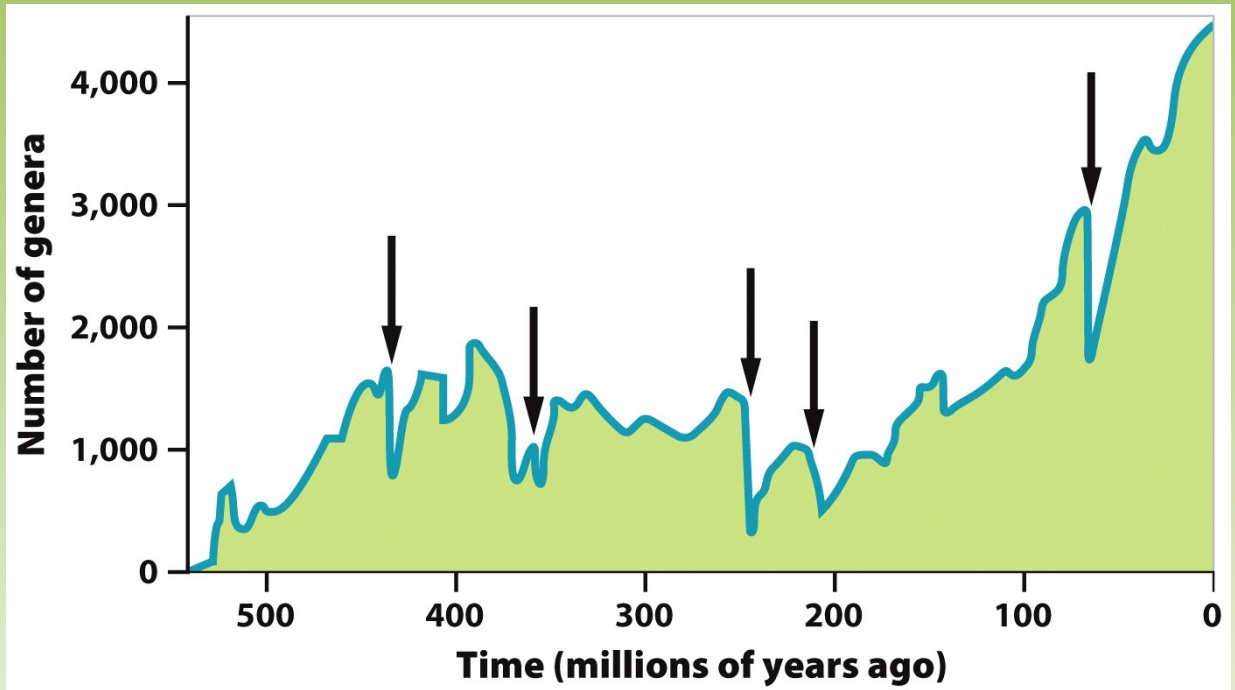


Figure 5.23
Environmental Science

The Sixth Mass Extinction

- Scientists feel that we are in our sixth mass extinction, occurring in the last two decades.
- Estimates of extinction rates vary widely, from 2 % to 25% by 2020.
- In contrast to previous mass extinctions, scientists agree that this one is caused by humans.

Let's Take a Random Walk
(a.k.a. Gambler's Ruin)

You'll need:

Graph paper and pencil

Y axis = Number of species

X axis = Years (x 100,000)

Betting card marked EVEN and ODD

Object (fossil?) for placing your bet

Cats Clade

Felis catus

F. chaus

F. silvestris

F. margarita

F. domesticus

F. concolor

F. leo

F. tigris

F. nigripes

F. pantera

Dogs Clade

Canis familiaris

C. lupus

C. latrans

C. mesomelas

C. simensis

C. adustus

C. aureus

C. rufus

C. indica

C. himalayensis

Maples Clade

Acer rubrum

Acer saccharinum

Acer saccharum

Acer floridanum

Acer japanicum

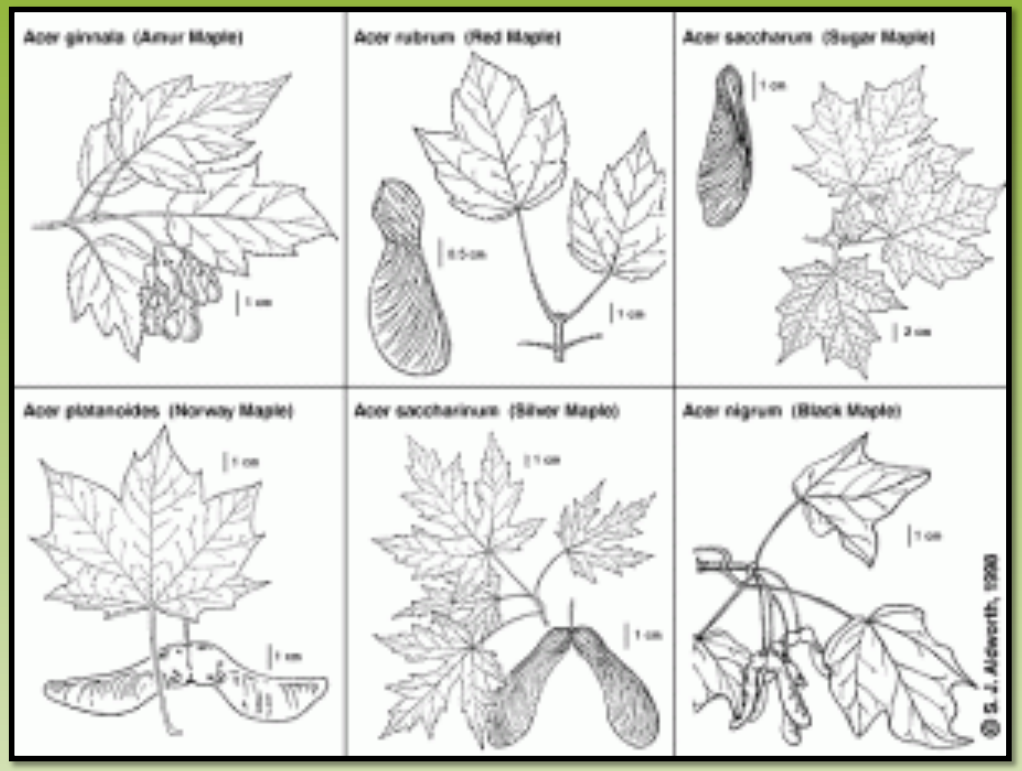
Acer nigrum

Acer palmatum

Acer spicatum

Acer triflorum

Acer wardii



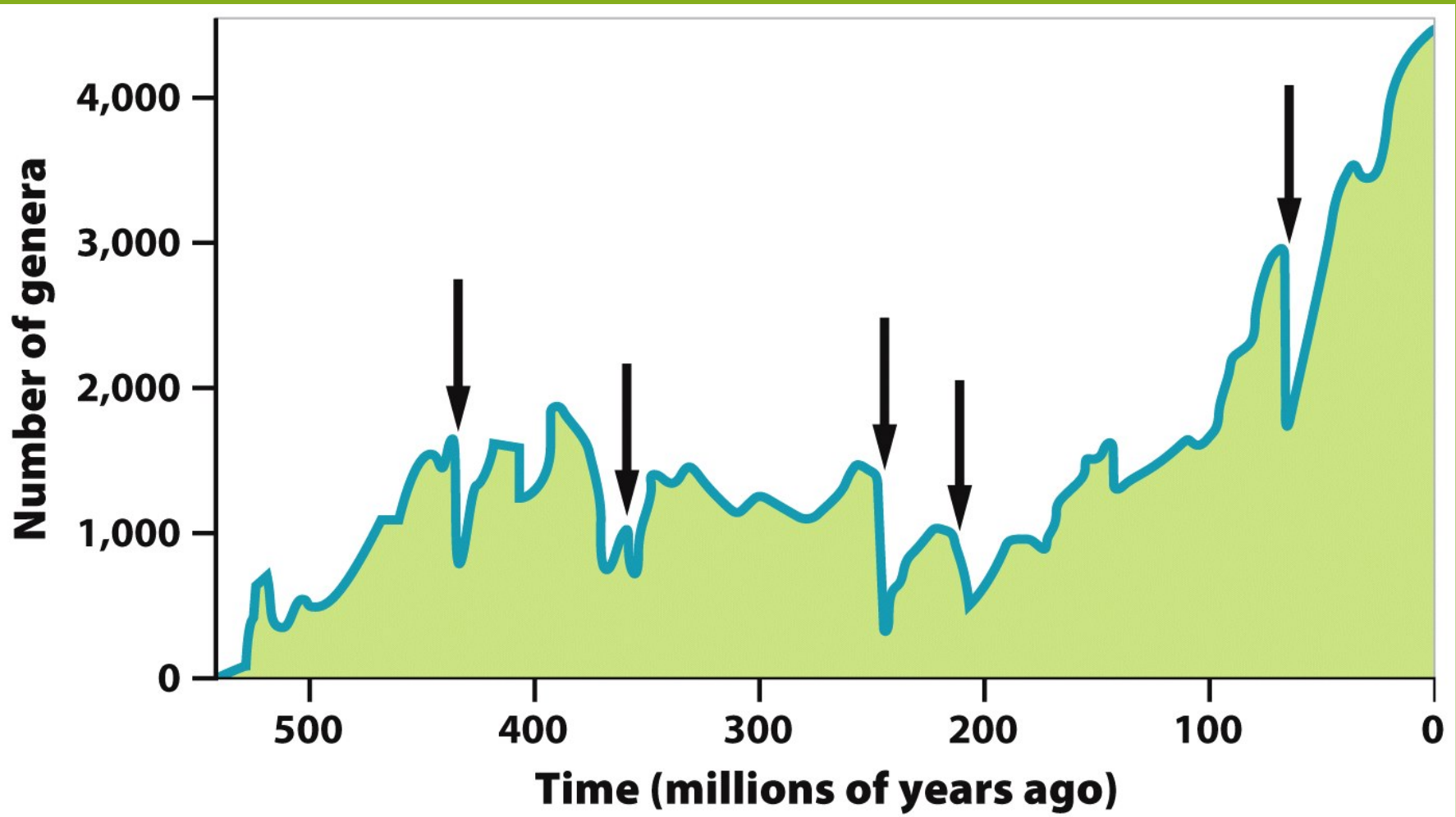


Figure 5.23
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Extinct!

Ordovician Brachiopods

Cause

unknown

Extinct!

Devonian Fish

Dunkleosteus

Cause

unknown

Extinct!

Triassic Period

Ammonites

Cause

unknown

Extinct!

Permian Period

Trilobites

Cause

unknown

Extinct!

Cretaceous Period

Dinosaurs

Asteroid

Impact?

Extinct!
The Dodo Bird of Mauritius

One of the early casualties of the 6th Mass Extinction…

Human actions

Introduced animals

Habitat loss

Lack of defense mechanisms

Recent Extinction!

Endangered Animals

Figure 5.24
Environmental Science

Forest A

Forest B

Unnumbered 5 p142

Environmental Science