Chapter 5
Evolution of Biodiversity

Earth is home to a tremendous diversity of species

- **Ecosystem diversity-** the variety of ecosystems within a given region.
- **Species diversity-** the variety of species in a given ecosystem.
- **Genetic diversity-** the variety of genes within a given species.

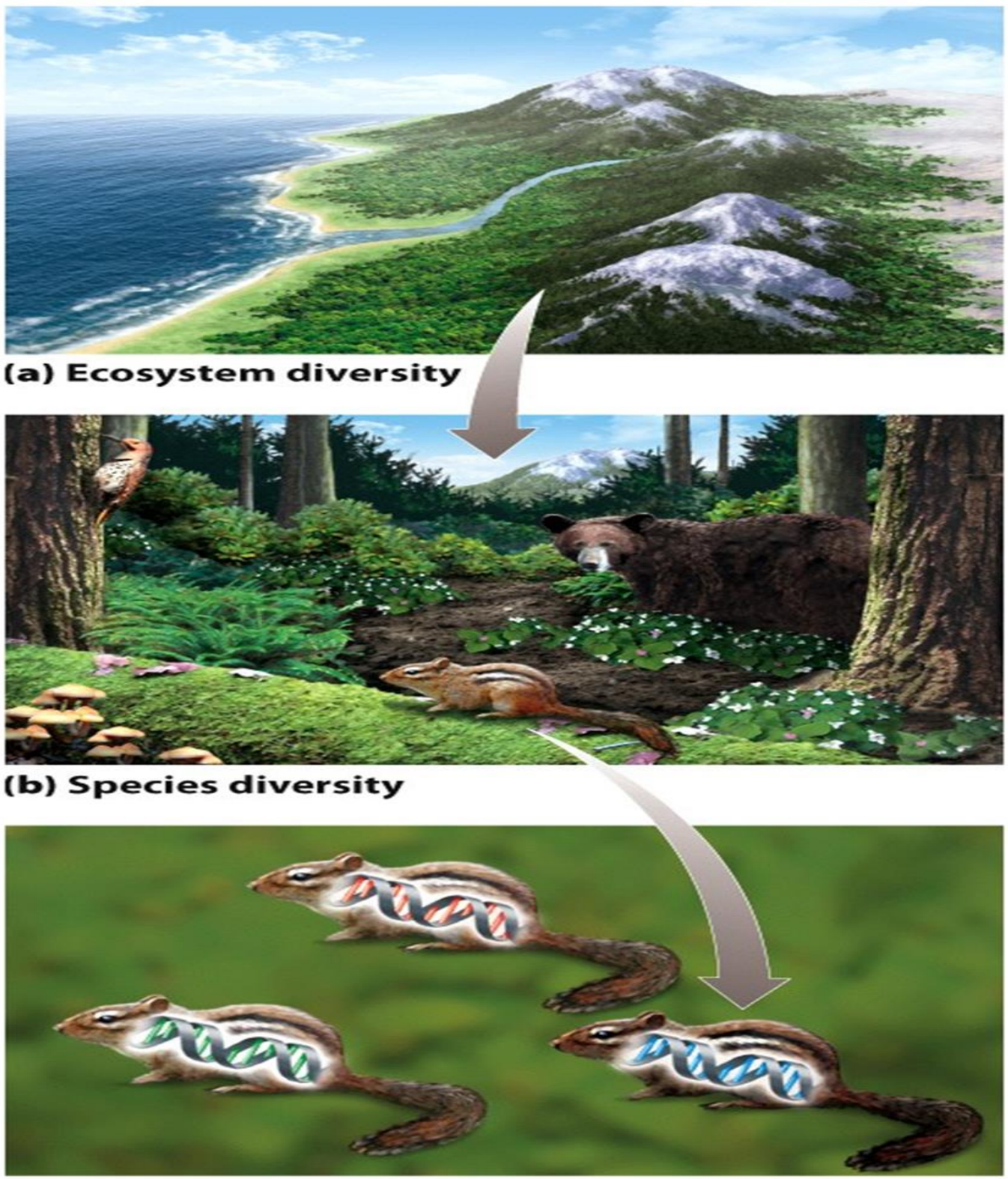

Figure 5.2
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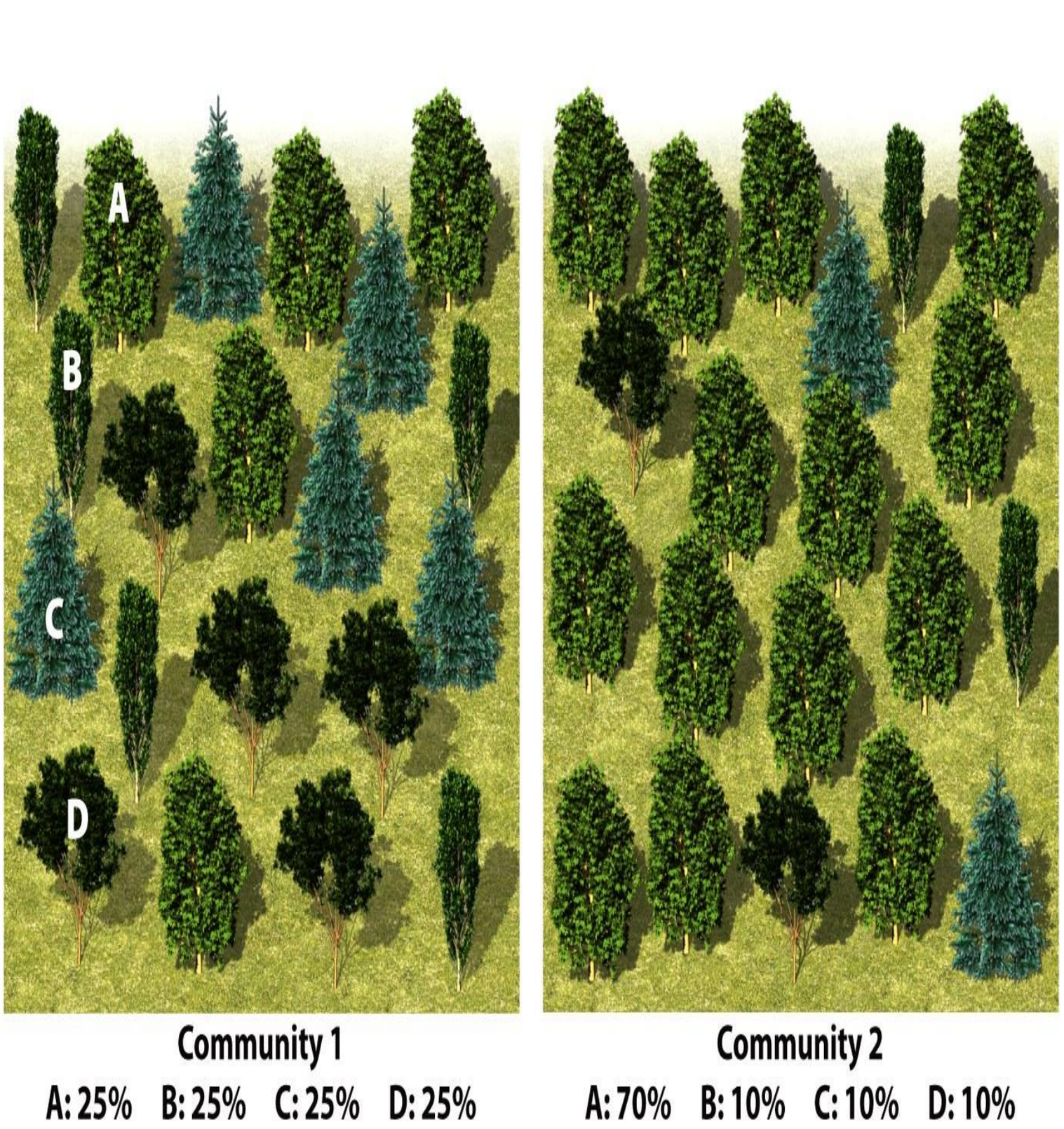
- **Species** – a group of organisms that is distinct from other such groups in terms of size, shape, behavior, or biochemical properties, and that can interbreed with other individuals in the same species to have viable offspring.

(Natural selection – survival of the fittest)

- Sometimes individuals from different species can mate, but will not produce offspring that will survive.

- The number of species in any given place is the most common measure of biodiversity.

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



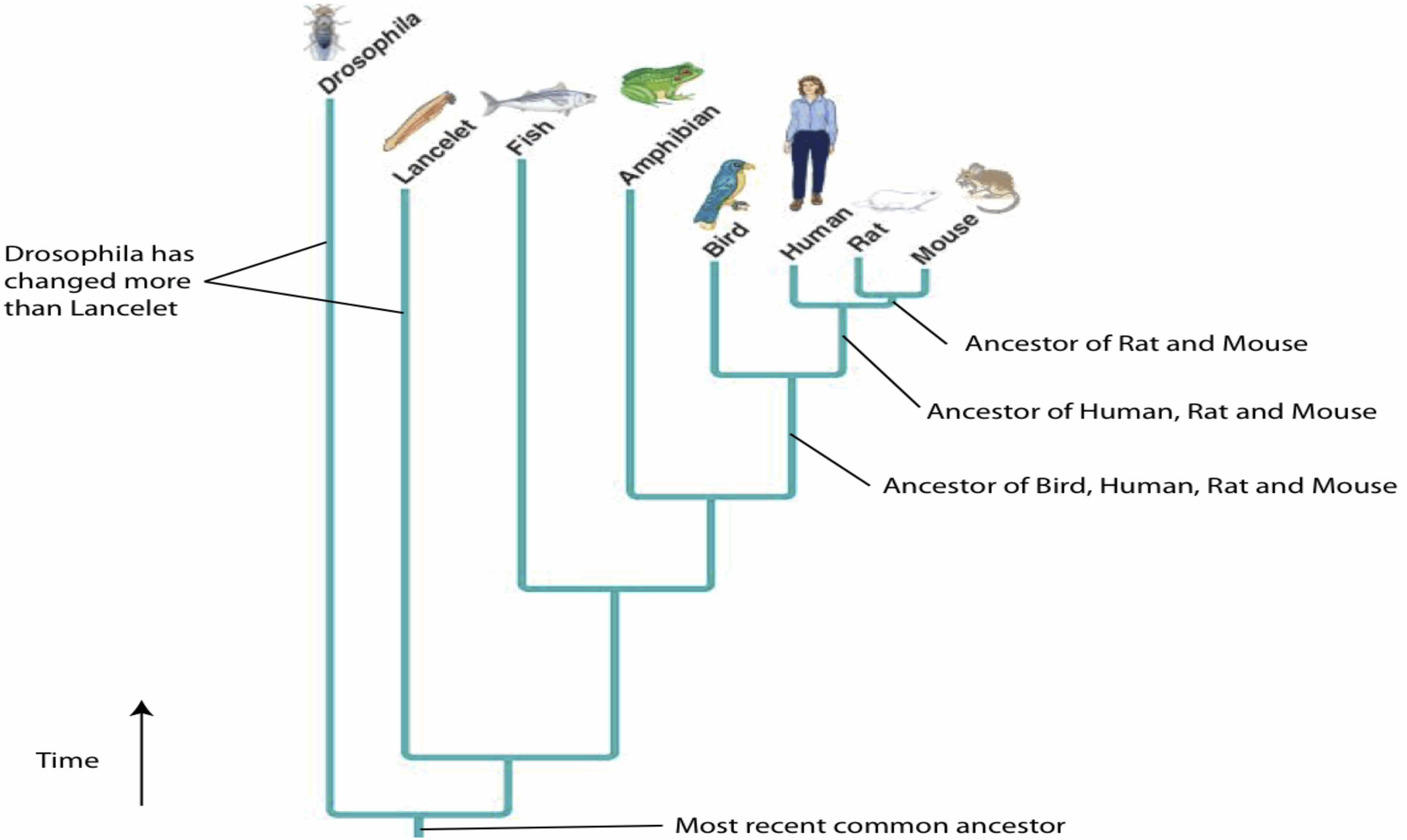
Knowing species richness & evenness, gives scientist a **baseline** of how much an ecosystem has changed over time due to *typically* human disturbances.

Evolution is the mechanism underlying biodiversity

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

Phylogenies – branching patterns of evolutionary relationships (phylogenetic tree)

Scientists base phylogenies on morphology (structure), behavior, and genetic similarity



Creating Genetic Diversity

- **Genes**- physical locations on chromosomes within each cell of an organism.
- **Genotype**- the complete set of genes in an individual (blueprint)
- **Phenotype**- the actual set of traits expressed in an individual.

Two processes that create genetic diversity…

1. Mutation- a random change in the genetic code (if not lethal, can add the genetic variation to population).

~Random or environmental (lifestyle) factors

~Good vs. Bad… in the wild, individuals have a poor chance in survival (ex. stand out more due to predators)

2. Recombination – chromosomes are duplicated during meiosis and piece of the chromosomes breaks off and attaches to another chromosome producing new combinations of the genes (no new genes) produce new traits.

~allow new gene combinations to come together, providing new immune defenses or resistances.

Evolution occurs by artificial and natural selection and random processes

- **Evolution by artificial selection-** when humans determine which individuals breed (we choose our mates – selective breeding).
  - Use of chemical agents such as herbicide…as we cover large areas of land with this chemical to kill the weeds, the chances of one weed possessing a mutation resisting that application…weed resistant….trait passed on. (same idea with use of antibiotics & antibacterial cleaners caused artificial selection of harmful drug-resistant bacteria)

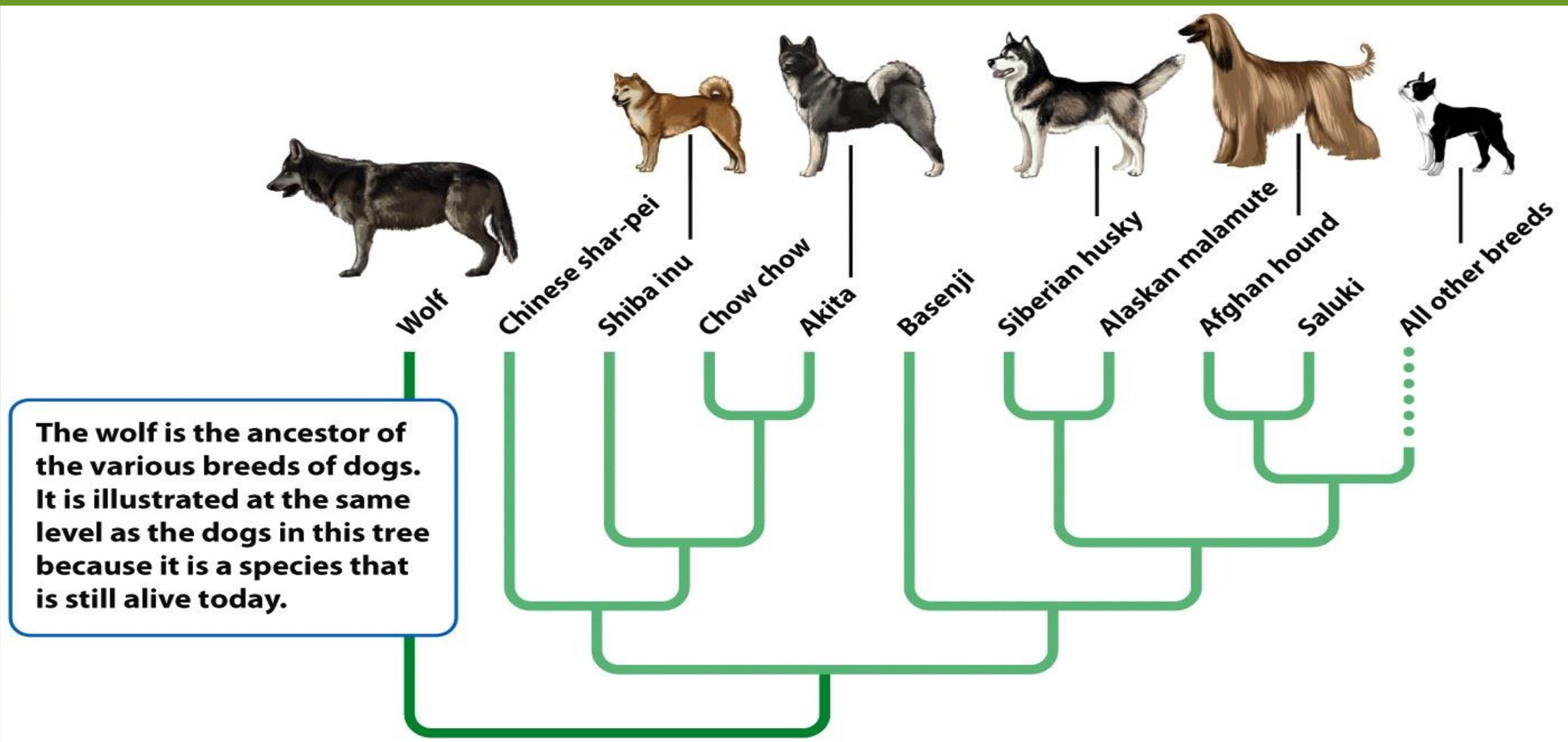


Figure 5.8
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Artificial Selection of Dog Breeding

- **Evolution by natural selection**- the environment determines which individuals are most likely to survive and reproduce.
- Traits or certain combination of traits an individual possess will determine the survival in the environment (*survival of the fittest* – be able to pass on your genetic code….offspring)
- **Fitness** – ability to survive and reproduce
- **Adaptions** – traits that improve an individual's fitness.

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.

Only those offspring having the fittest genotype will pass on their genes to the next generation.

ex. Prey vs. Predator

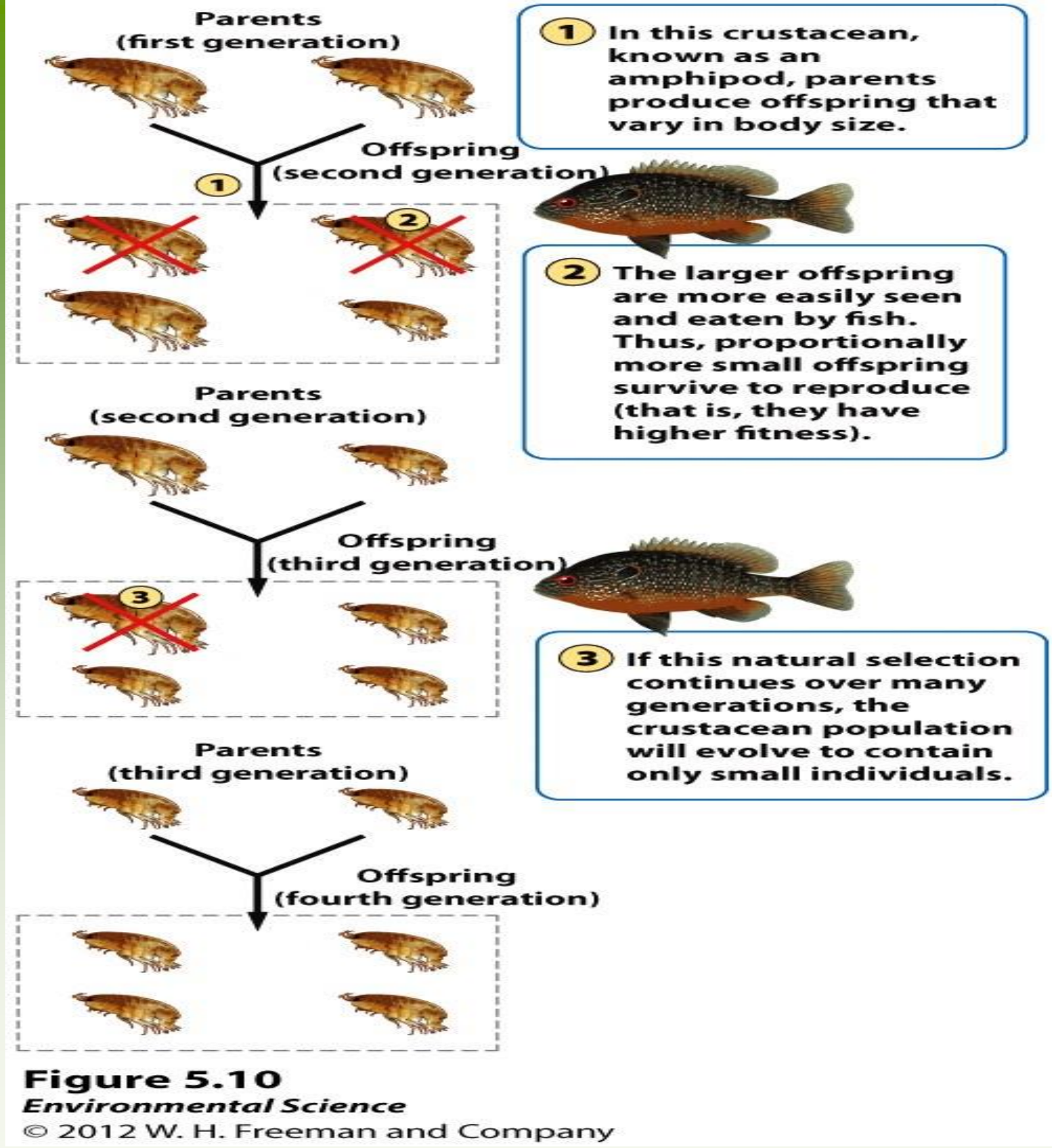

Figure 5.10
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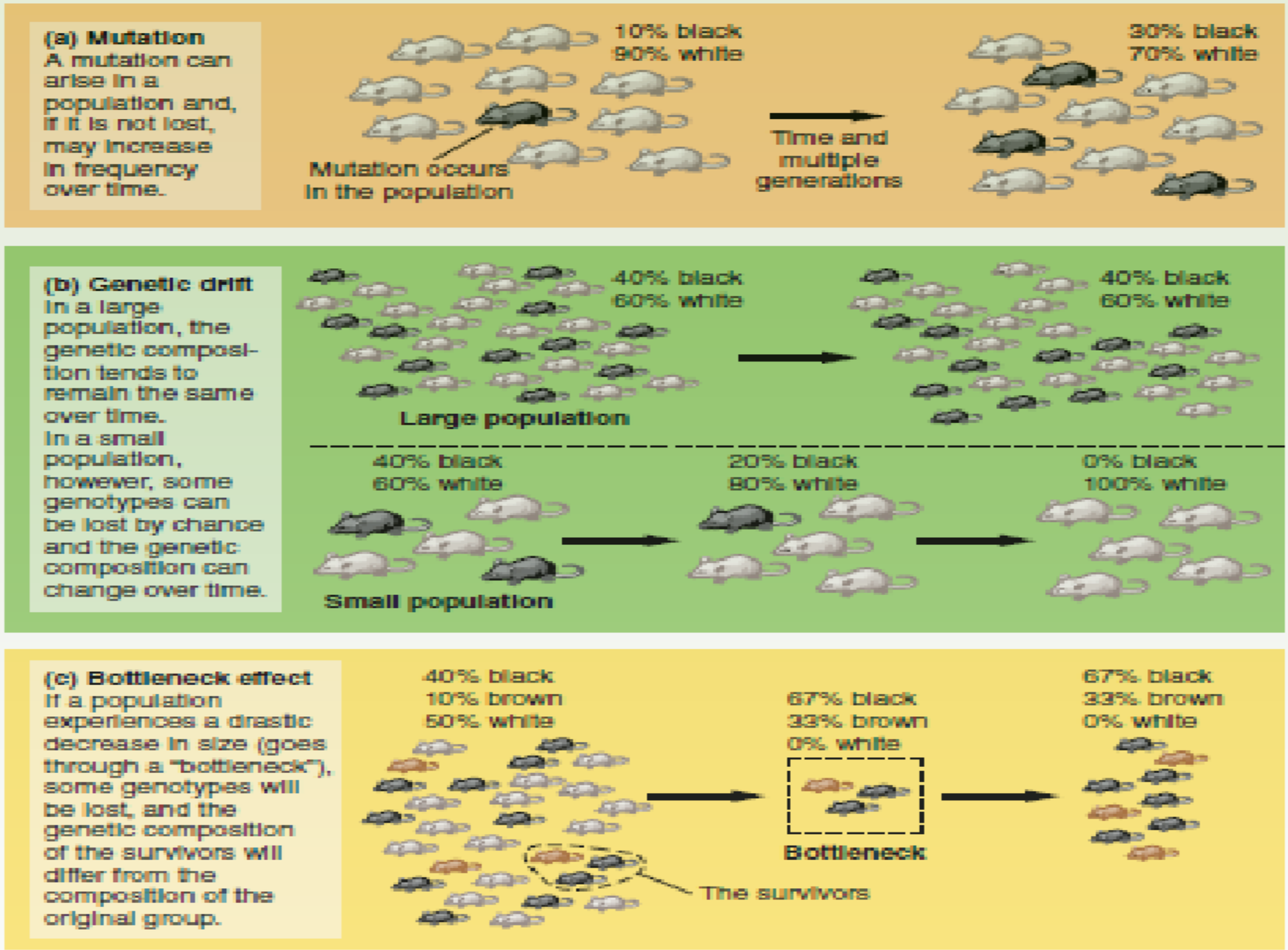
Evolution by Random Processes

- **Mutations**
- **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. *Habitat loss, natural disaster, hunting, or changes in the environment* …resulting low genetic diversity cause it to decline to extinction.
- **Founder effect-** a change in a population descended from a small number of colonizing individuals (new location to colonize).

Theory of Island Biogeography states that a larger island will have a greater number of species than a smaller island.



Speciation and extinction determine biodiversity

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

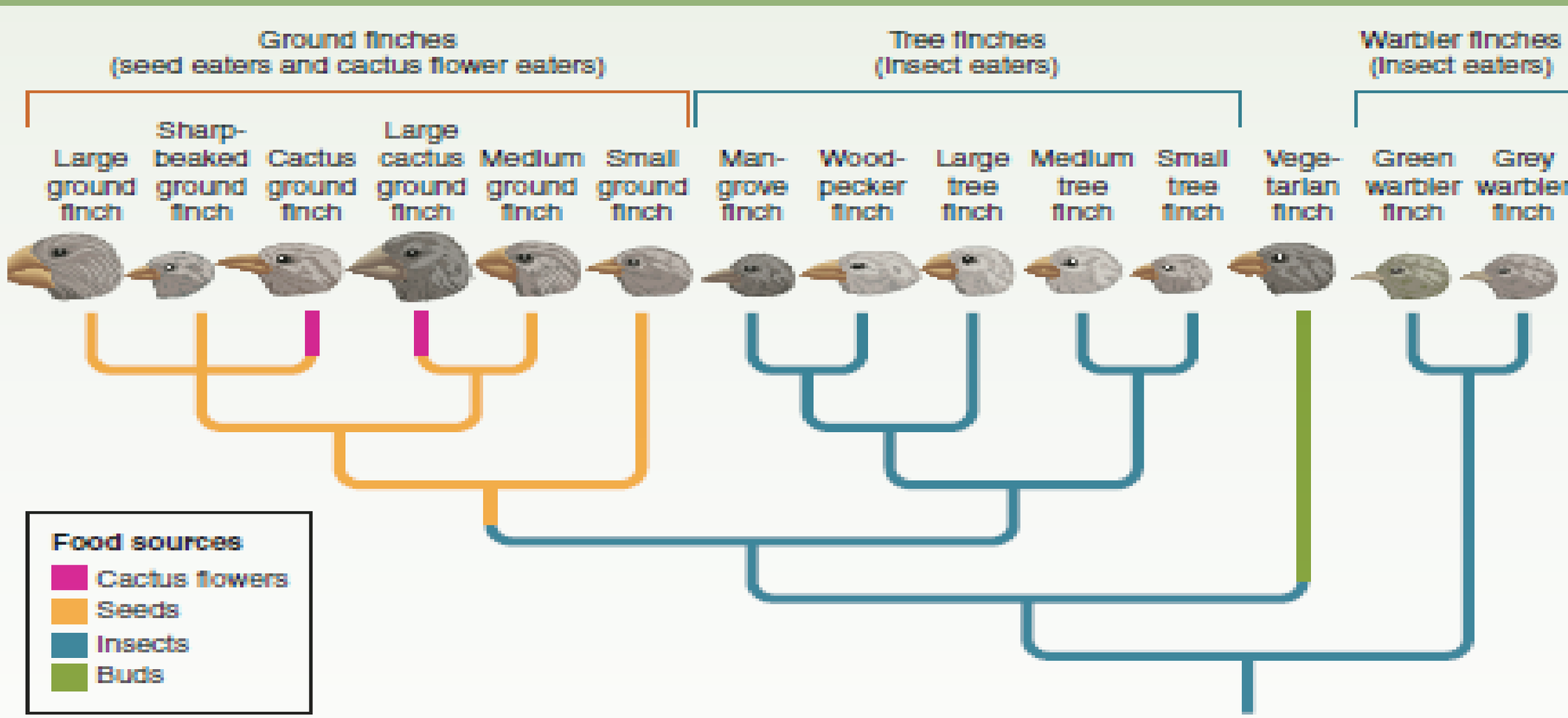


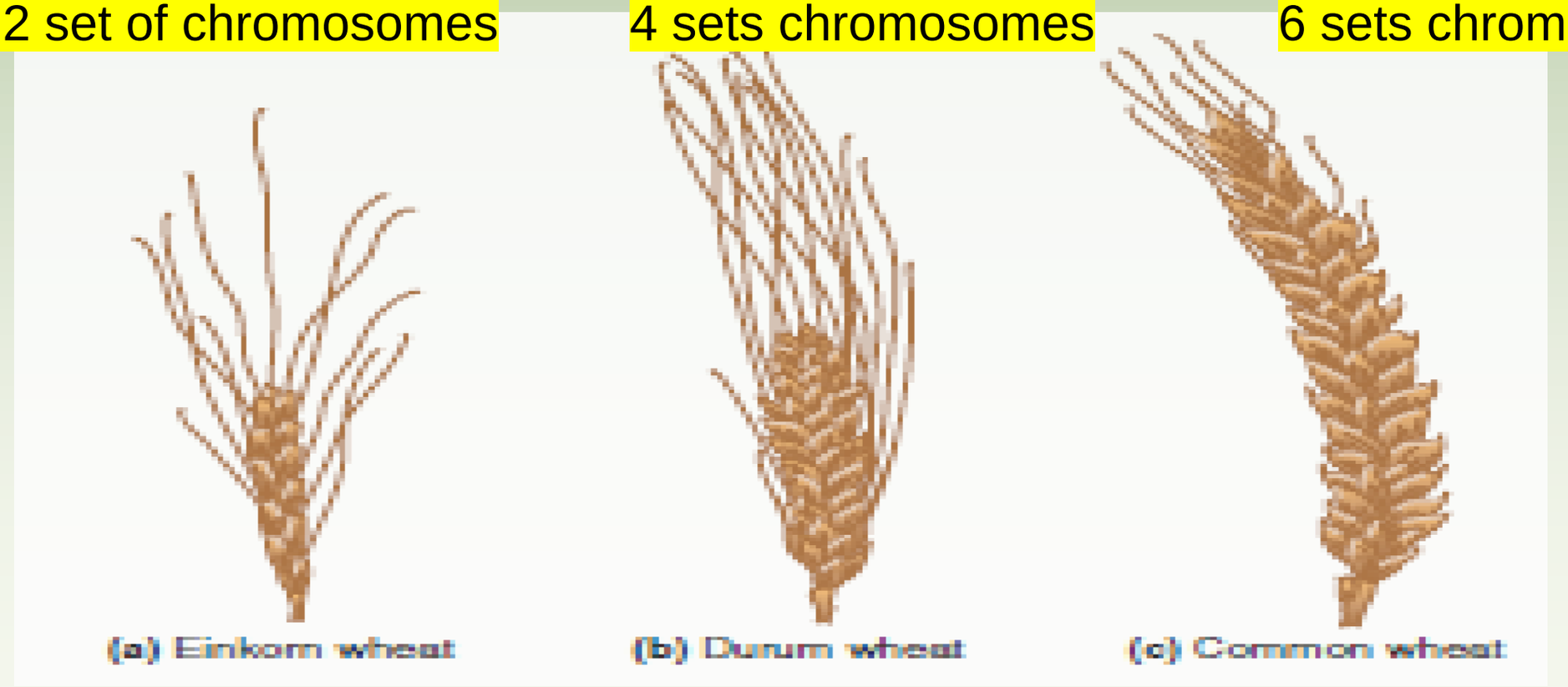
FIGURE 5.14 **Allopatric speciation of Darwin's finches.** In the Galápagos Islands, allopatric speciation has led to a large variety of finch species, all descended from a single species that colonized the islands from the South American mainland.

- **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*.

Ancestor- 2 set of chromosomes

4 sets chromosomes

6 sets chromosomes



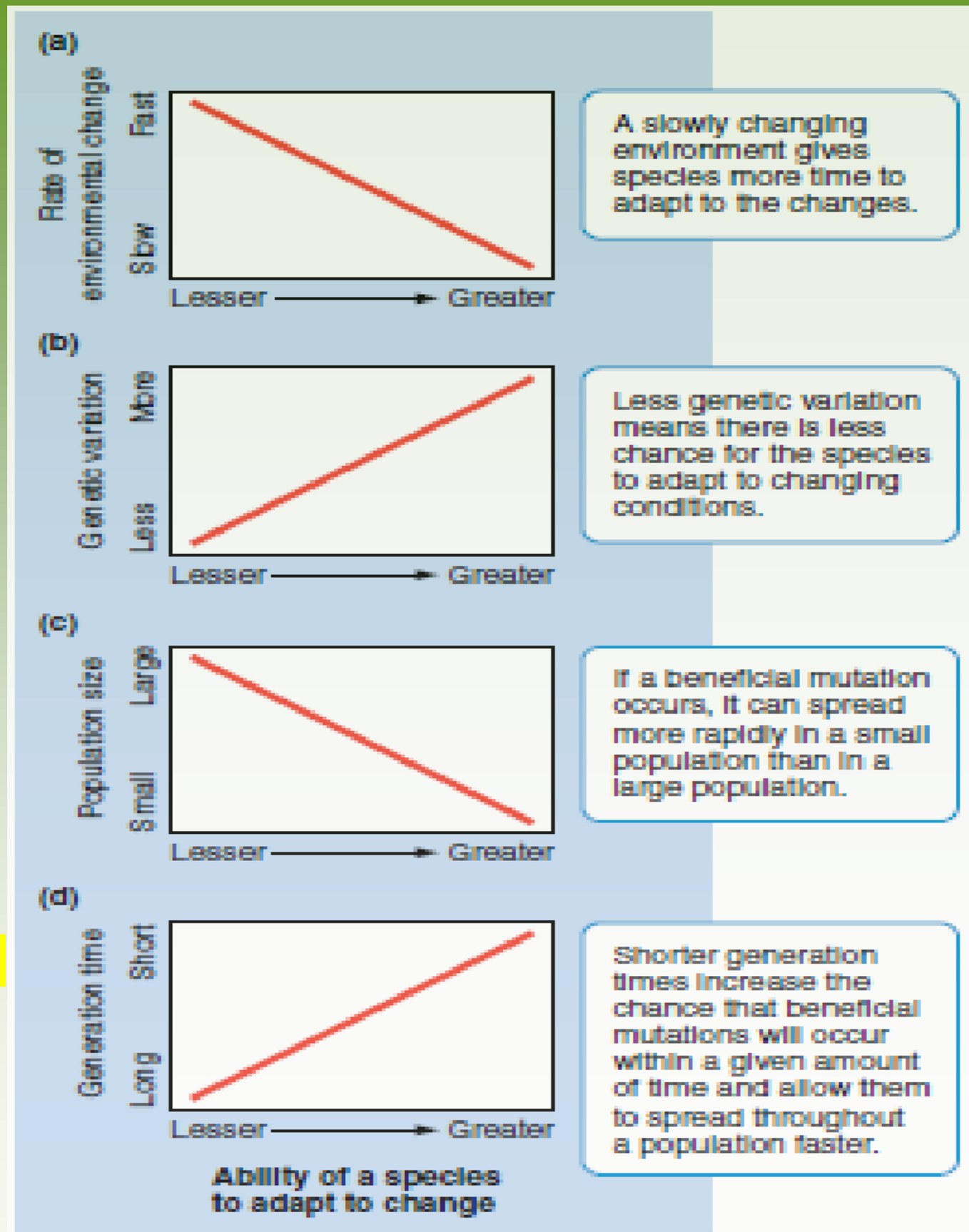
The pace of evolution

a. The rate of the environmental change is slow (more time to adapt = acclimate).

b. The population has high genetic variation (wide variety of phenotypes) allows more rapid evolution by natural selection (less genetic variation means less chance for species to adapt to changing conditions).

c. The population is relatively small (if a mutation is beneficial, it will be a selective trait, mating w/mutation, spread in the small population faster) =genetic drift.

d. The generation time is short.(shorter generation time increases the chance that mutation spread throughout the population in a shorter time) = more mutations to take place w/a shorter generation time.



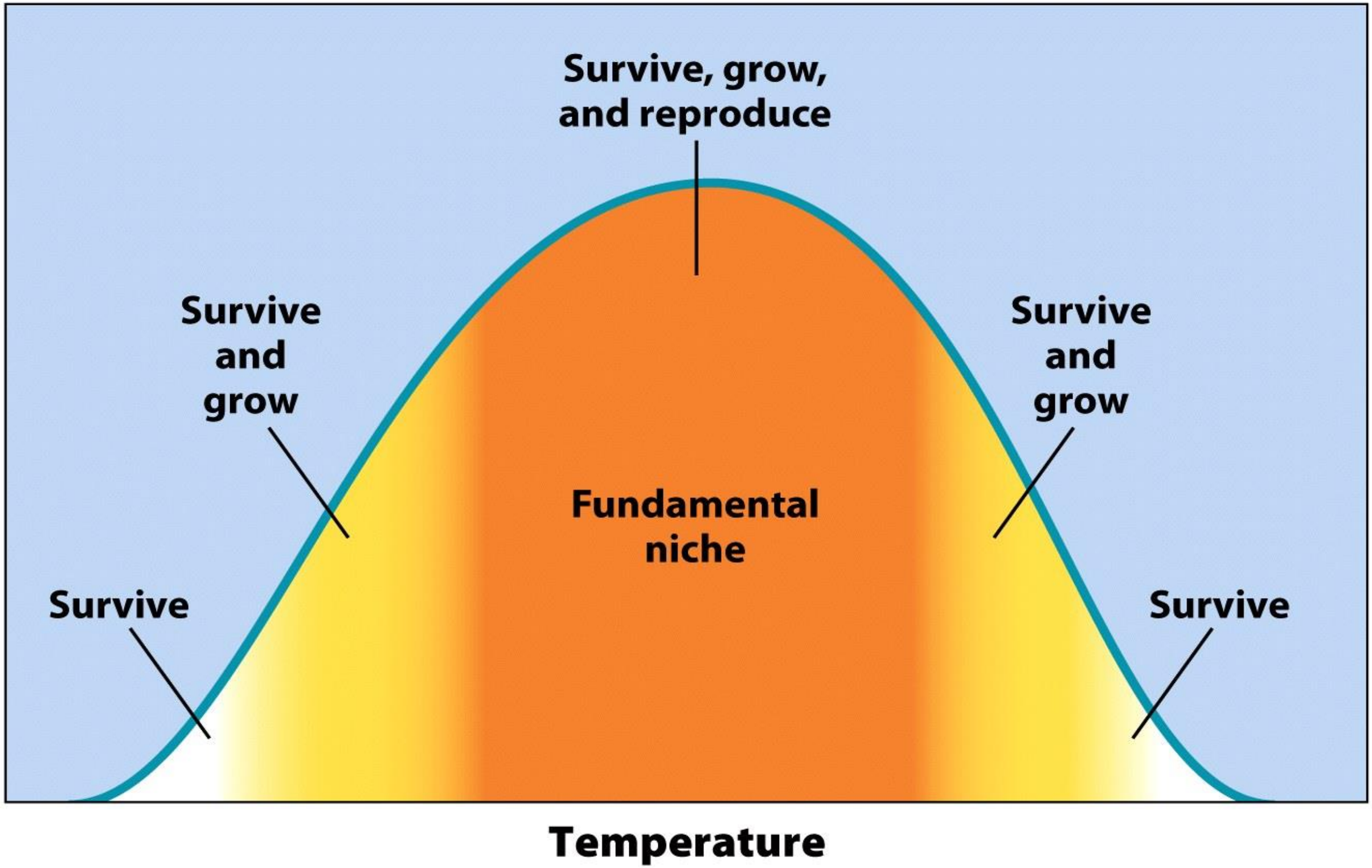
- **Genetic engineering** – scientist can uses techniques to copy genes from a species with some desirable traits, such as rapid growth or disease resistance.

- **Genetically Modified Organisms (GMO's)**– species of plants, animals, or microbes that have had desirable traits inserted into their genotype.

  - These inserts become part of the species' "blueprint" which is capable of passing to their offspring's.

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.
  - **Potential abiotic limitations**: Extreme temps, humidity, salinity, and pH.
  - **Potential biotic limitations:** presence of competitors, predators, diseases.
- **Fundamental niche-** the ideal conditions for a species.



All species have an ideal/optimal range of biotic and abiotic conditions = **Niche** *(specialized job role or function in an ecosystem*)

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.
- **Niche specialist-** species that live only in specific habitats.

Figure 5.19a
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Meadow Spittlebug – niche generalist that have a board diet and wide habitat preference.

Leaf Beetle– niche specialists that have a narrow diet and highly specific habitat preference.

Figure 5.19b
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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.

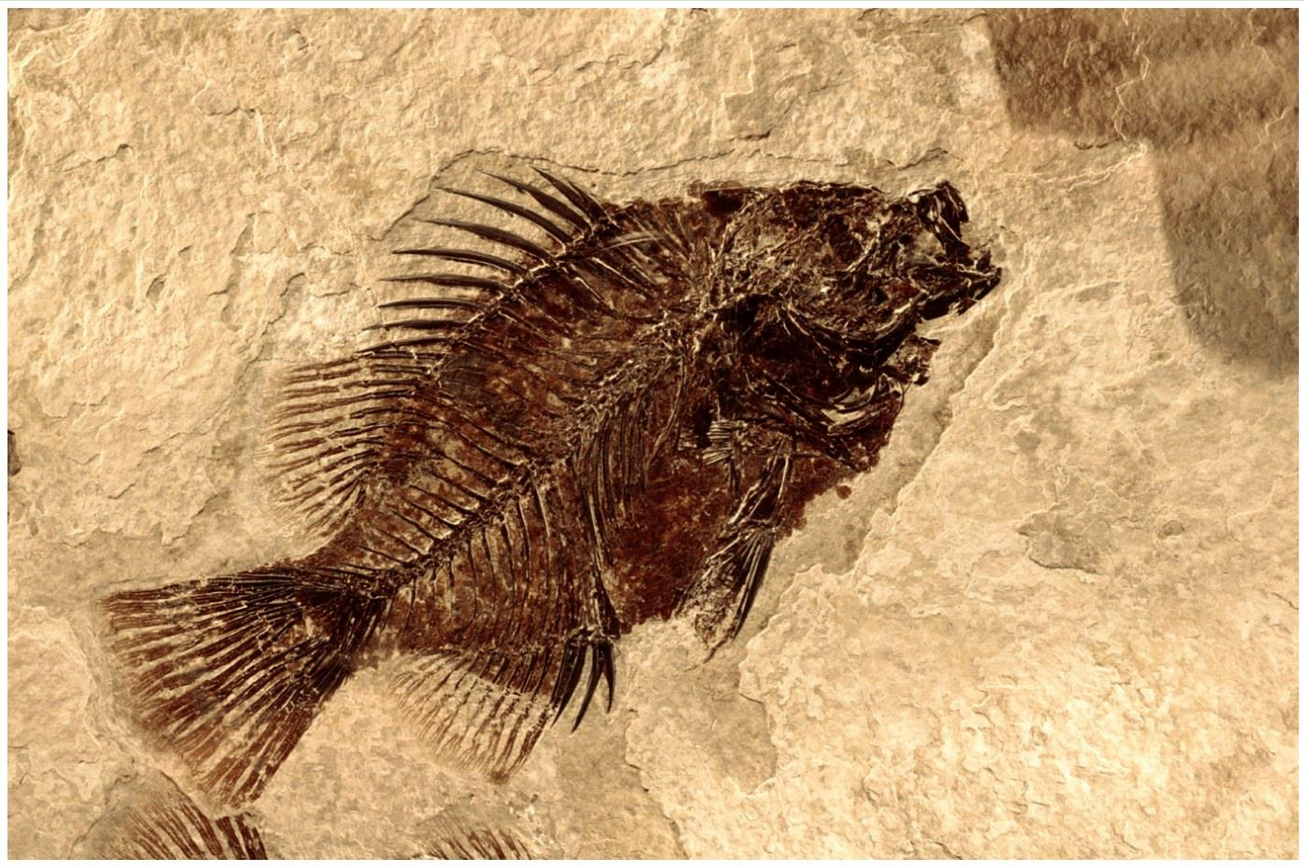

Figure 5.22
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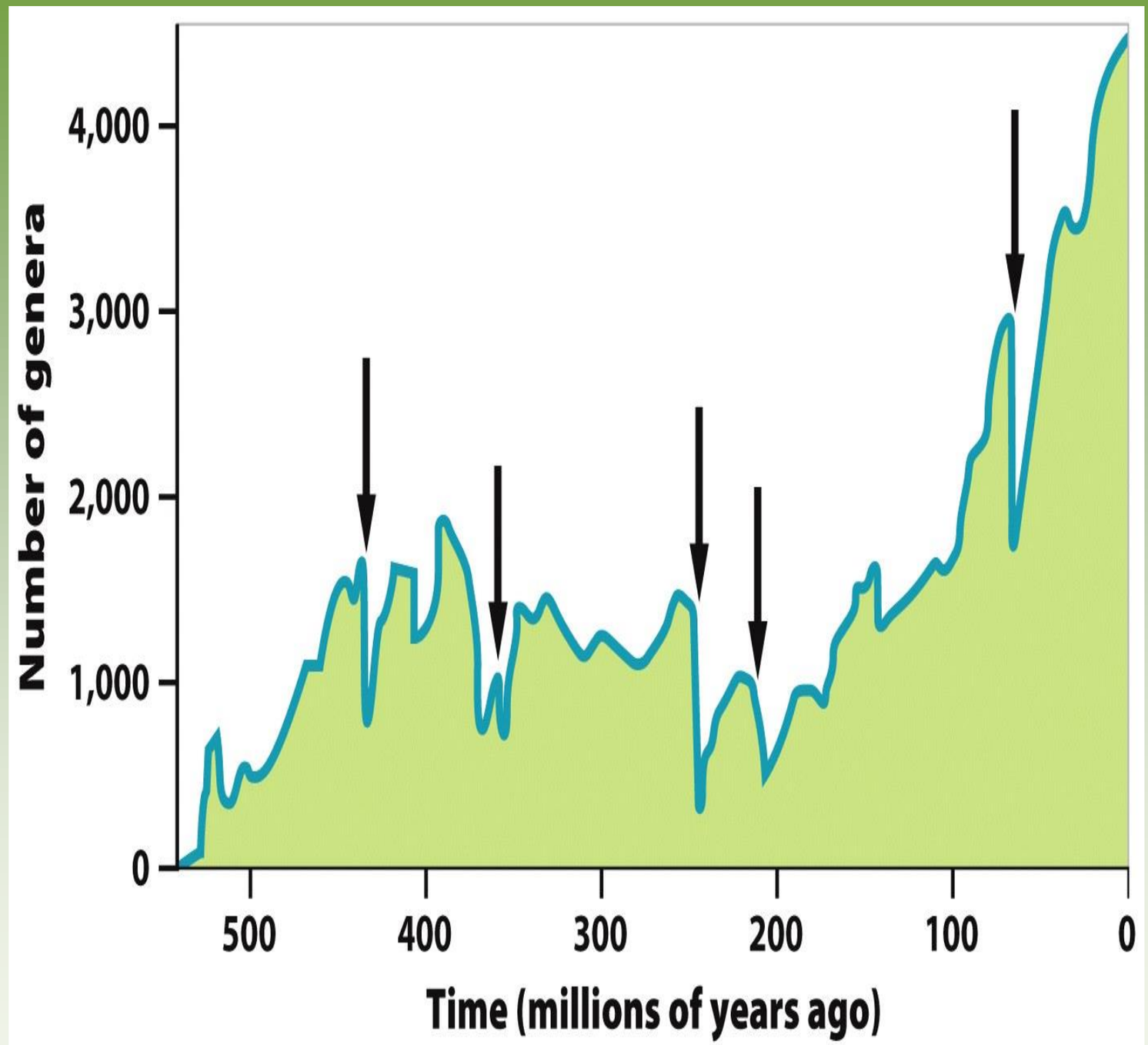
The Five Global Mass Extinctions

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

Ex. Cretaceous period (65 million years ago), roughly half of the Earth's species, including dinosaurs, went extinct.



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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% of species going extinct by 2020.
- In contrast to previous mass extinctions, scientists agree that this one is caused by humans.
- Wide-ranging causes include habitat destruction, overharvesting, intro to invasive species, climate change and emerging disease.
- Recovery of biodiversity from last mass extinction took about 10 million years.