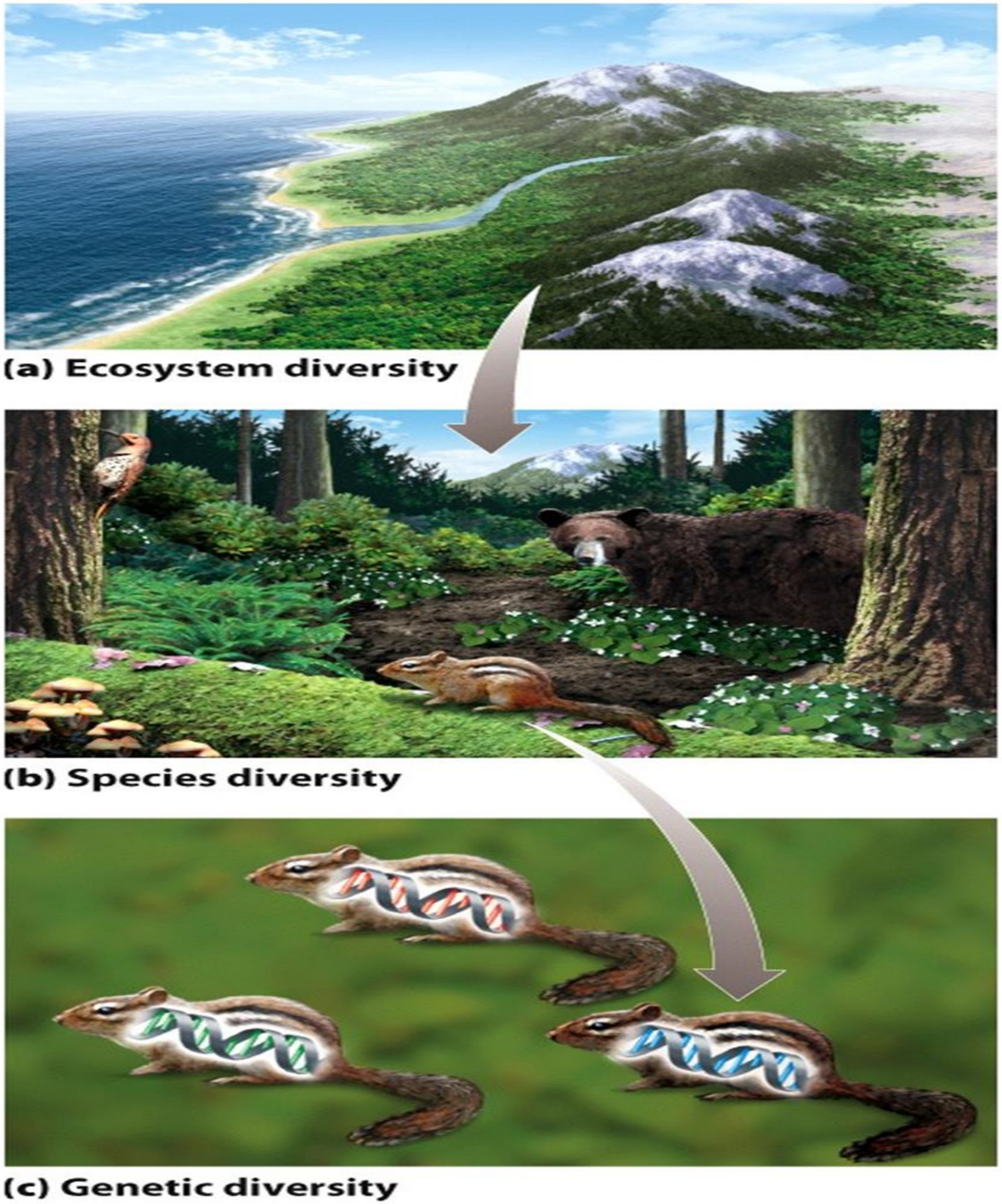
# Chapter 5
# Evolution of Biodiversity

# 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.

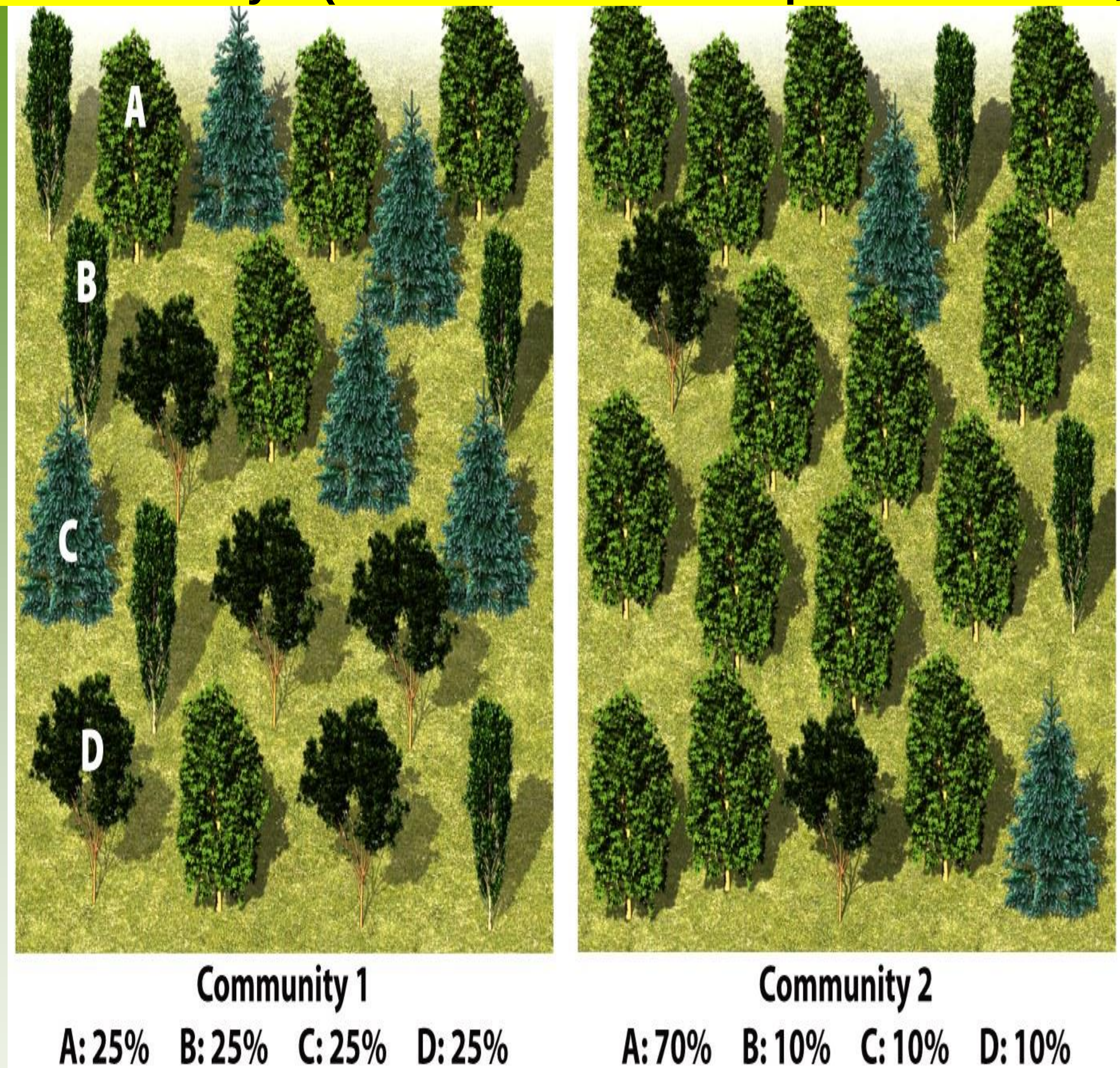



**Sometimes individuals from different species can mate, but will not produce offspring that will survive or sterile.**

***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.

**Community 1 has higher evenness and equal richness to Community 2 (both have the same species richness)**




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

**Shannon-Wiener Index (H): Measurement of both species richness and evenness (biodiversity)**

H = -sum (Pi ln [Pi])

(neg sign makes the index a positive number)

- **H** = uncertainty of predicting species based on level of diversity

  (0 *single species* - 7 *diverse community*)

- **N** = total # of individuals in the ecosystem

- **ni** = # of individuals in species (specific)

- $Pi = \frac{ni}{N}$ *relative abundance* (proportion of indiv.)

- **Ln** = *natural log*

- $E = \frac{H}{\ln(R)}$

E = evenness

R = richness

## 3 communities of 100 individuals is most diverse…

10 species with 10 individuals in each species…

**Givens:**

**Population (N) = 100 indiv.**

**1. ni = 10**

**(pi = 10/100 = .1)**

**1. H = -sum (.1ln.1)**

**H = -(-.23) x 10 species**

**H = 2.3**

**Species based on level of diversity…**

## 3 communities of 100 individuals is most diverse…

10 species with 91 individuals in the first species, 1 individual each of 9 species…

**Givens:**

**Population (N) = 100 indiv.**

**1. ni = 91 (pi = 91/100 = .91)**

**2. ni = 1 (pi = 1/100 = .01)**

**1. H = -sum (.91ln.91)**

**H = -(-.086) x 10 species**

**H = .86**

**2. H = -sum (.01ln.01)**

**H = -(-.046) x 9 species**

**H = .414**

**H = .86 + .414**

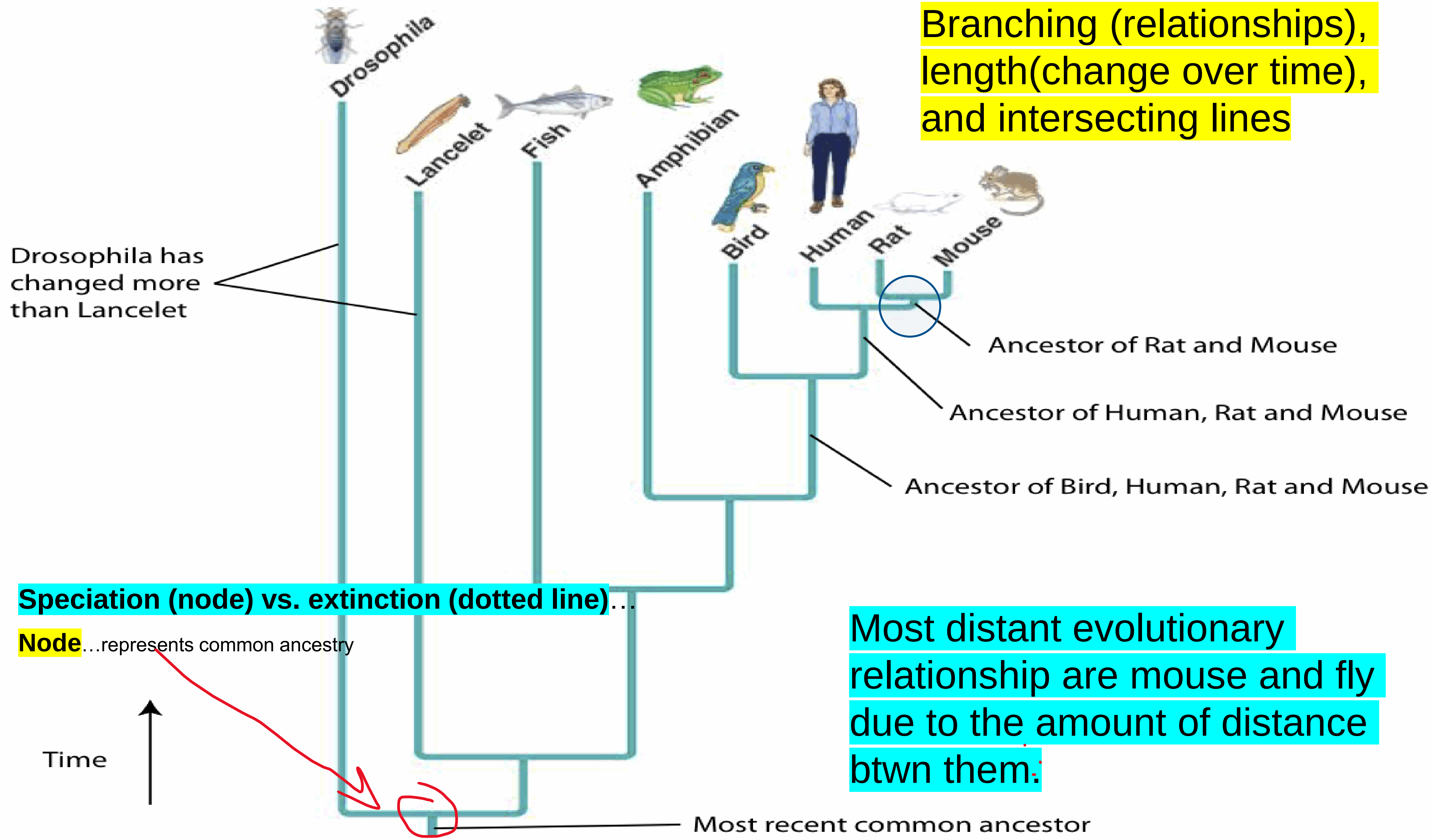
**H = 1.3**

**Who has the most diverse ecosystem…??**

# **Phylogenies** – branching patterns of evolutionary relationships **(phylogenetic tree)**

Scientist's base phylogenies on morphology (structure), behavior, and genetic similarity

Branching (relationships), length(change over time), and intersecting lines




**Speciation (node) vs. extinction (dotted line)**…

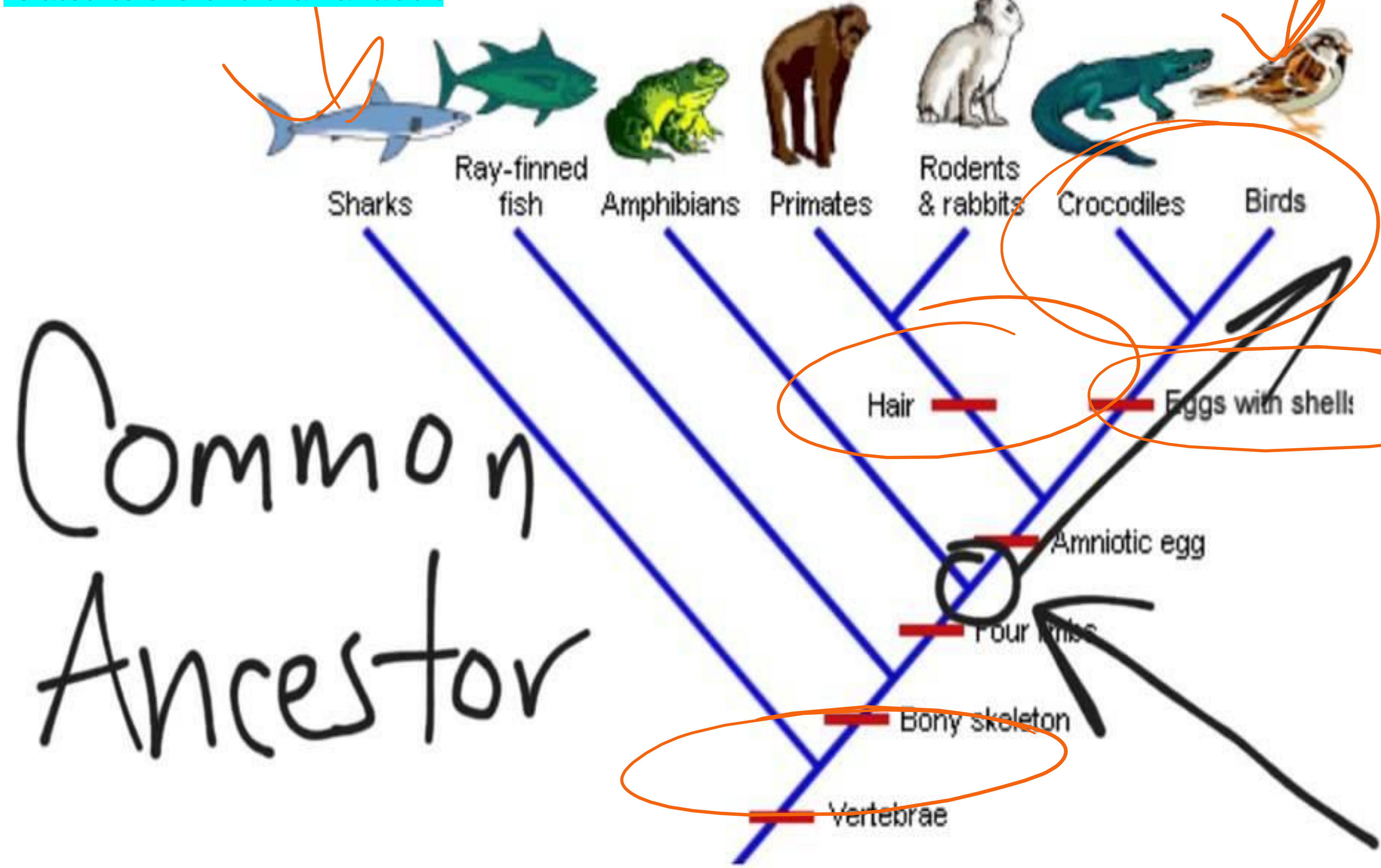
**Node**…represents common ancestry

Most distant evolutionary relationship are mouse and fly due to the amount of distance btwn them.

**Cladograms** - classifying organisms according to their common characteristics

**Closer relationship to the right than the left…Recent common ancestry**

**Ray-finned fish are equally related to an amphibian and a shark due to the branching…whereas, a crocodile is more related to the bird than a rabbit.**




**Node**…represents common ancestry

**Most primitive = vertebrae (all organisms have – ancestorial characteries)**
**Most advanced = hair or eggs with shells (only above that dash)**

# 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, most controlled by humans).
  - 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)

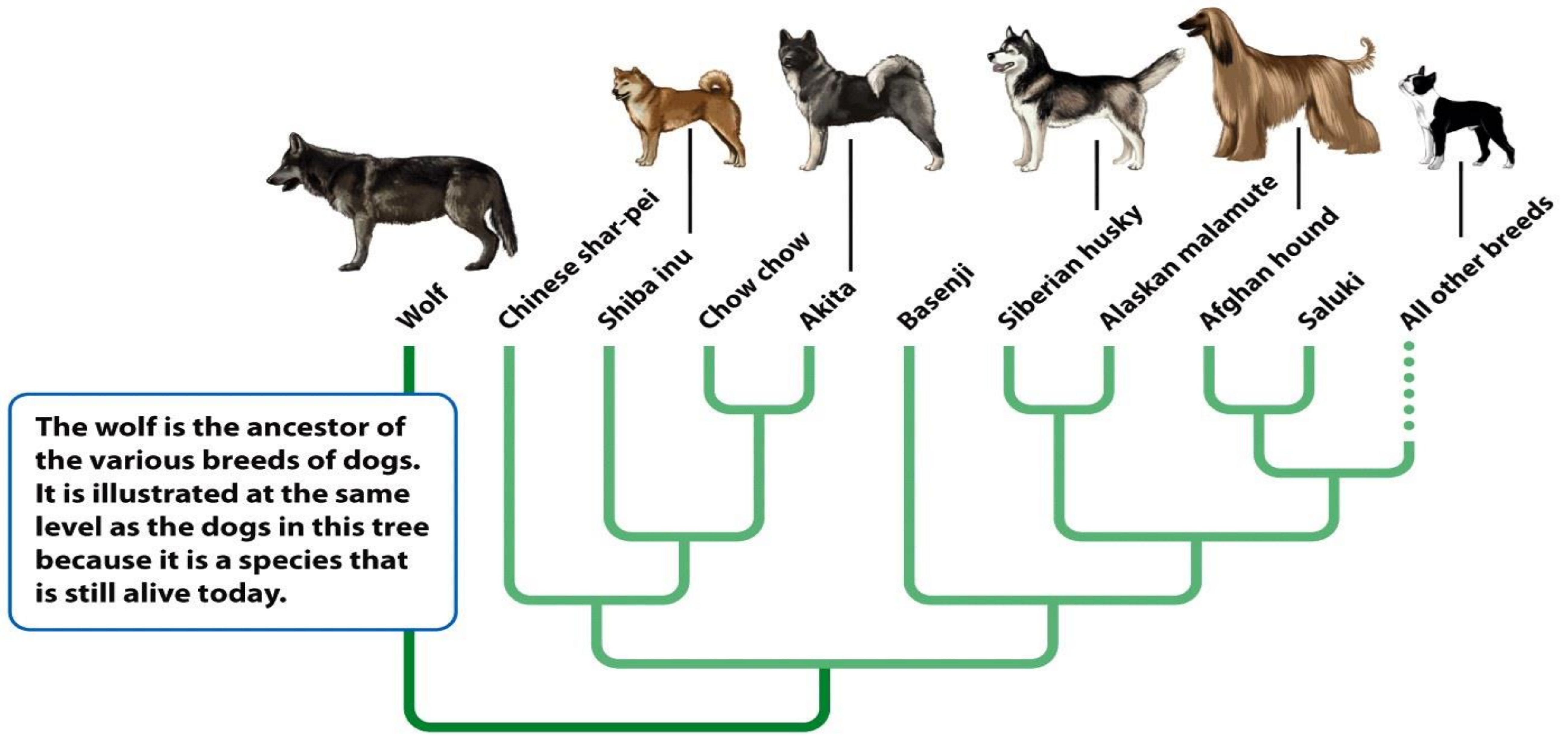



**Figure 5.8**
***Environmental Science***


# 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

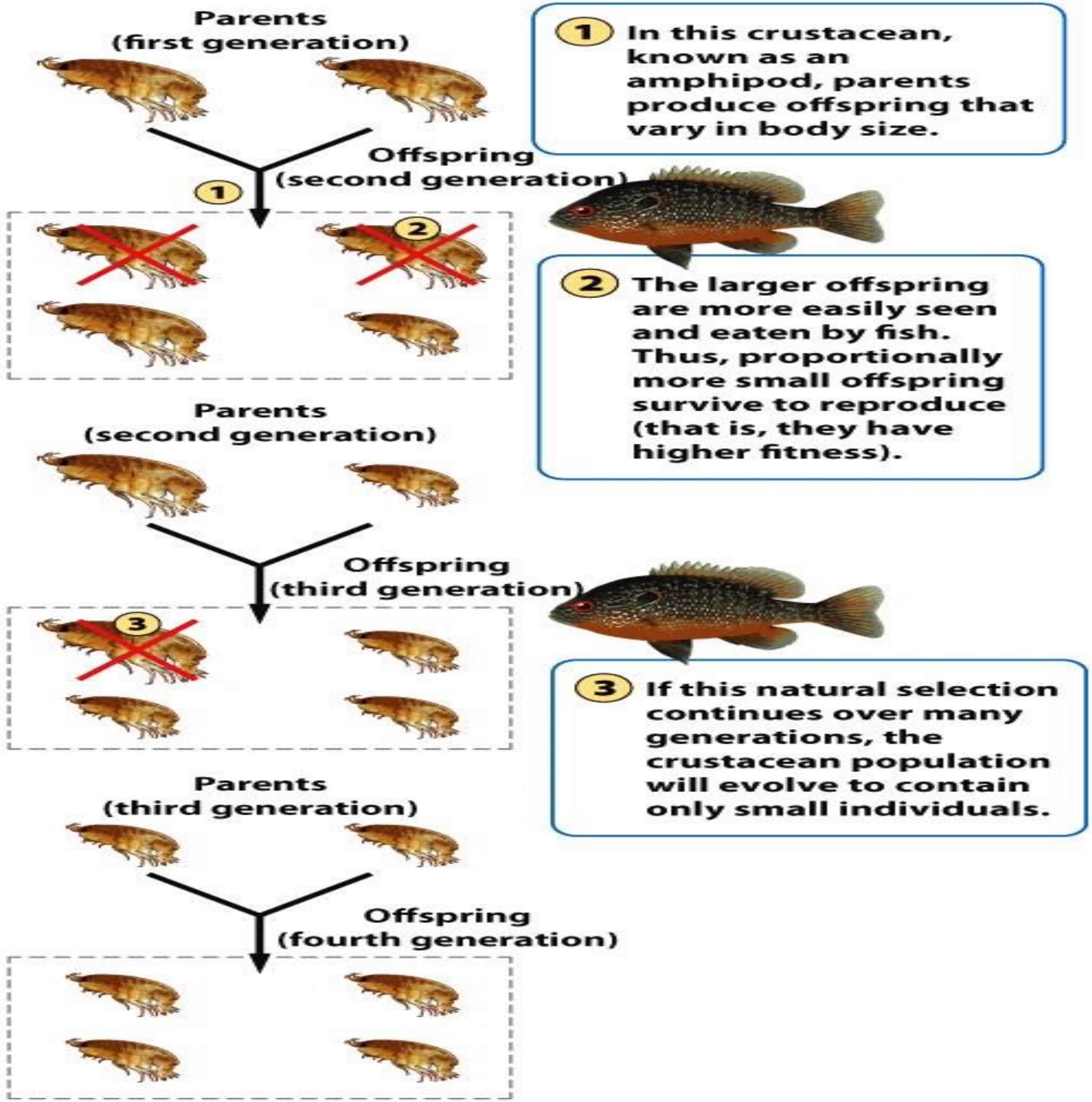


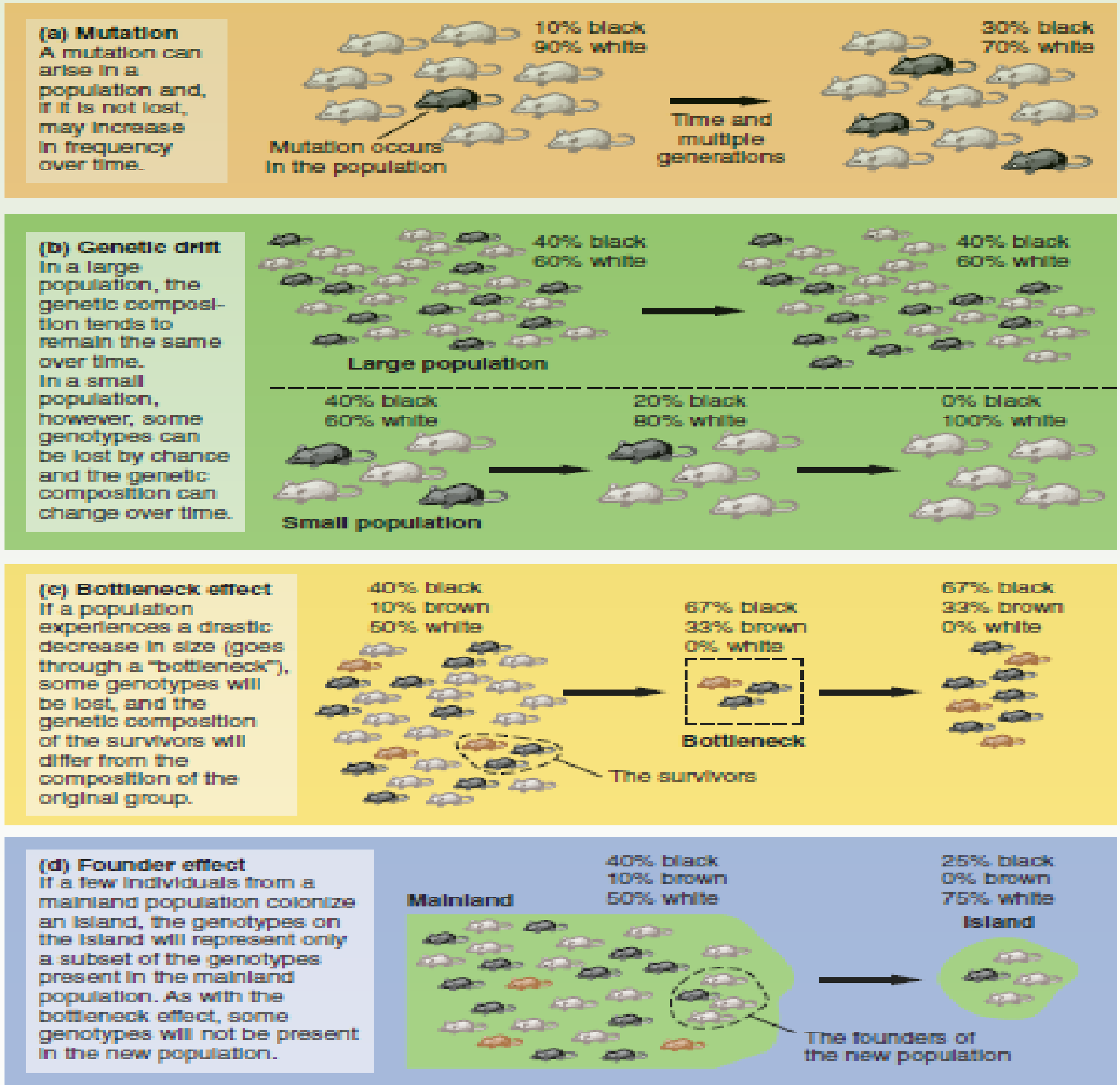

**Figure 5.10**
*Environmental Science*

# Evolution by Random Processes

- **Mutations**
- **Genetic drift-** change in the genetic composition of a population over time as a result of random mating.
  Ex. A population of rabbits can have brown fur and white fur with brown fur being the dominant allele. By **random chance**, the offspring may all be brown and this could reduce or eliminate the allele for white fur.
- **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.

**~Habitat Size and Distance** *(size of land)* determines **species richness** *(quantity of species).*



# Speciation and extinction determine biodiversity

- **Allopatric speciation-** when new species are created by geographic or reproductive isolation.
- If ever reunited…what would happen to species of generations to come???? (no interbreeding…diff. species)

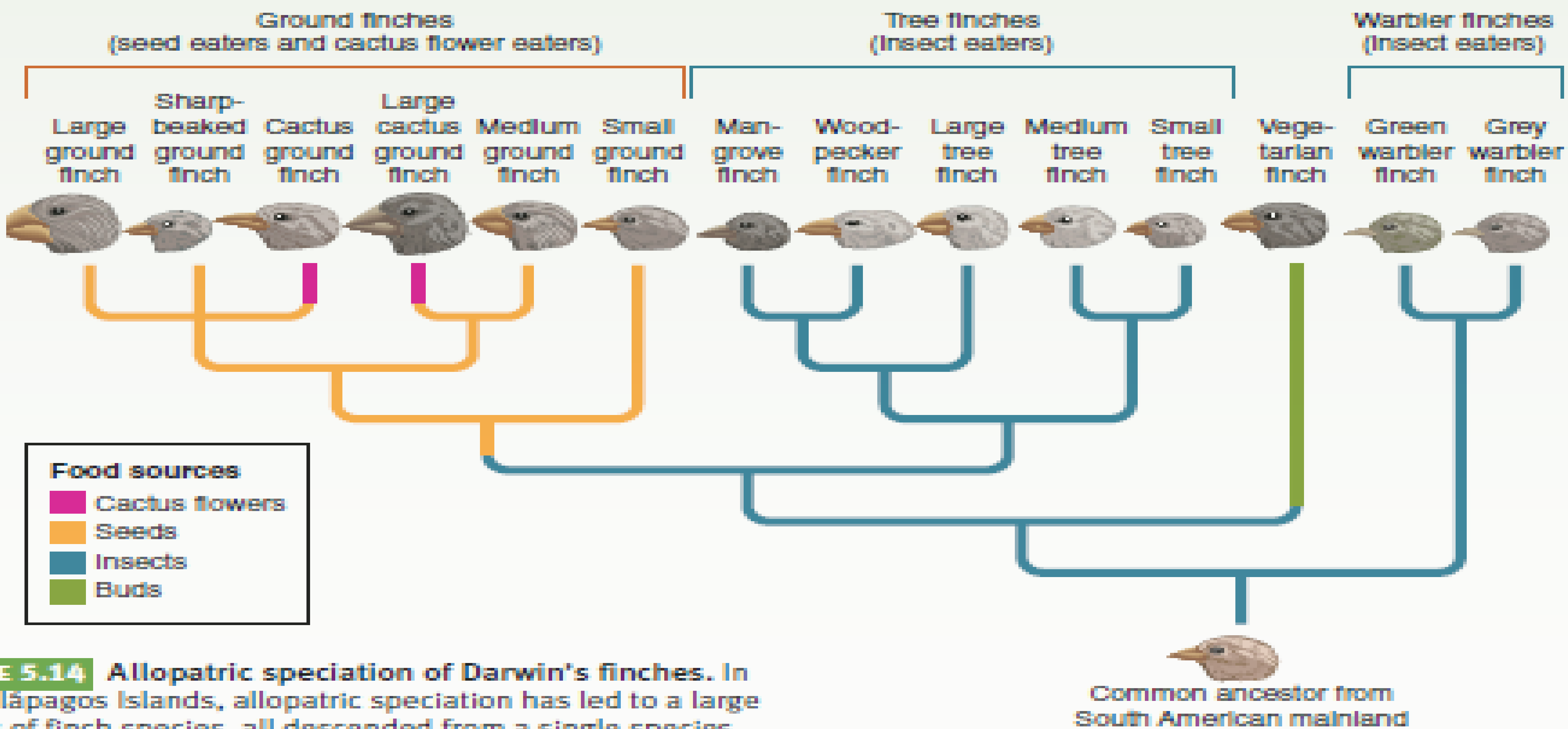



**FIGURE 5.14** **Allopatric speciation of Darwin's finches.** In the Galápagos Islands, allopatric speciation has led to a large variety of finch species, all descended from a single species that colonized the islands from the South American mainland.

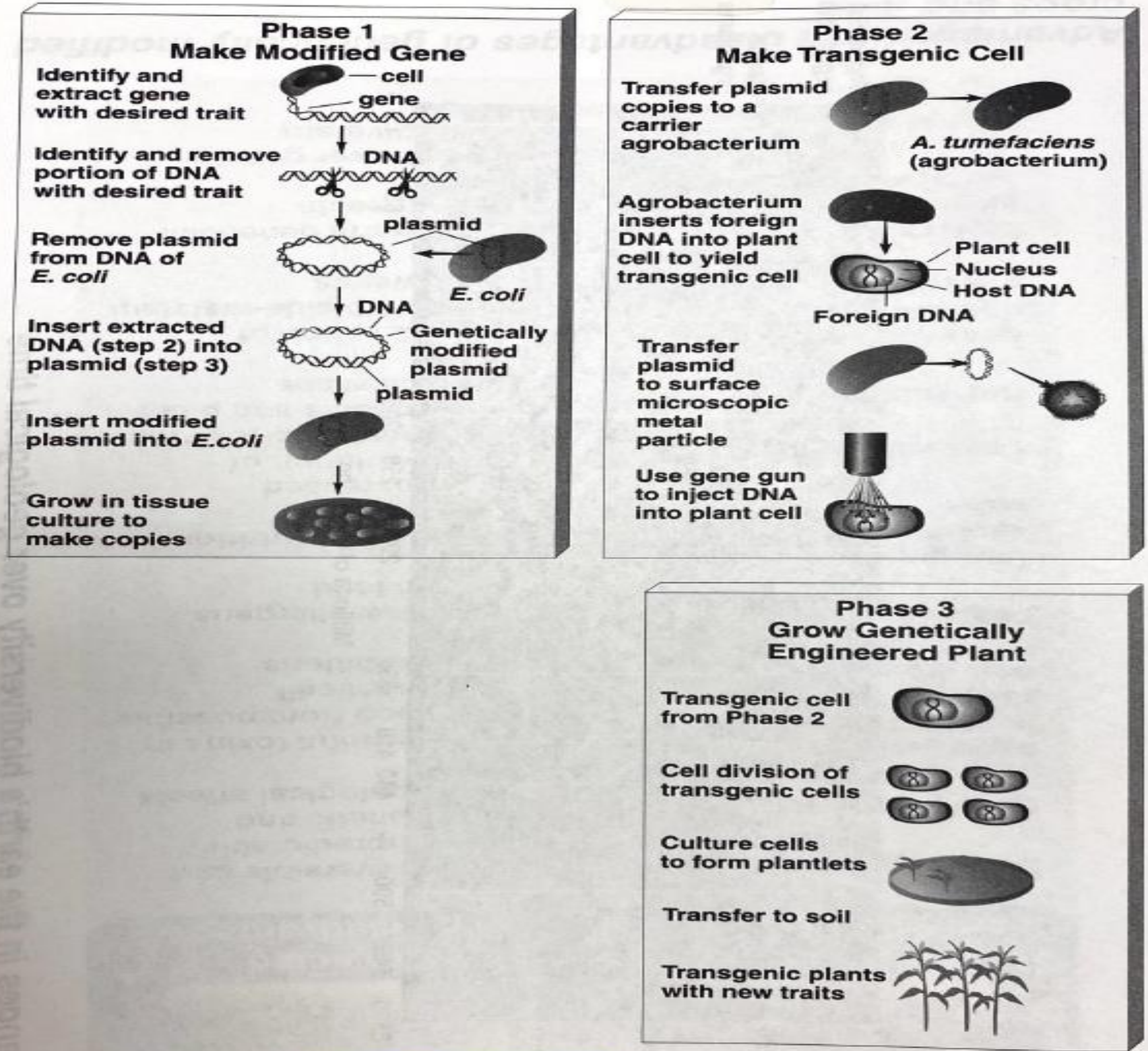
- **Sympatric** speciation- the evolution of one species into two species in the **absence** of geographic isolation, usually through the *process of polyploidy*, an *increase in the number of sets of chromosomes*.

**Ancestor-** 2 set of chromosomes | 4 sets chromosomes | 6 sets chromosomes

(a) Einkorn wheat (b) Durum wheat (c) Common wheat

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

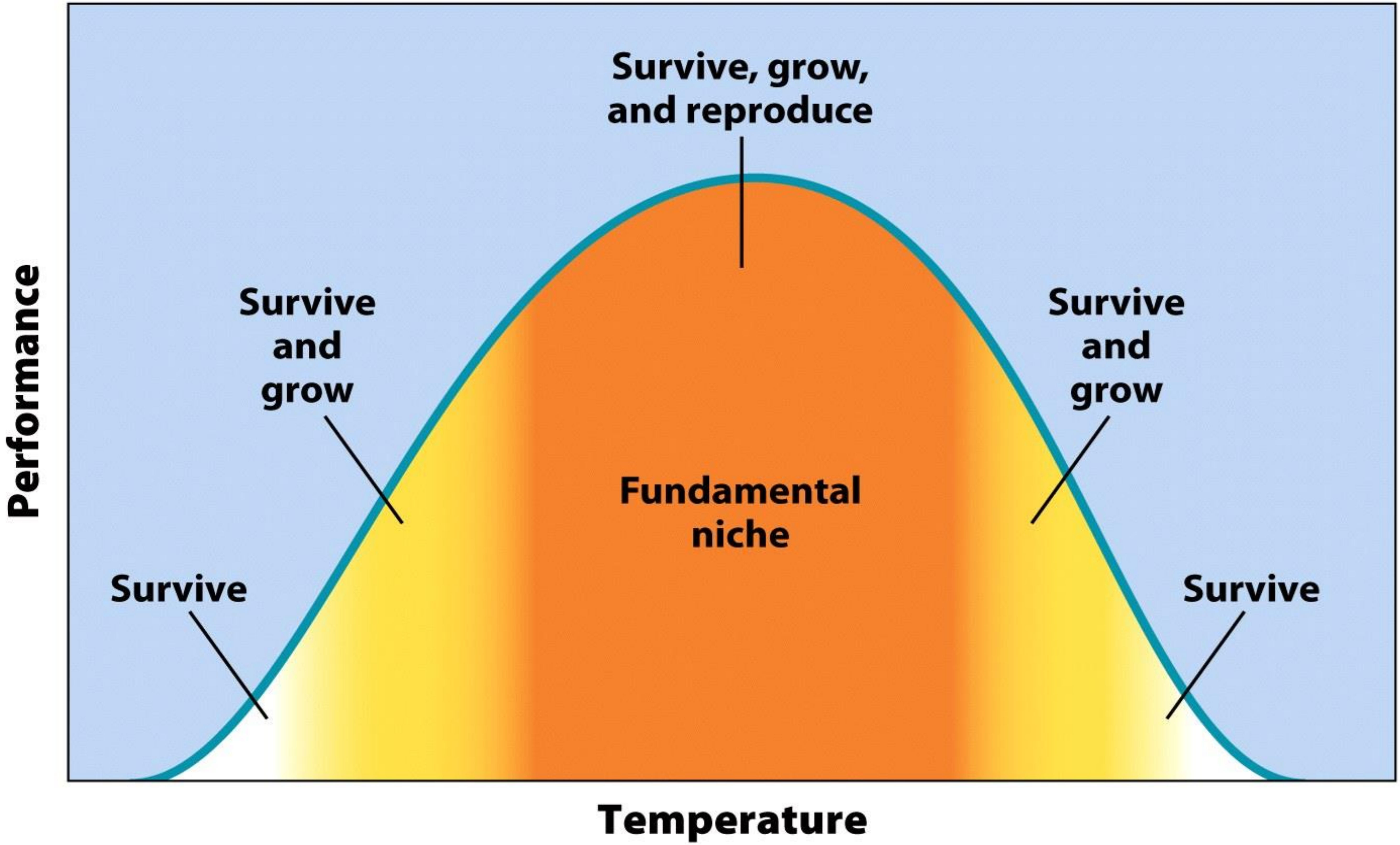
- **Genetically Modified Organisms (GMO's)**– species of plants, animals, or microbes that have had desirable traits inserted into their genotype.
  - Leads to most rapid rate of evolution
  - These inserts become part of the species' "blueprint" which is capable of passing to their offspring's.



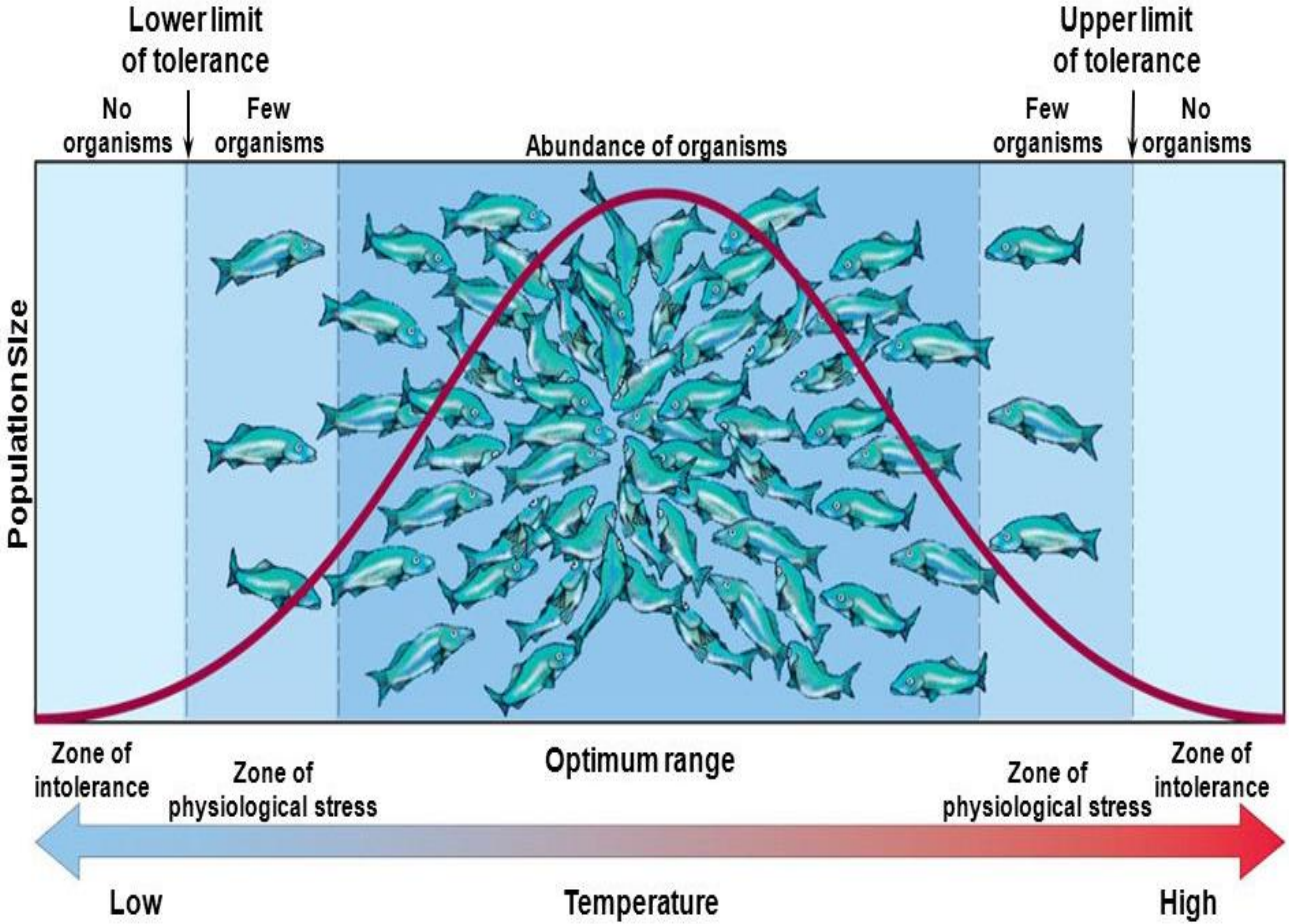

***Steps in genetically modifying a plant***

# 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…***Generalist** *(wide range)* *vs.* ***Specialist*** *(narrow/specific*)


Lower limit
of tolerance
Upper limit
of tolerance
No
organisms
Few
organisms
Abundance of organisms
Few
organisms
No
organisms
Population Size
Zone of
intolerance
Zone of
physiological stress
Optimum range
Zone of
physiological stress
Zone of
intolerance
Low
Temperature
High