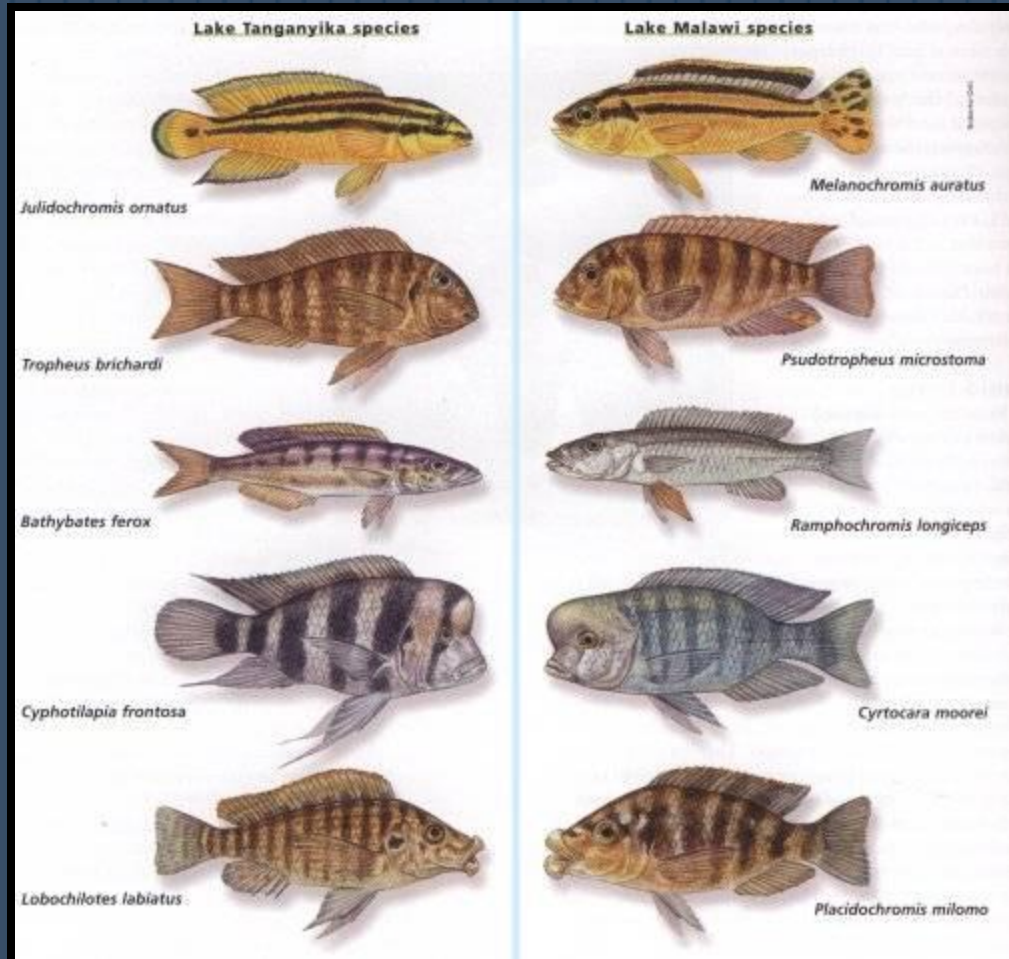


Evolution in a Genetic Context

What is evolution?

- Evolution is the process of change over time.
- In terms of genetics and evolution, our knowledge of DNA and phenotypic expression allow us to understand that the *genes* of the organisms on Earth have changed over time.

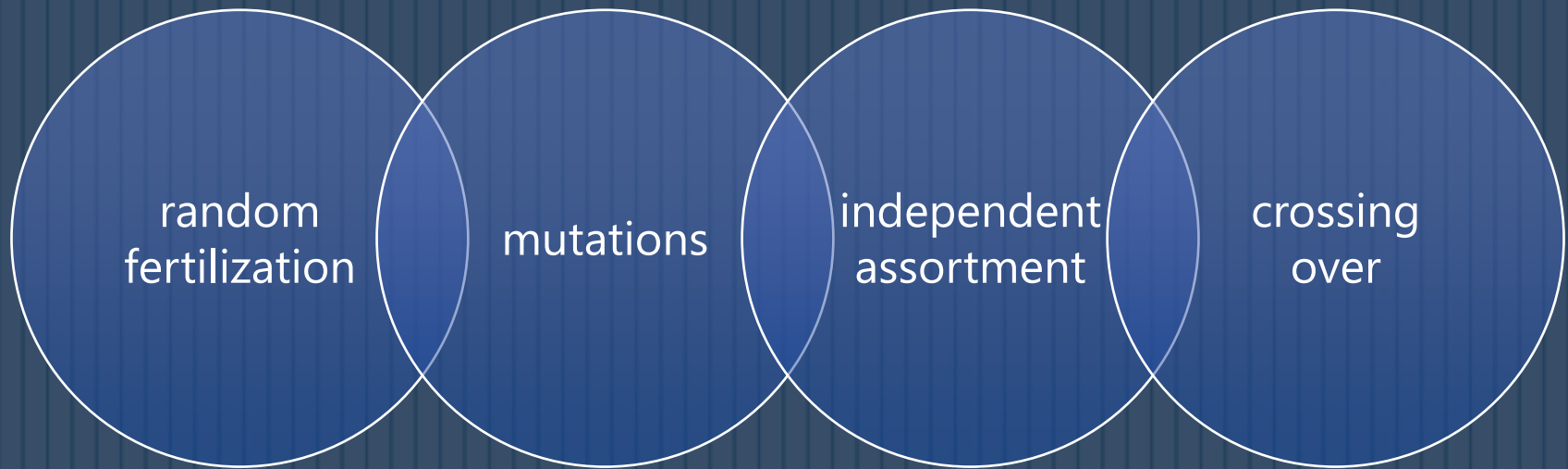
What is variation, and why is it important?



- Within a population, variety exists. It is from this variation that evolution has the means to occur.
 - Population genetics studies the variety in a population.
 - The gene pool is the total of all of the alleles (variety) in a population. It is discussed in terms of gene frequency.

How do we get variety in a population?

- Think back to our discussion of meiosis. What events occur during this process that allow for genetic diversity?



What is the difference between macroevolution and microevolution?

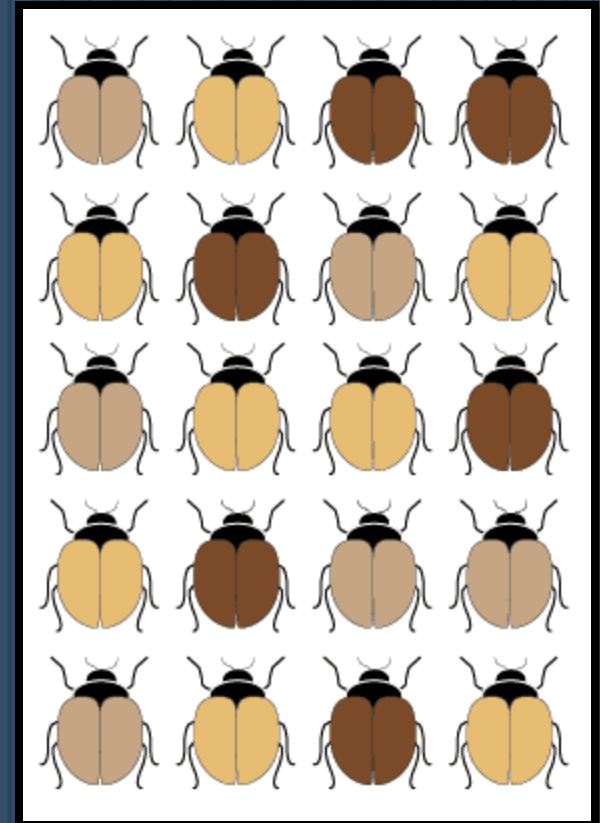
- Macroevolution is evolution on a large scale. It creates new species over a long period of time.
- Microevolution is the change in allele frequency within a population over a short period of time—1 to 2 generations.

What is a population?

- A population is a group of organisms of the same species that live in the same area.
- Individuals in a population will demonstrate variation.

How can you measure evolution?

- We can measure evolution in terms of genetics when we measure the change in allelic frequencies within a population.
 - Within this species, the light brown/beige allele is present in a higher frequency than in the dark brown and grey-brown alleles.

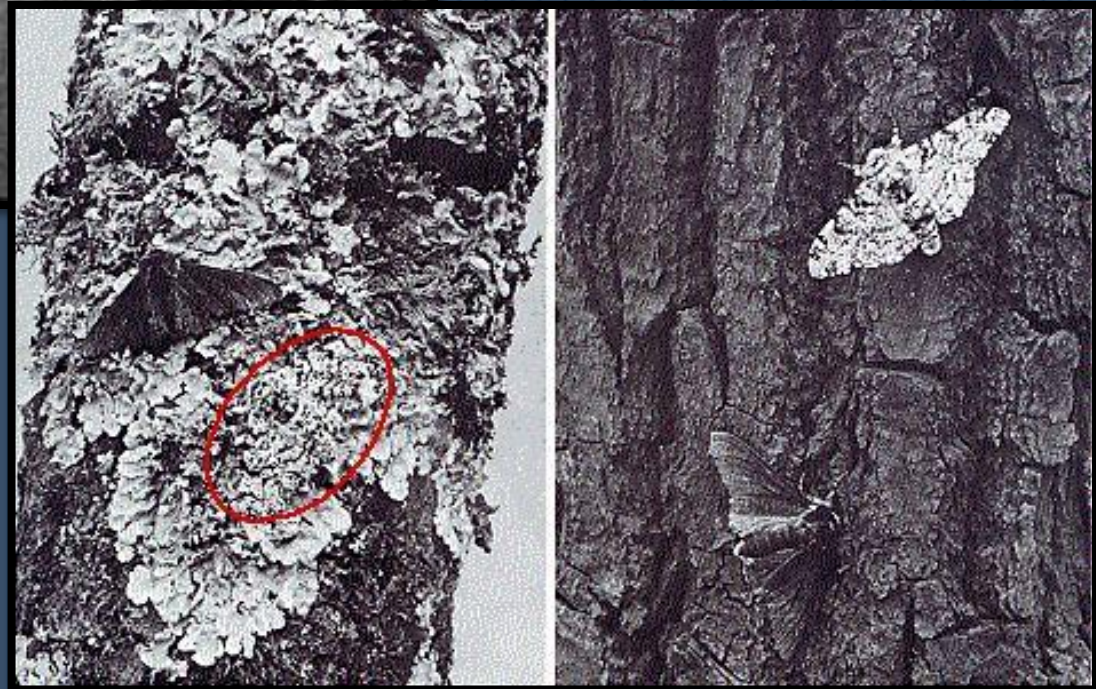


corbis

What is a real-life example of microevolution?

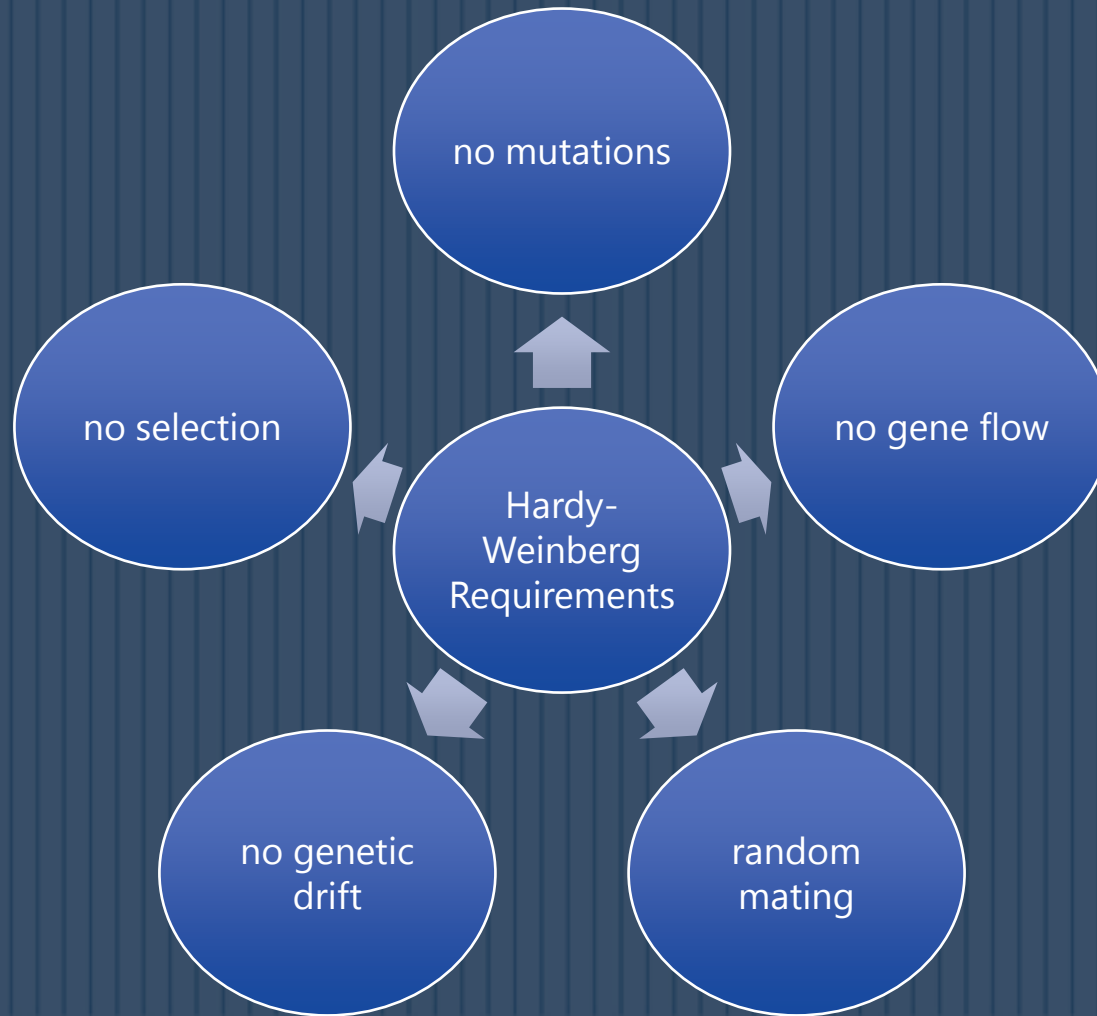


What is a real-life example of microevolution?



What is the Hardy–Weinberg Law?

- This law states an equilibrium of allele frequencies in a gene pool remains in effect in each succeeding generation of a sexually reproducing population if five conditions are met...



What are the requirements of Hardy–Weinberg?

- The Hardy-Weinberg Law requires there is:
 - no mutation—no changes in the alleles can occur
 - no gene flow—alleles do not migrate in or out of a population
 - random mating—individuals mate randomly, not according to genotype or phenotype
 - no genetic drift—the population of organisms is so large that any change in allelic frequency is insignificant
 - no selection—no genotype or phenotype is naturally preferable and selected for
- Any change in the allele frequencies in a gene pool indicates that evolution has occurred.

What is the Hardy–Weinberg Equation?

- The Hardy-Weinberg equation is:

$$p^2 + 2pq + q^2 = 1$$

$$p + q = 1$$

- p^2 represents the percent of homozygous dominant individuals, p is the frequency of the dominant allele
- q^2 represents the percent of homozygous recessive individuals, q is the frequency of the recessive allele
- $2pq$ is the percentage of heterozygous individuals

Example

An investigator has determined by inspection that 16% of a human population has a recessive trait. Using this information, we can complete all the genotype and allele frequencies for the population, provided the conditions for Hardy-Weinberg equilibrium are met.

Given: $q^2 = 16\% = 0.16$ are homozygous recessive individuals

Therefore, $q = \sqrt{0.16} = 0.4$ = frequency of recessive allele

$p = 1.0 - 0.4 = 0.6$ = frequency of dominant allele

$p^2 = (0.6)(0.6) = 0.36 = 36\%$ are homozygous
dominant individuals

$2pq = 2(0.6)(0.4) = 0.48 = 48\%$ are heterozygous
individuals

} 84% have the
dominant phenotype

or

$$= 1.00 - 0.52 = 0.48$$



Hardy



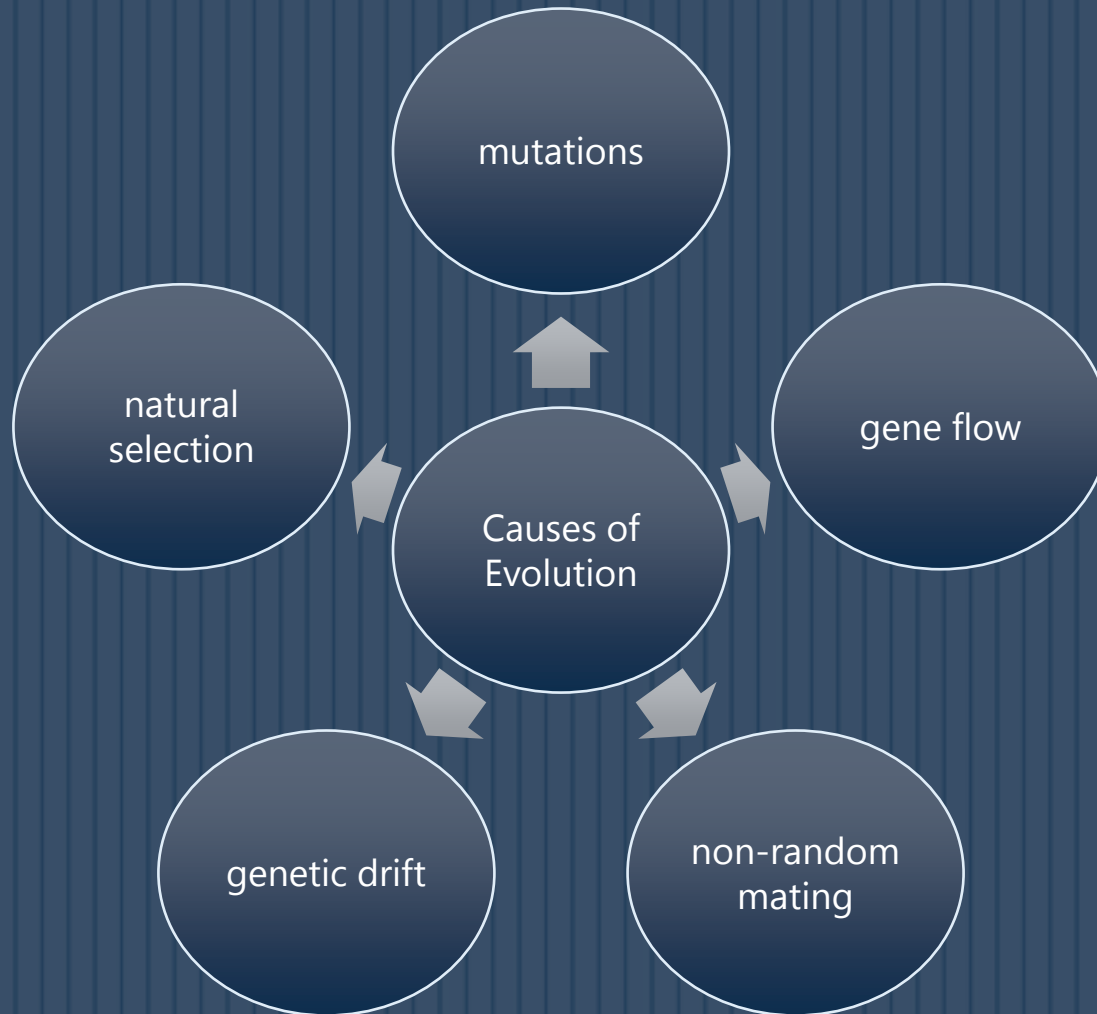
Weinberg

Realize that

$$p + q = 1 \text{ (There are only 2 alleles.)}$$

$$p^2 + 2pq + q^2 = 1 \text{ (These are the only genotypes.)}$$

What causes evolution?



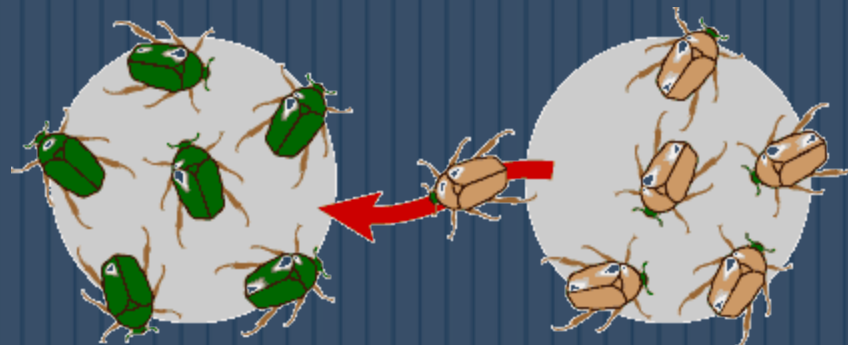
What is mutation?



- A genetic mutation is a change in a DNA nucleotide sequence. This change in DNA alters its expression as an allele.
- Because genetic mutation creates new alleles, it is the ultimate source of fuel for evolution.

What is gene flow?

- Gene flow moves alleles among populations by the migration of breeding individuals.
- Gene flow can increase variation within a population by introducing novel alleles produced by mutation into another population.
- Continued gene flow lessens the amount of variation between different populations. As a result, gene pools to become similar.
- Gene flow among populations can prevent speciation from occurring.

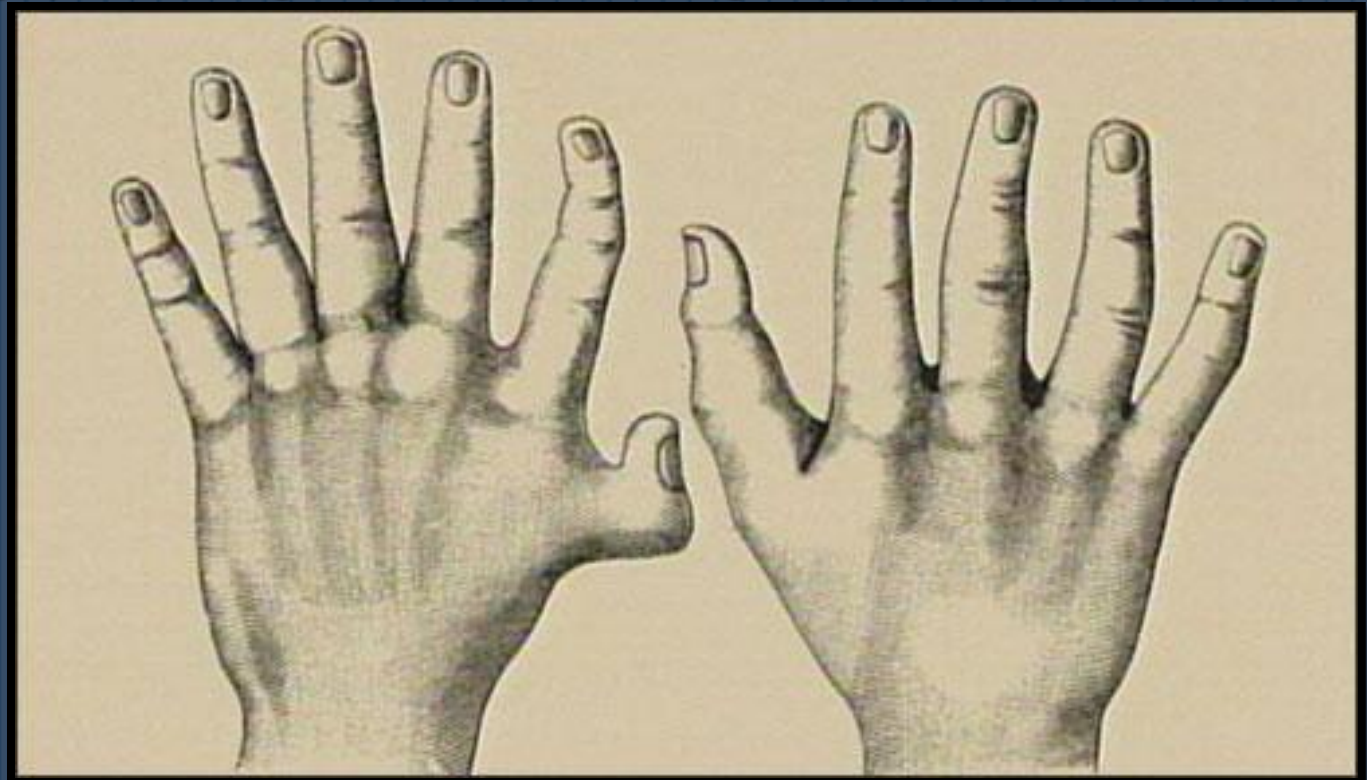


What is genetic drift?

- Chance events that cause the allele frequency to change is called genetic drift.
- The effect of genetic drift becomes increasingly important as the size of the population decreases.

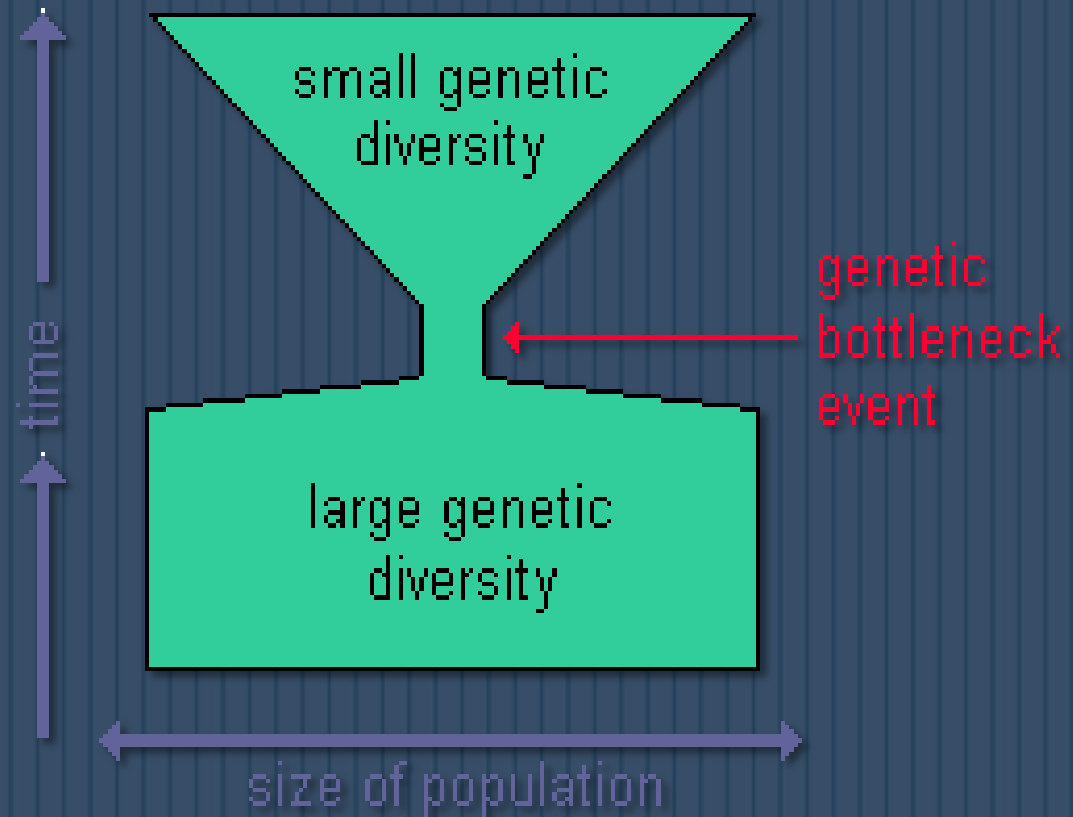
What is the Founder Effect?

- The Founder Effect is a high prevalence of a rare trait present within an isolated population as compared to the general population.
- In the Amish population, the genetic disease Ellis-van Creveld is more common because they breed within their own community, preventing the influx of new genes.



What is the Bottleneck Effect?

- The bottleneck effect is caused by a severe reduction in population size due to natural disaster, predation, or habitat reduction.
- Bottleneck effect causes severe reduction in total genetic diversity of the original gene pool.
- The cheetah bottleneck causes relative infertility because of the intense interbreeding when population were reduced in earlier times.



What is non-random mating?

- Non-random mating occurs when we choose who we mate with due to preference in genotype or phenotype—random mating would occur by chance.
 - What in animals may affect who mates with whom?
- This phenomenon has also been called sexual selection, and it may explain why blue eyes had persisted in the northern European population.


What is natural selection?

- Natural selection occurs when one allele is more successful than another in an environment. Those that are “best fit” for an environment survive and are given the opportunity to reproduce, passing their genes to subsequent generations.
- The result of natural selection is that a population becomes specifically adapted to its environment.



What is required for natural selection to occur?

- Natural selection requires the following things be present:



Variation	<ul style="list-style-type: none">• Members of a population differ from one another
Inheritance	<ul style="list-style-type: none">• Difference in individuals are heritable
Differential Adaptedness	<ul style="list-style-type: none">• Different organisms are better adapted to an environment than others
Differential Reproduction	<ul style="list-style-type: none">• Better adapted individuals are more likely to reproduce

What are the different types of natural selection?

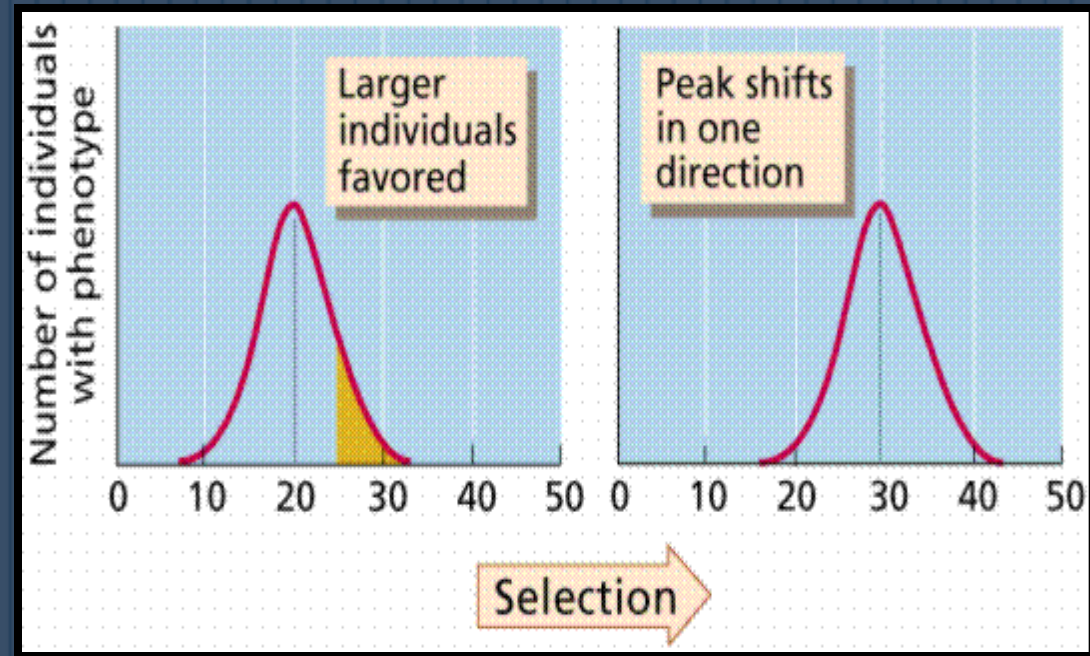
Directional Selection

Stabilizing Selection

Disruptive Selection

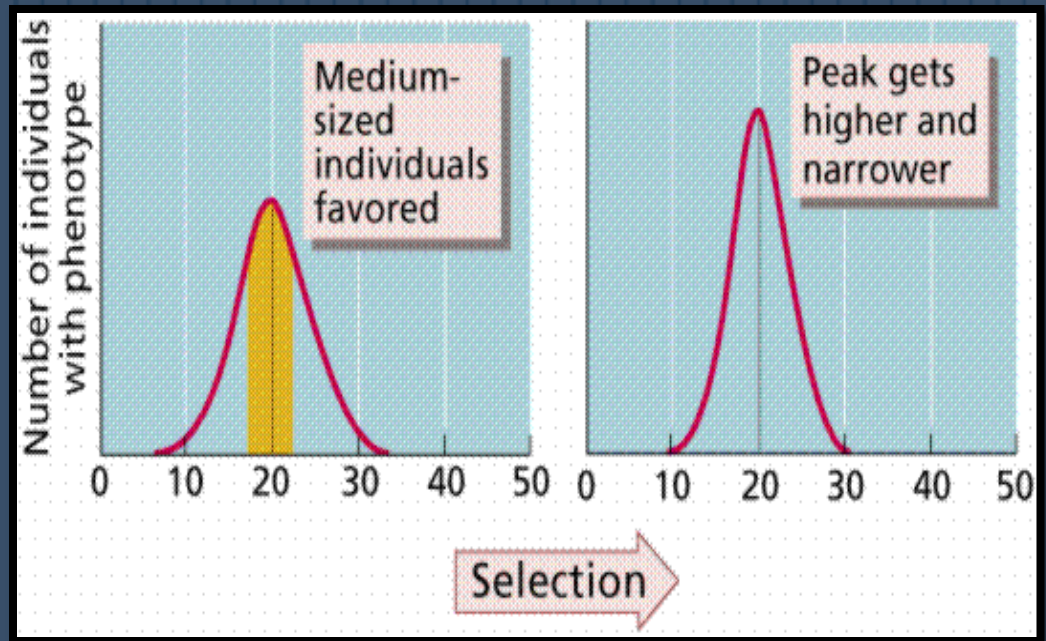
What is directional selection?

- Directional selection occurs when one phenotype is favored strongly over another.
- The distribution of the allele in a population will shift toward this phenotype.
- Examples of directional selection include:
 - a shift in dark-colored moths from light-colored moths with increasing pollution
 - an increase the insecticide-resistant mosquitoes with an increase in anti-malaria efforts

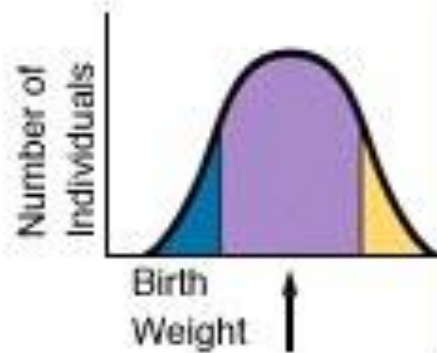


What is stabilizing selection?

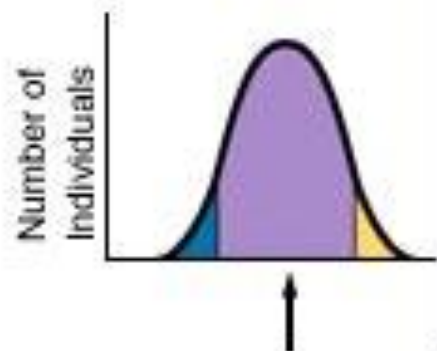
- Stabilizing selection favors what is average instead of the extremes.
- The distribution curve is very narrow.
- Examples of stabilizing selection includes the weight of human babies. Babies with low or high birth weights have a low change of survival.



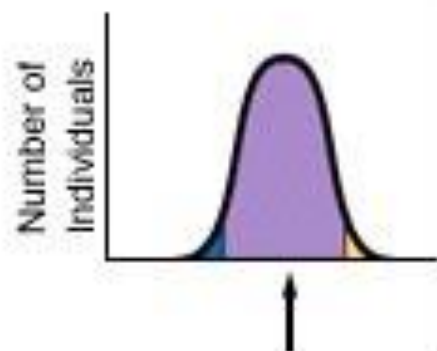
Initial
distribution



After
time

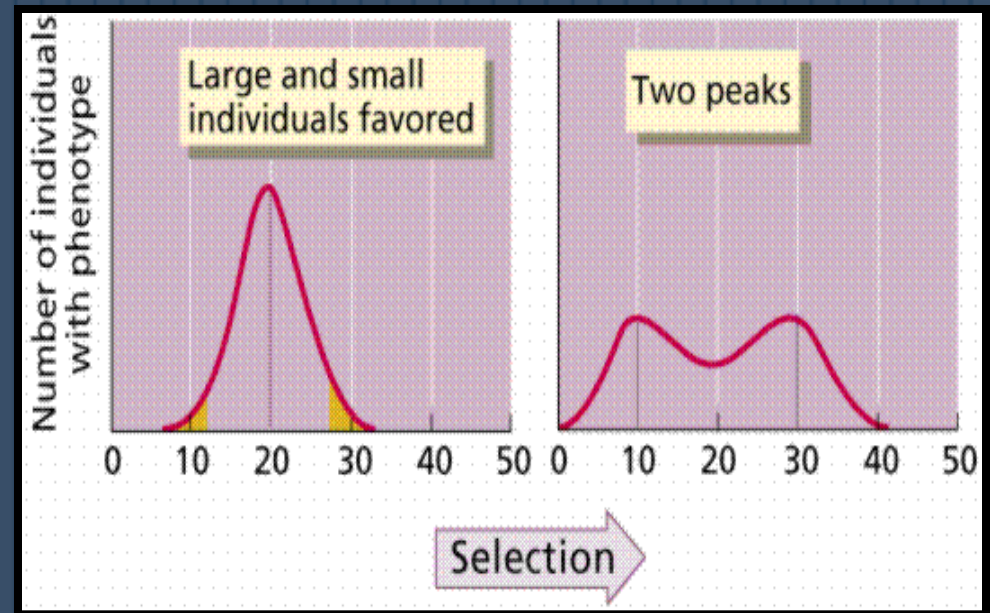


After
more
time



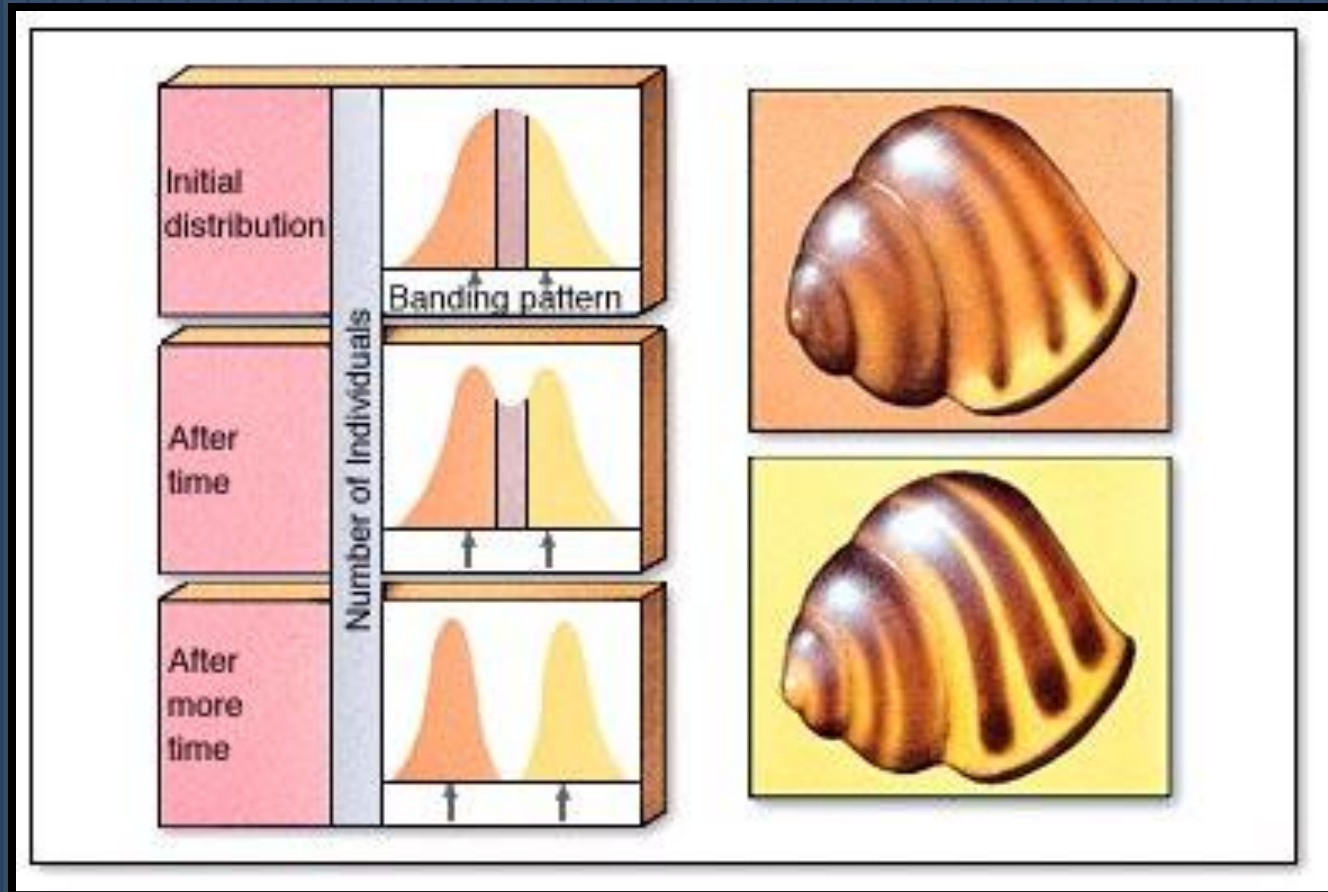
What is disruptive evolution?

- In disruptive evolution, extremes in phenotypes are favored, as they are better fit for the environment than an intermediate phenotype.
- This results in 2 peaks on the distribution curve.

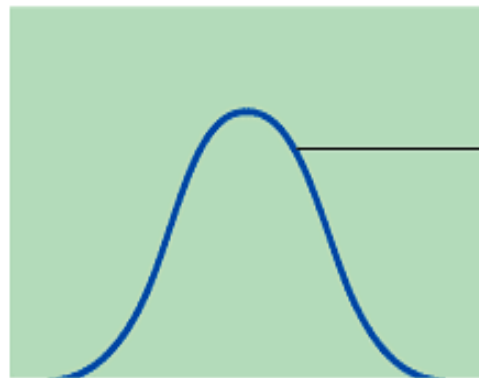


What is disruptive evolution?

- Snails are a great example of disruptive evolution. In darker forests, darker snails escape predators better than lighter snails. In lighter, less-dense areas, lighter snails blend better than darker snails, escaping predation by thrushes.



↑
Frequency of
individuals

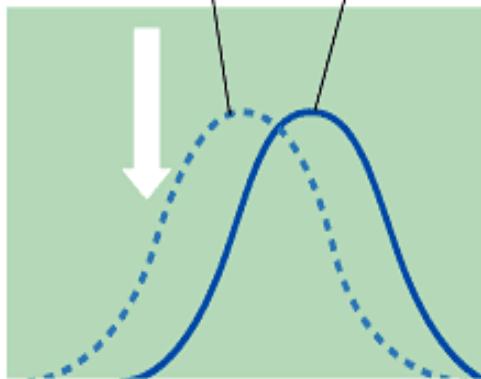


Original population

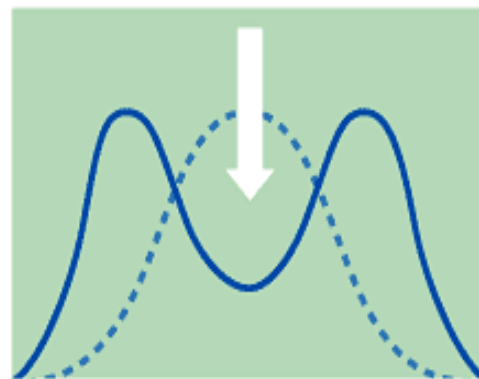


Phenotypes (fur color)

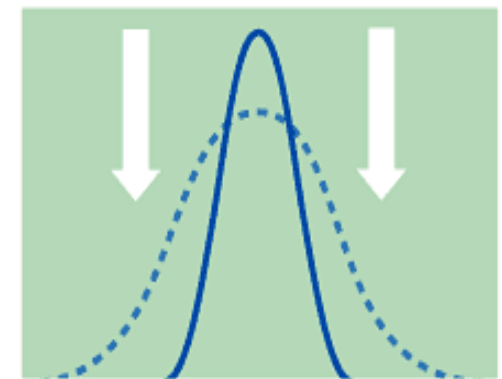
Original population Evolved population



(a) Directional selection



(b) Diversifying selection



(c) Stabilizing selection

What is the result of disruptive evolution?

- Disruptive evolution can lead to speciation, or the creation of 2 new species from 1 original species.

What defines a species?

- A species is a group of individuals that share a common gene pool, can interbreed, and are reproductively isolated from every other species.
- When speciation occurs, two groups of individuals are so dissimilar that they will no longer breed. They are said to be reproductively isolated from other species.

How does reproductive isolation occur?

- Reproductive isolation occurs when a structural, functional, or behavioral obstacle prevents reproduction from occurring.
- Reproductive isolation can occur because of prezygotic or postzygotic factors:

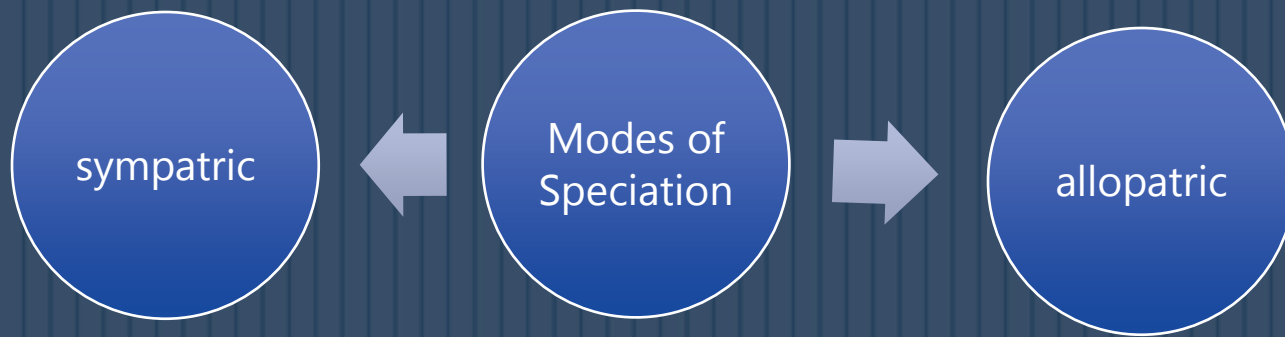
Prezygotic Isolation:
prevents fertilization from occurring

- habitat: where reproduction occurs
- temporal: when reproduction occurs
- behavioral: how organism act during reproduction
- mechanical: differences in reproductive structures

Postzygotic Isolation:
prevents successful development

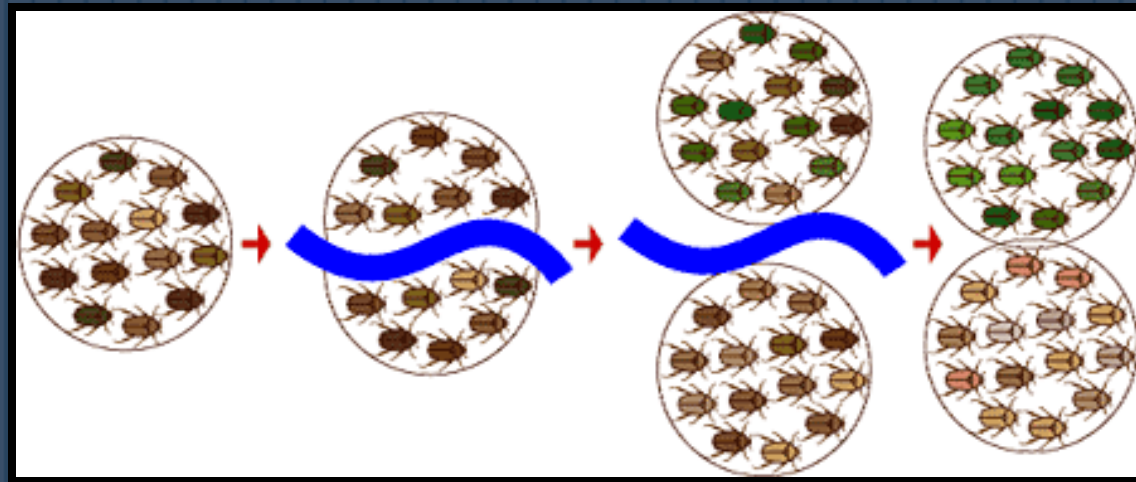
- gamete isolation: gametes are incompatible
- zygote mortality: hybrids do not live to reproduce
- hybrid sterility: sterile offspring (mules, tiger muskies)

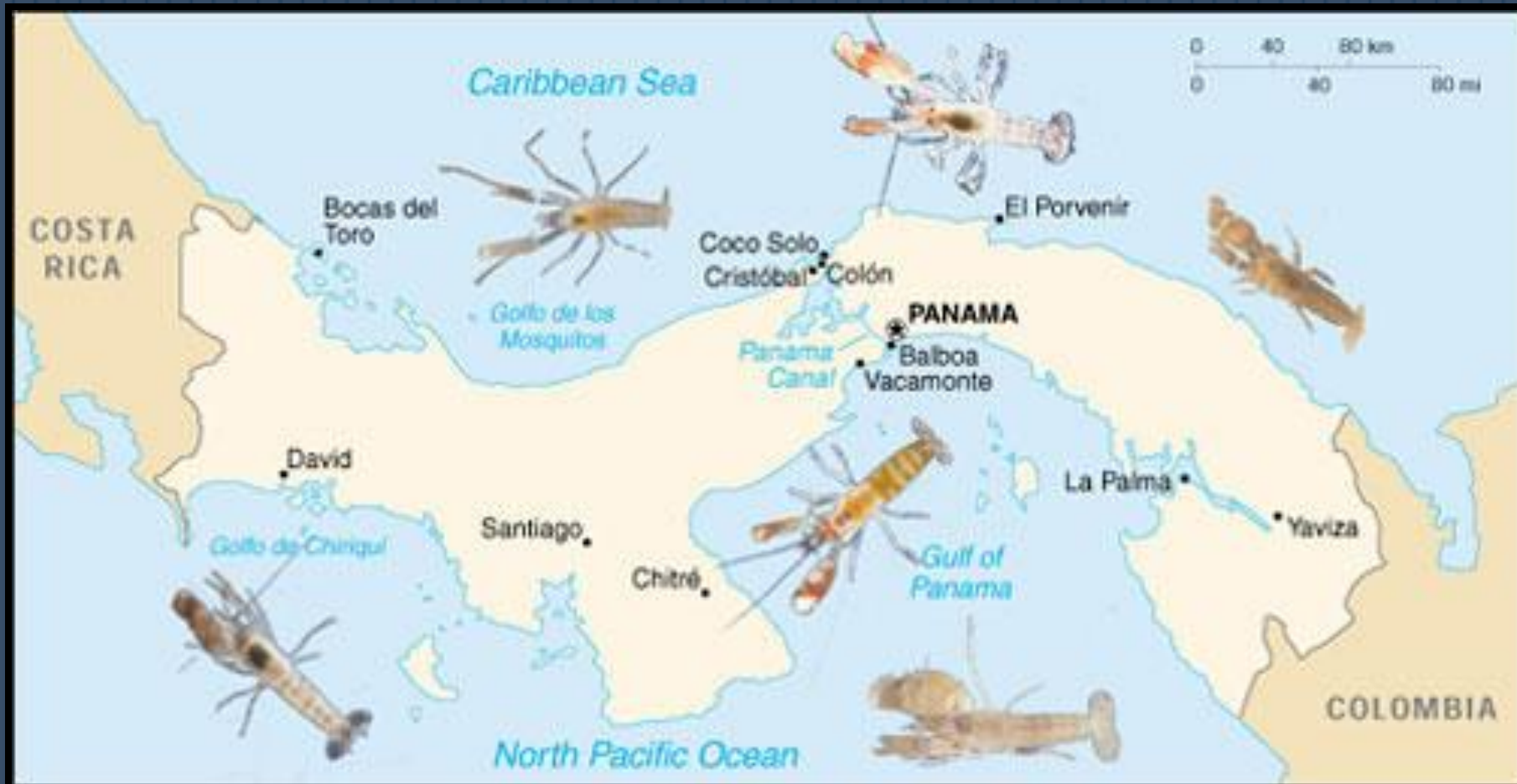
How does speciation occur?



What is allopatric speciation?

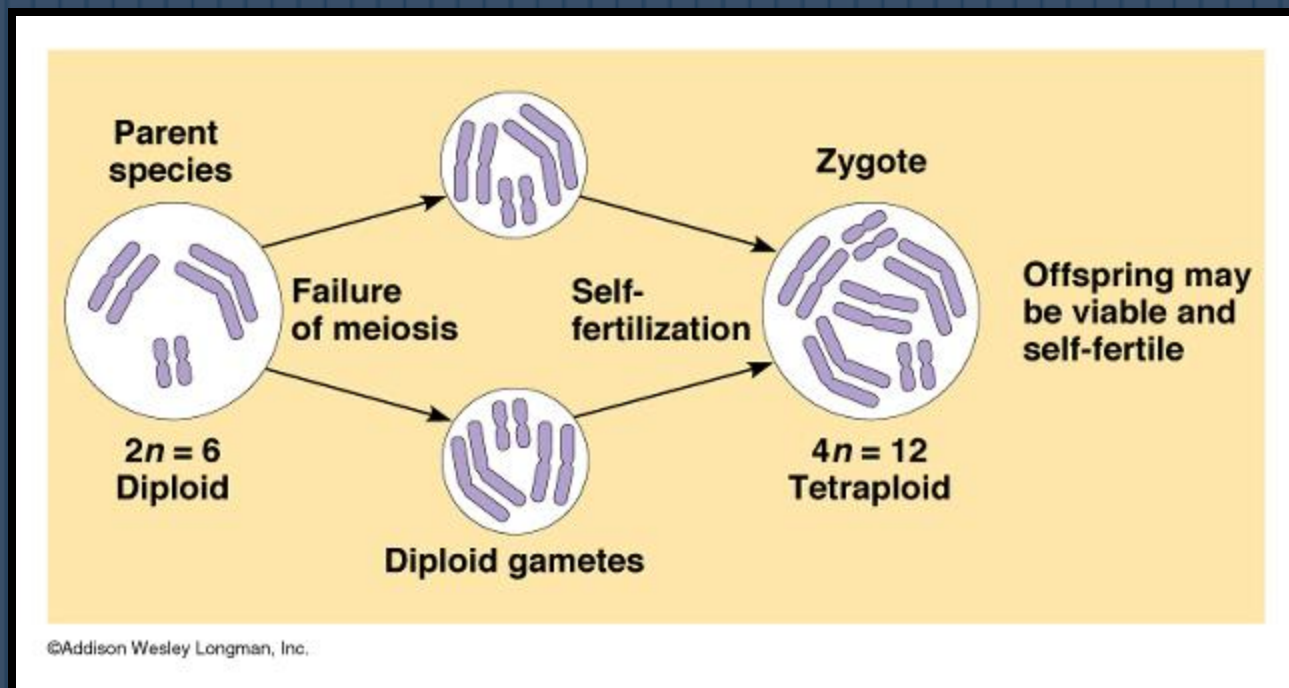
- Allopatric speciation occurs when geographic barriers prevent populations from breeding.
- Populations diverge when enough variation has accumulated that they can no longer interbreed.





What is sympatric speciation?

- Allopatric speciation occurs individuals within a population develop mutations that do not allow them to breed with the parental generation.
- A change in chromosome number could result in sympatric speciation.
- This type of speciation occurs in plants, where a failure to reduce the number of chromosomes results in polyploid plants. These polyploids will reproduce successfully with other polyploids.



What is adaptive radiation?

- Adaptive radiation involves the evolution of several new species from an ancestral species.
- Adaptive radiation occurs as natural selection drives members of the ancestral species to adapt to several different environments.

