Chapter 17: Evolution of populations

Dr. Bertolotti

Essential Question:

How does genetics explain evolution?

How are camas, zorses, ligers and tions similar?

Previous vocabulary

- **Population**- group of individuals of the SAME species that live in the same area
- **Species**- a group of similar organisms that can breed and produce FERTILE offspring
- **Allele**- one of a number of different forms of a gene
- **Phenotype**- physical characteristics of an organism
- **Genotype**- genetic make-up of an organism

WARNING

The following slides are ***hybrids*** produced through artificial selection (human involvement) and do not naturally occur in the wild. Some of these organisms are infertile (typically males) because each parent belongs to a different species.

Each hybrid does NOT represent a new species!

And yes, they are all real…

Cama (camel and llama)-infertile

Zorse (zebra and horse)- infertile

Liger (lion and tiger)

Male lion and female tiger parents.

~~Male ligers are sterile but females can reproduce.~~

Tigon (tiger and lion)- infertile

Male tiger and female lion parents.

The male tigon is sterile but the female is fertile.

QUESTION AND ANSWER

How are camas, zorses, ligers and tions similar?

How is evolution defined in genetic terms?

- **Gene Pool**: All the genes, including the different alleles for each gene, that are present in a population at any one time.
  - Homozygous lethal traits can be carried by heterozygous individuals and thus remain in a gene pool.

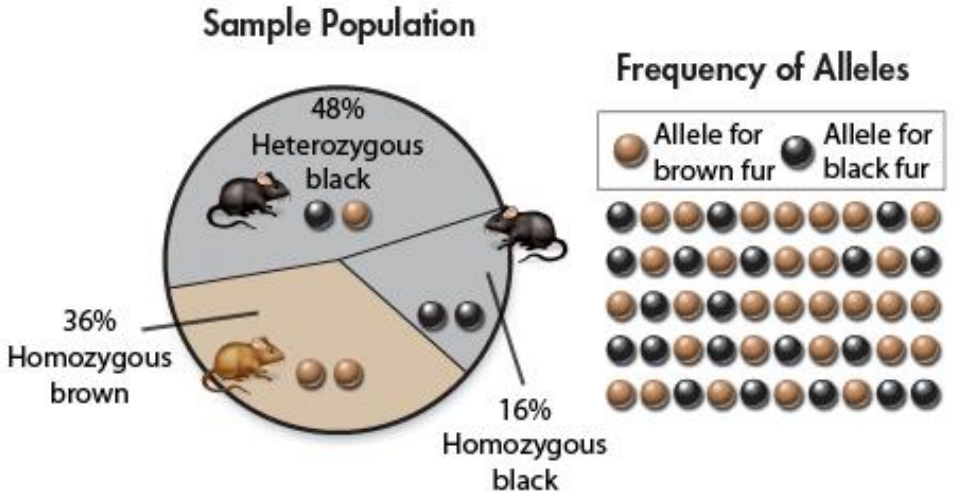
- **Allele Frequency** is the number of times an allele occurs in a gene pool compared with the number of times other alleles occur.
  - It is often expressed as a percentage.
    - Ex. the allele frequency of the dominant *A* allele (widow's peak) is 40% and the allele frequency of the recessive *a* allele (no widow's peak) is 60%

- ***In genetic terms, evolution is any change in the relative frequency of alleles in a population***

Video:
Gene Pools

Populations and Gene Pools

- Researchers study gene pools by examining the **relative frequency** of an allele. The relative frequency of an allele is the number of times a particular allele occurs in a gene pool, compared with the number of times other alleles for the same gene occur.



Natural Selection

- Over time natural selection results in changes in the inherited characteristics of a population. These changes increase a species' ***fitness*** *(ability to survive and reproduce)* in its environment. Organisms that are better suited to their environment are more likely to survive, reproduce, and pass on their genes to the next generation (i.e., more fit).

- Natural Selection acts on the **phenotype** rather than the genotype of a species.
  - Natural selection acts on the entire organism- not a single gene- because it is the entire organism that either survives and reproduces or dies without reproducing.

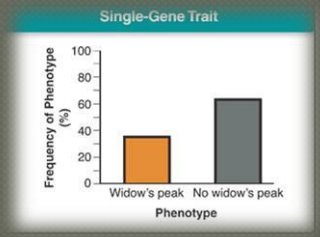
QUESTION AND ANSWER

How is evolution defined in genetic terms?

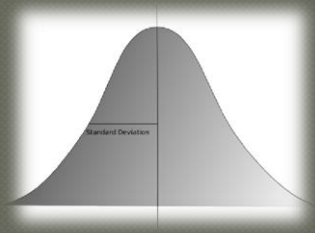
What determines the number of phenotypes for a given trait?

The number of phenotypes produced for a given trait depends on how many genes control the trait

- **A single gene trait** is a trait controlled by a single gene that has 2 alleles
  - Variation in this gene leads to only 2 or 3 distinct phenotypes
  - Examples: widow's peak and tongue rolling
  - Represented by a bar graph



- **A Polygenic trait** is a trait controlled by 2 or more genes
  - Variation in these genes leads to variations in phenotypes
  - Examples: height and skin color
  - Represented by a symmetrical bell-like shape curve of normal distribution



QUESTION AND ANSWER

What determines the number of phenotypes for a given trait?

How does natural selection affect single gene and polygenic traits?

Natural Selection on Single-Gene Traits

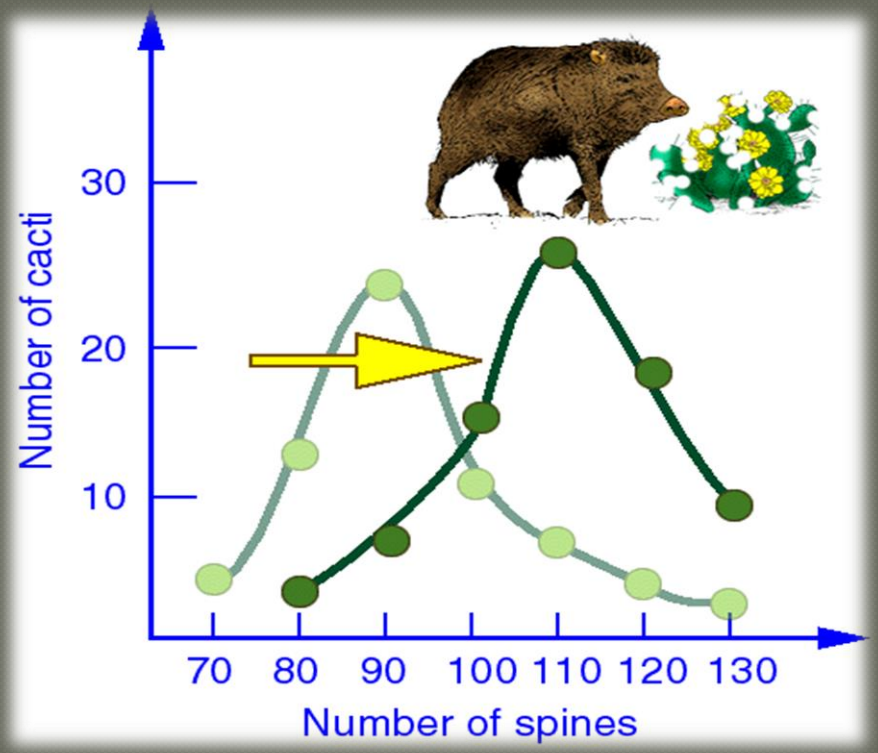
- Natural selection on single-gene traits can lead to changes in allele frequencies, and, thus to changes in phenotype frequencies.
- If the change is beneficial to the organism, the change may cause the original form to fade out and the newer organisms to be more fit and take over.

Natural Selection on Polygenic Traits

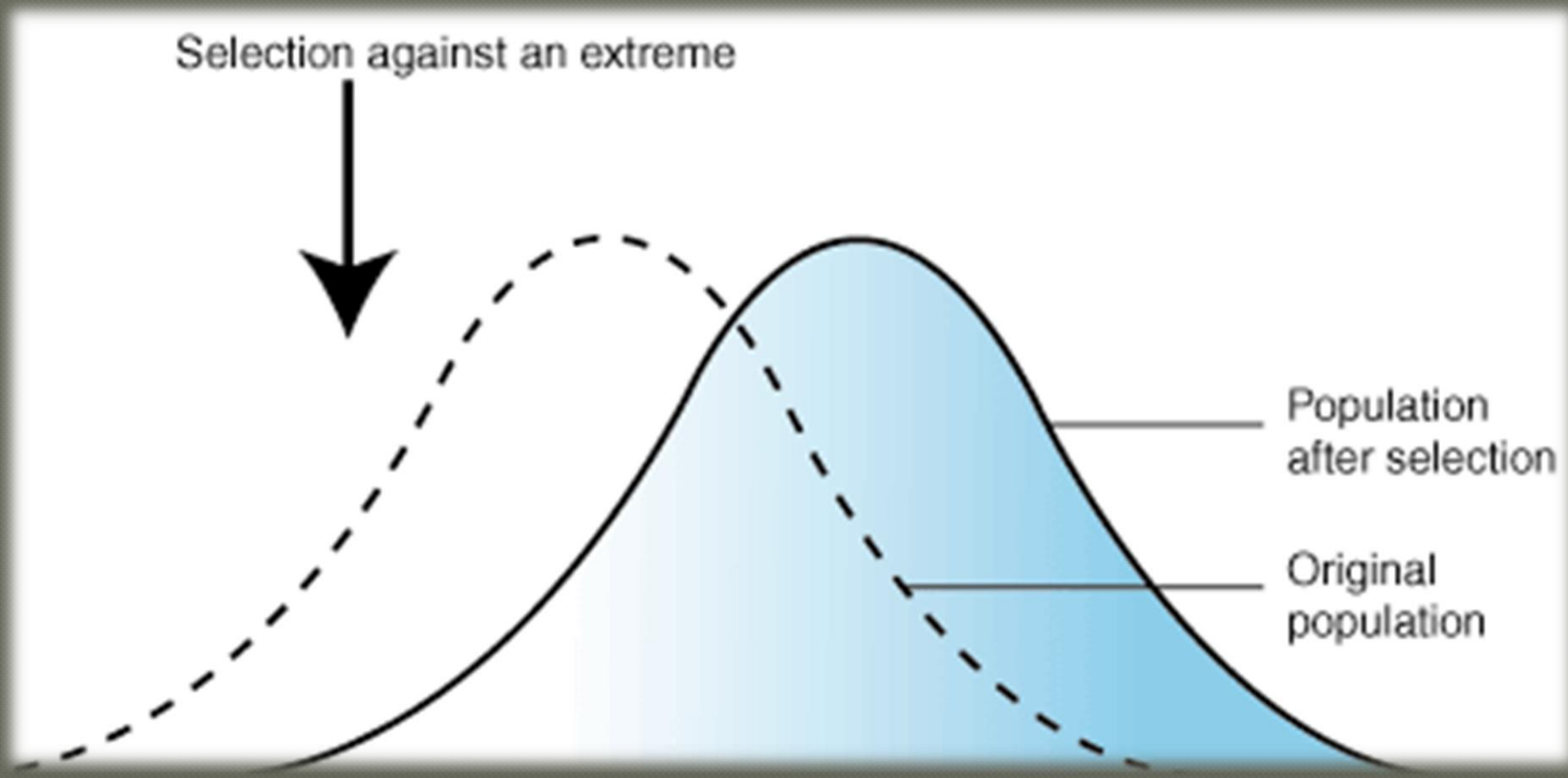
- The effects of natural selection is more complex when they are controlled by more than 1 gene because the fitness of individuals may vary from one end of the bell-shaped curve to the other
- Natural Selection can affect the distribution of phenotypes in a population in any of three ways:
  - 1.directional,
  - 2. disruptive, and
  - 3. stabilizing.

1. Directional Selection

- Directional Selection – Evolution causes an increase in the number of individuals with the trait at one end of the curve.
- This is because individuals at one end of the curve have higher fitness than individuals in the middle or at the other end.
- Individuals at one end of the curve are favored so they contribute more offspring so the curve shifts in one direction .

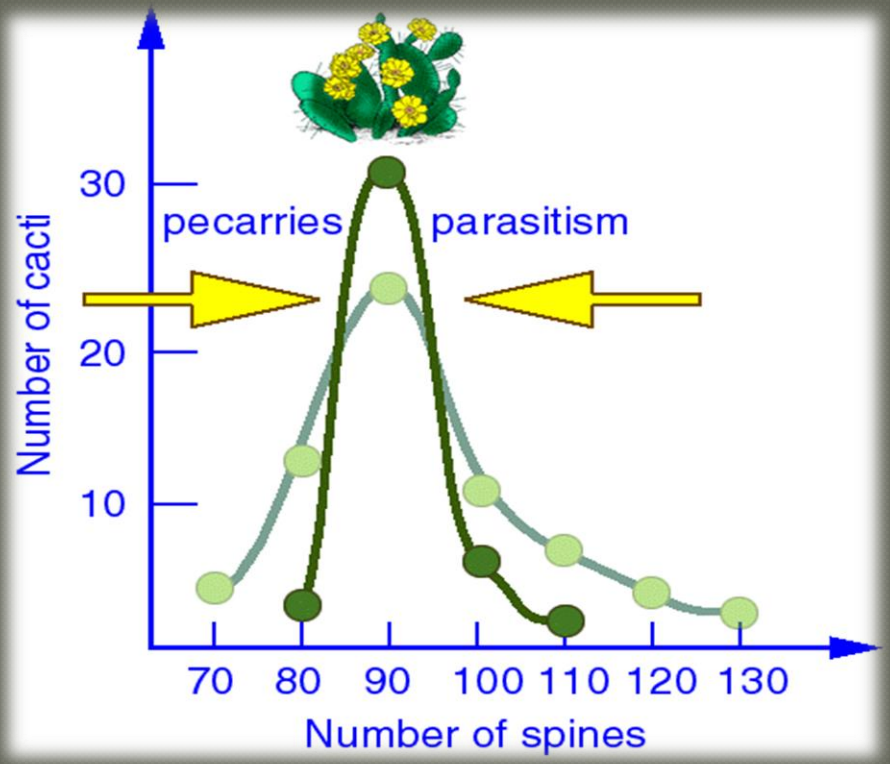


Directional selection

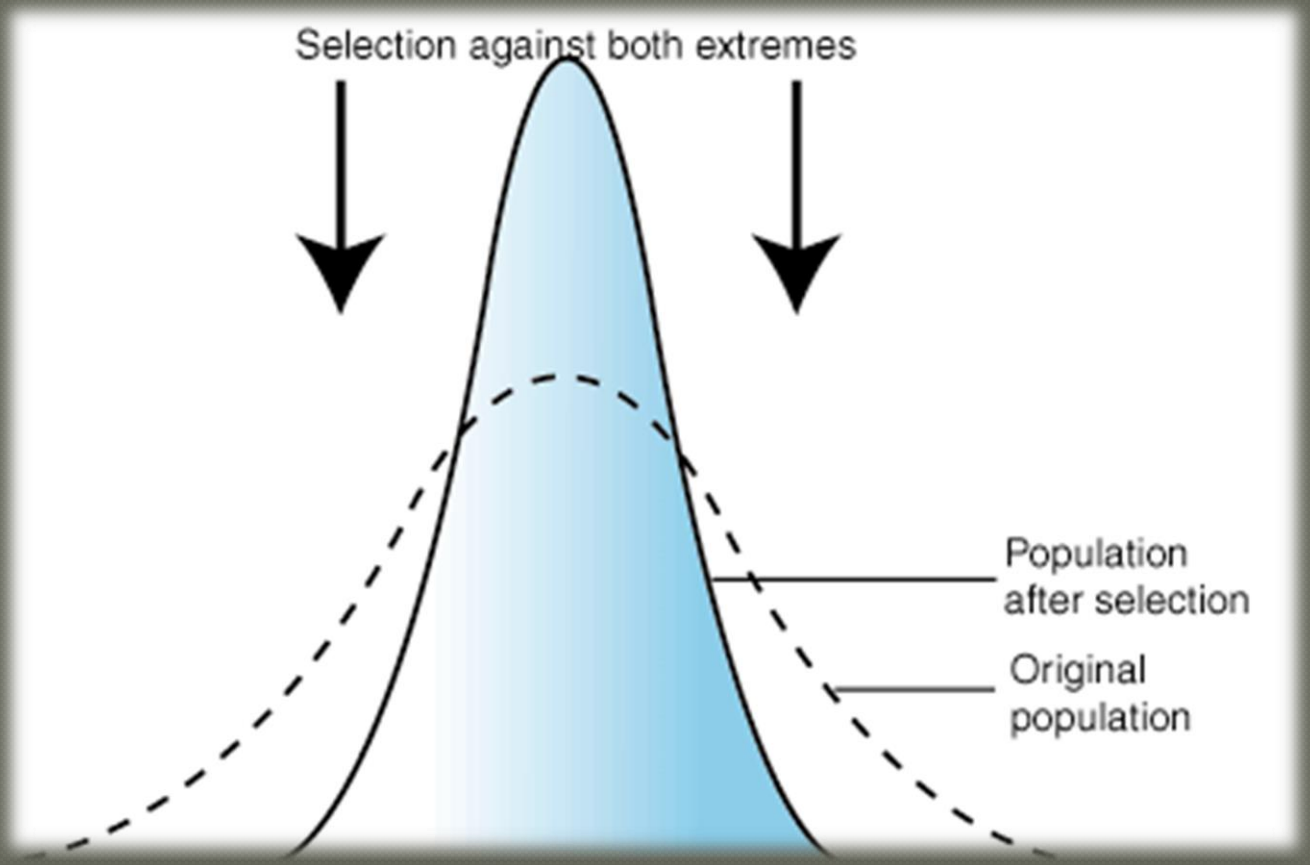


2. Stabilizing Selection

- Individuals in the center of the curve are more fit and thus the curve narrows

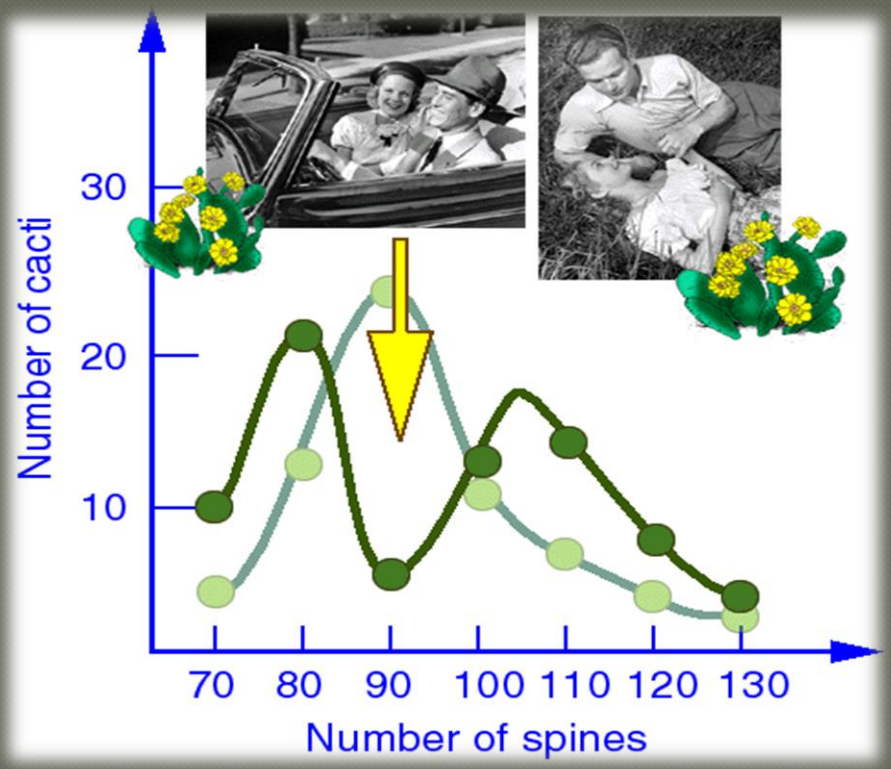


Stabilizing selection- average individuals are favored so the middle of the curve increases.

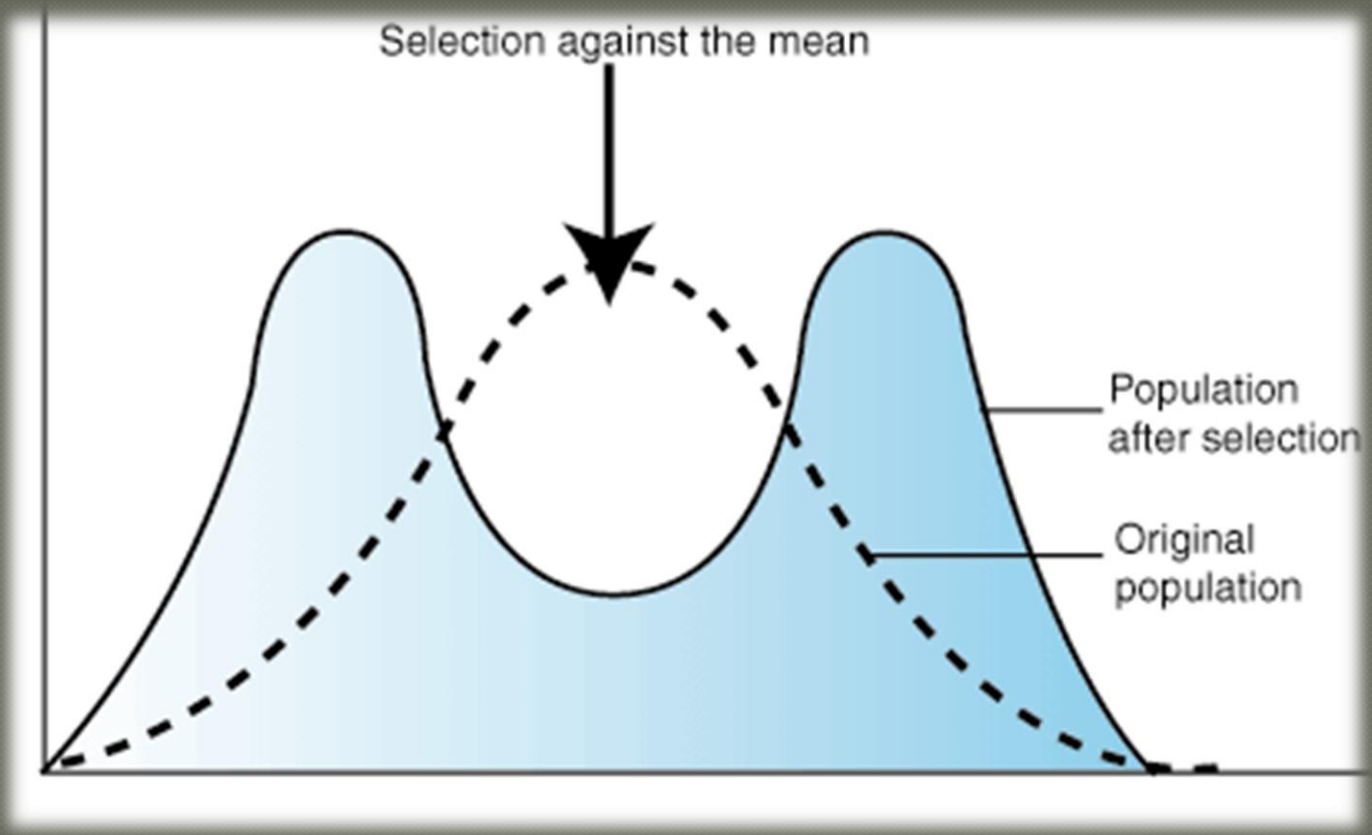


3. Disruptive Selection

- Individuals at the ends of the curve are more fit than the ones in the middle causing two curves to form and possible new species to form.



Disruptive selection- individuals at both extremes are favored so they contribute more offspring and two peaks result over time.



QUESTION AND ANSWER

How does natural selection affect single gene and polygenic traits?

What are other mechanisms of evolution other than natural and sexual selection?

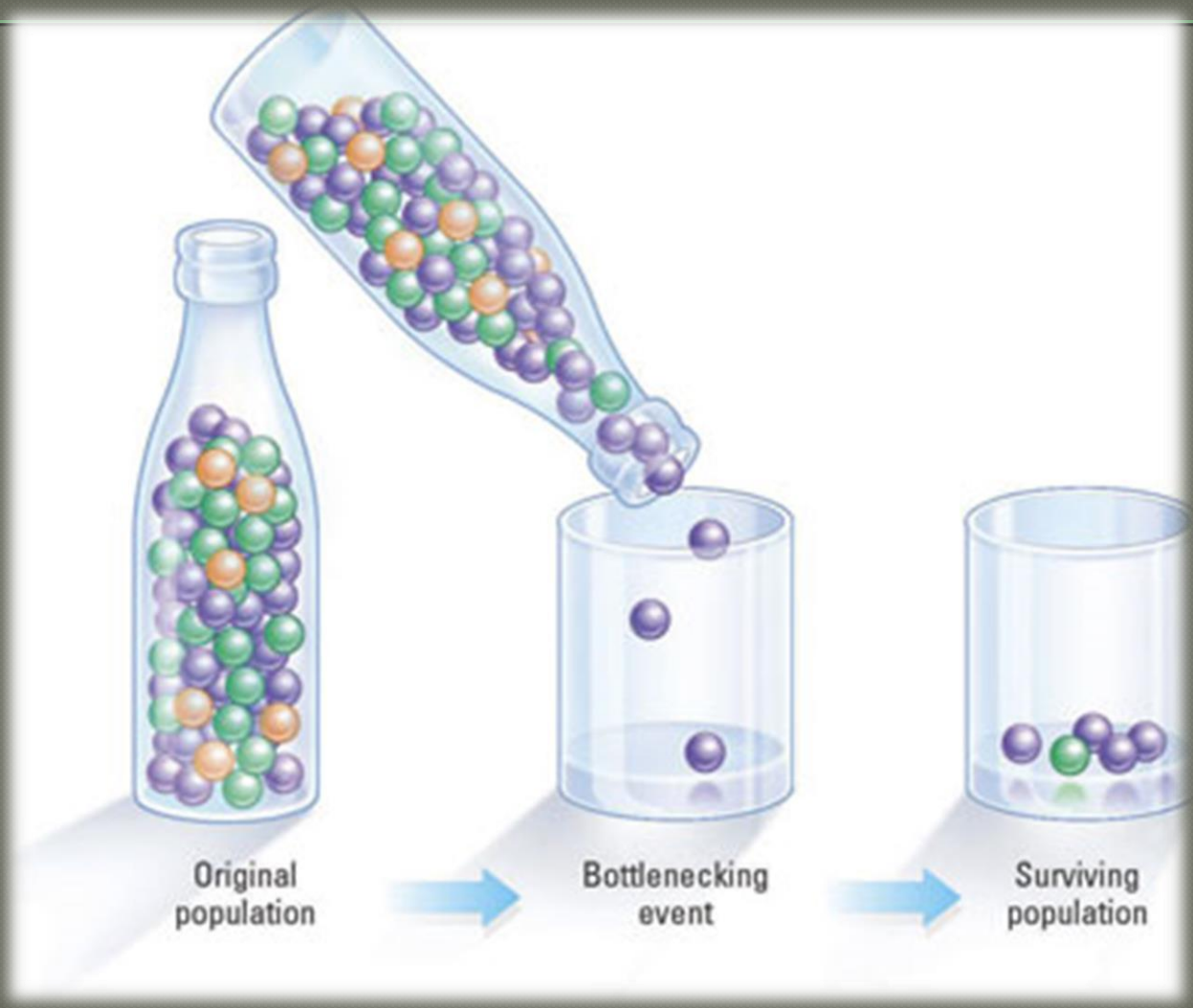
Genetic Drift

- Natural selection is not the only source of evolutionary change.
- In small populations, individuals that carry a particular allele may leave more descendants than other individuals, just by chance. Over time, a series of chance occurrences of this type can cause an allele to become common in a population.
- This random change in allele frequency is called **genetic drift**
- Examples: bottleneck effect or founder effect

Genetic Bottlenecks

- **Bottleneck effect**: is a change in allele frequency following a dramatic reduction in the size of the population
- Can occur due to a disaster, such as disease, that can kill many individuals in a population
- By chance, the smaller population's gene pool may have allele frequencies that are different from the original gene pool

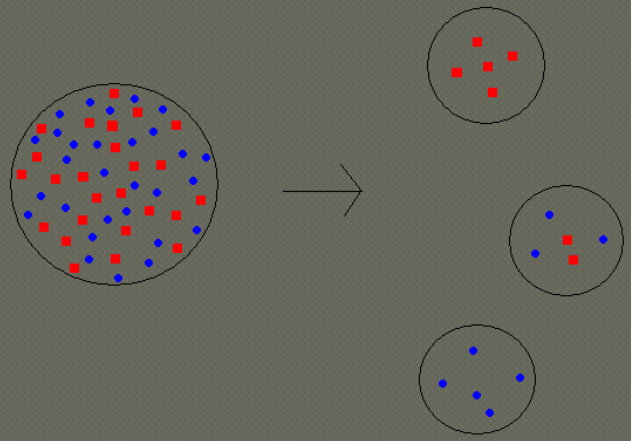
Bottleneck Effect



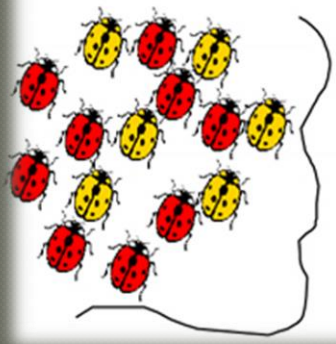
The Founder Effect

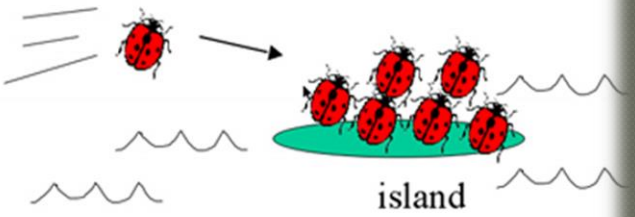
- Genetic drift can also occur when a few individuals colonize a new habitat.
- The founding individuals may carry alleles that differ in relative frequencies from those of the main population, just by chance.
- The new gene pool may therefore start off with allele frequencies different from those of the parent gene pool
- **Founder effect**: the situation, in which allele frequencies change as a result of the migration of a small subgroup of a population.

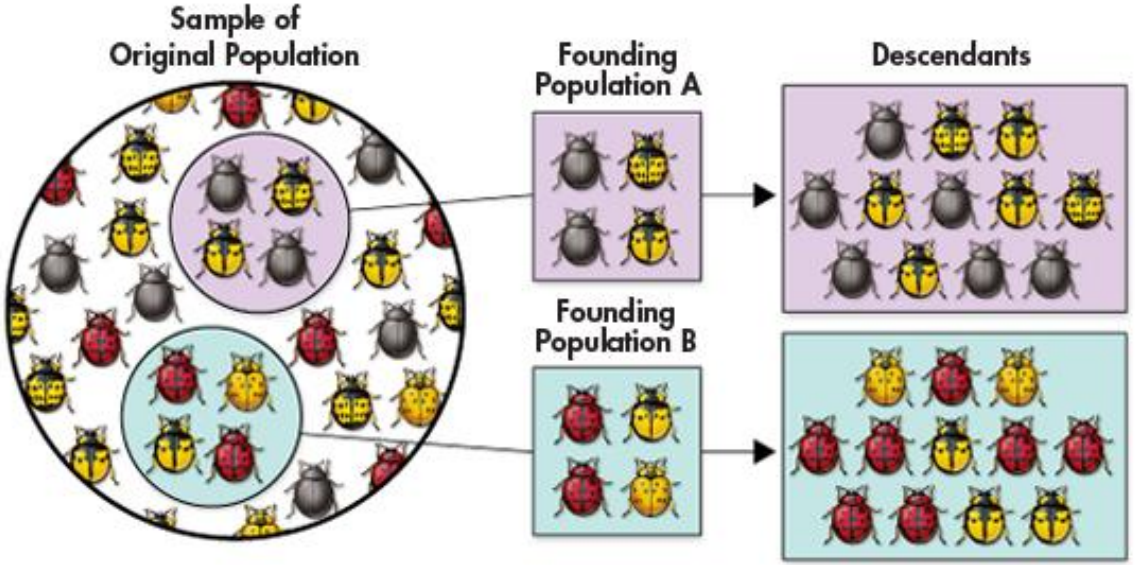
Founder Effect



- **founder effect**: a few individuals from a population start a new population with a different allele frequency than the original population







QUESTION AND ANSWER

What are other mechanisms of evolution other than natural and sexual selection?

What conditions are required to maintain genetic equilibrium?

Hardy-Weinberg

- **Genetic equilibrium:** situation in which allele frequencies in a population remain the same
- The **Hardy Weinberg principle** states that allele frequencies in a population should remain constant unless one or more factors cause those frequencies to change.
  - Represented by the equation:
    - $p^2 + 2pq + q^2 = 1$ and $p + q = 1$

- The Hardy-Weinberg principle predicts that five conditions can disturb genetic equilibrium and cause evolution to occur. They are:
  - 1. Nonrandom mating
  - 2. Small Population
  - 3. Movement in or out of the population (Immigration and Emigration)
  - 4. Mutations
  - 5. Natural Selection

***These conditions are NEVER all met, so populations are always changing and NOT in H-W equilibrium.

- A population is in genetic equilibrium if allele frequencies in the population remain the same. If allele frequencies don't change, the population will not evolve.

Video:
Hardy Weinberg

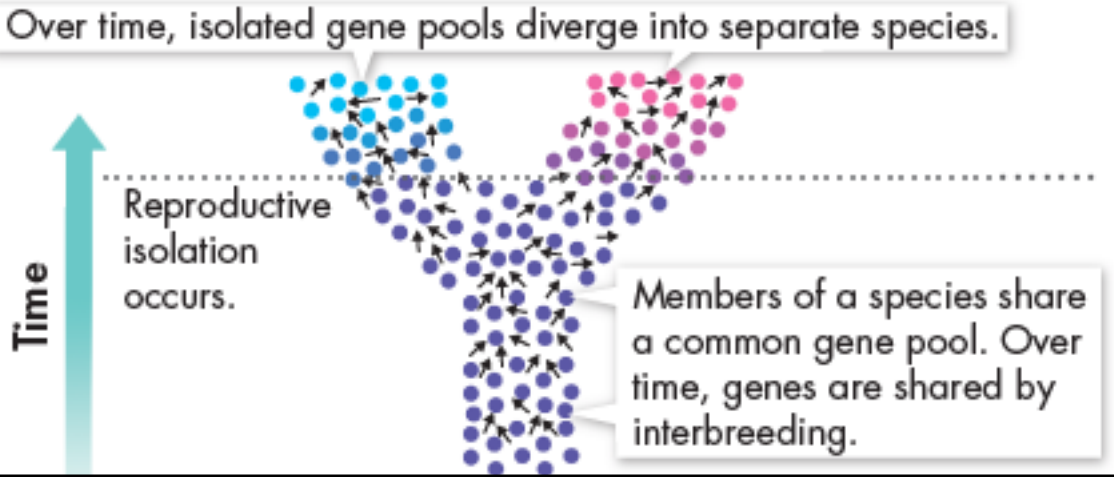
QUESTION AND ANSWER

What conditions are required to maintain genetic equilibrium?

What types of isolation lead to the formation and maintenance of new species?

Speciation

- The formation of a new species is called **speciation**
- If members of a population stop breeding with other members, the gene pool can split. Once a population has thus split into 2 groups, changes in one of those gene pools cannot spread to the other. Because these 2 populations no longer interbreed, reproductive isolation has occurred.
- **Reproductive Isolation:** separation of a species or population so that they no longer interbreed and evolve into 2 separate species.
- When populations become reproductively isolated, they can evolve into 2 separate species. Reproductive isolation can develop into a variety of ways, including behavioral isolation, geographic isolation, and temporal isolation.



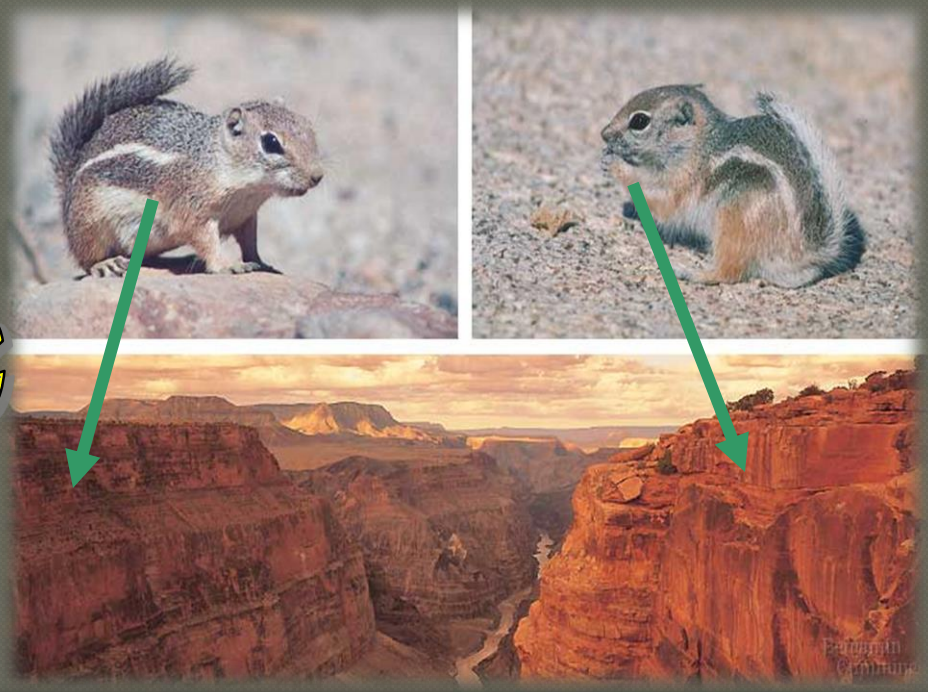
Types of Isolation

There are 3 types of isolation mechanisms that prevent mating between organisms of different species. They are:

- **Behavioral Isolation** – Two populations capable of interbreeding but have differences in courtship rituals or other types of behavior.
- **Geographic Isolation** – Populations are separated by geographic barriers such as rivers, mountains, or bodies of water.
- **Temporal Isolation** – Species reproduce at different times of the year.

An Example of Speciation

- **Geographical isolation:** members of a population are separated geographically→ leads to speciation.
  - Due to volcanoes, earthquakes, flooding, etc.
  - Can lead to divergence and then speciation.



Geographic Isolation!

QUESTION AND ANSWER

What types of isolation lead to the formation and maintenance of new species?

How can you determine how evolution occurs on the genetic (DNA) level?

Estimating evolutionary time

- Researchers compare stretches of DNA to mark the passage of time by studying a molecular clock
- A **molecular clock** is a method used by researchers that uses mutation rates in DNA to estimate the length of time that two species have been evolving independently.
  - Researchers compare neutral mutations of different species
  - The more differences there are between the DNA sequences of the two species, the more time has elapsed since the 2 species shared a common ancestor

Gene Duplication

- Modern genes are probably descendants of a smaller number of genes
- Genes evolved through duplication, and then modification of existing genes
- Researchers study hox genes to determine their influence on embryos and adults
- **Hox genes** are a group of genes that determine the head to tail identity of body parts in animals.
  - Therefore they determine which parts of the embryo develop arms, legs, and wings; as well as the size and shape of those structures

- Small changes in Hox gene activity during embryological development can produce large changes in adult animals
- Mutations can turn on/off the Hox gene which can alter the development of the organism
- In addition to Hox genes, the timing at which the embryo develops also affects the organism.
  - Small changes can result in changing the starting and stopping times of human development

QUESTION AND ANSWER

How can you determine how evolution occurs on the genetic (DNA) level?

QUESTION AND ANSWER

Essential Question:

How does genetics explain evolution?