Chapter 17 Section 1: Genetic Variation

Adapted from Holt Biology 2008

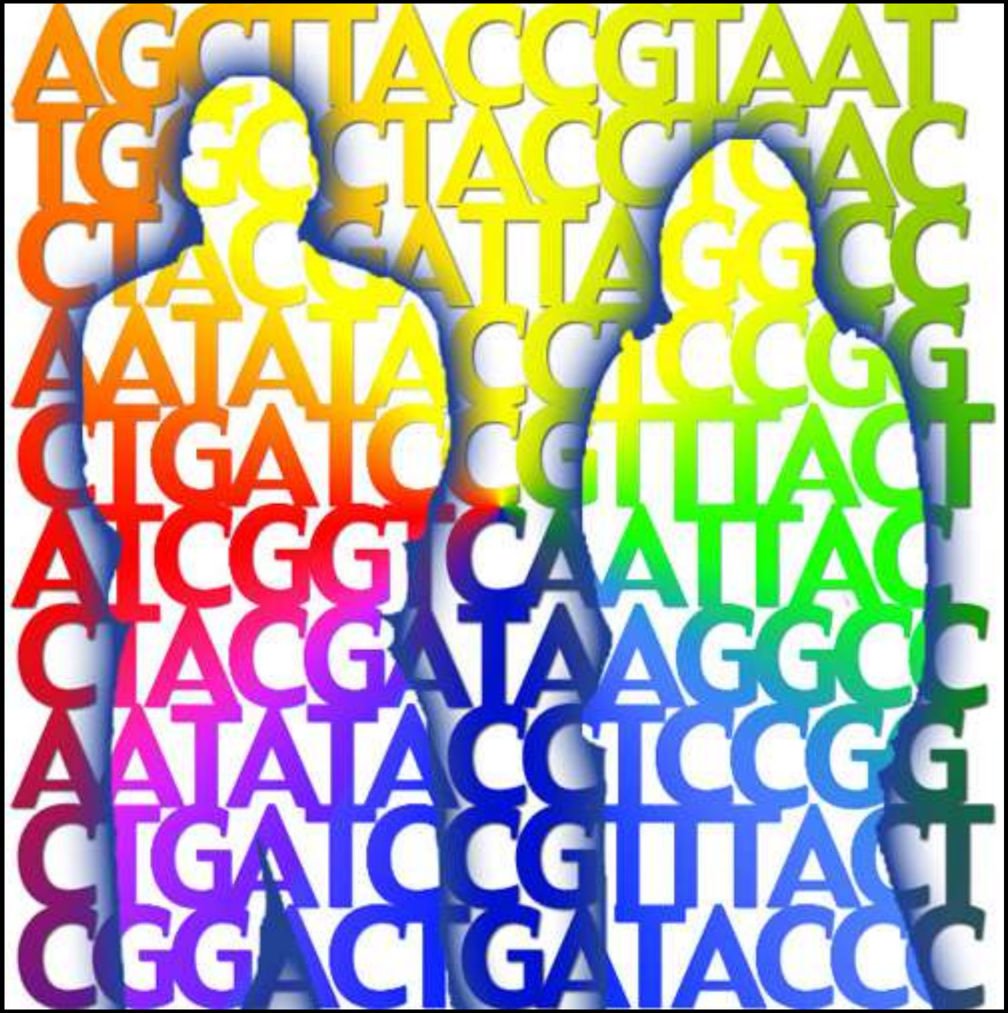
Chapter 17 Section 1: Genetic Variation

Key Vocabulary Terms

Adapted from Holt Biology 2008

Population genetics

The study of the frequency and interaction of alleles and genes in populations



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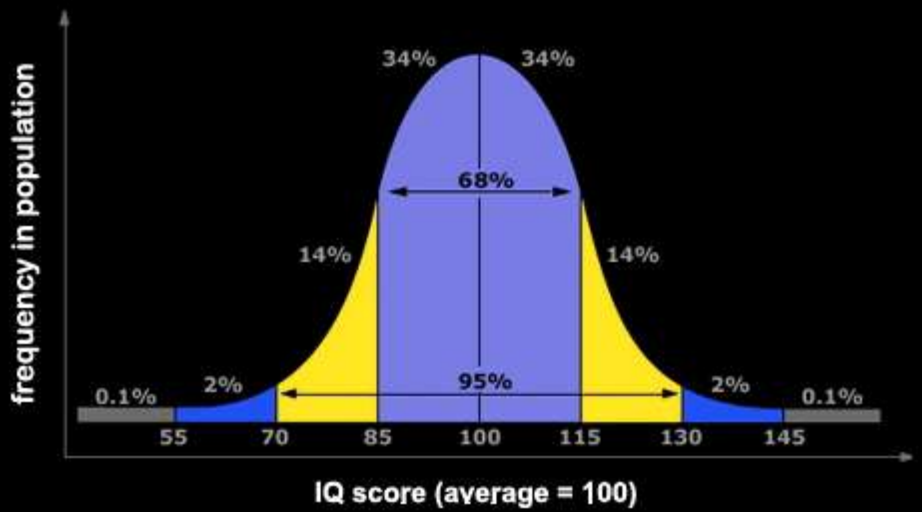
Normal Distribution

1. A distribution of numerical data whose graph forms a bell-shaped curve that is symmetrical about the mean.
2. A line graph showing the general trends in a set of data of which most values are near the mean (average).



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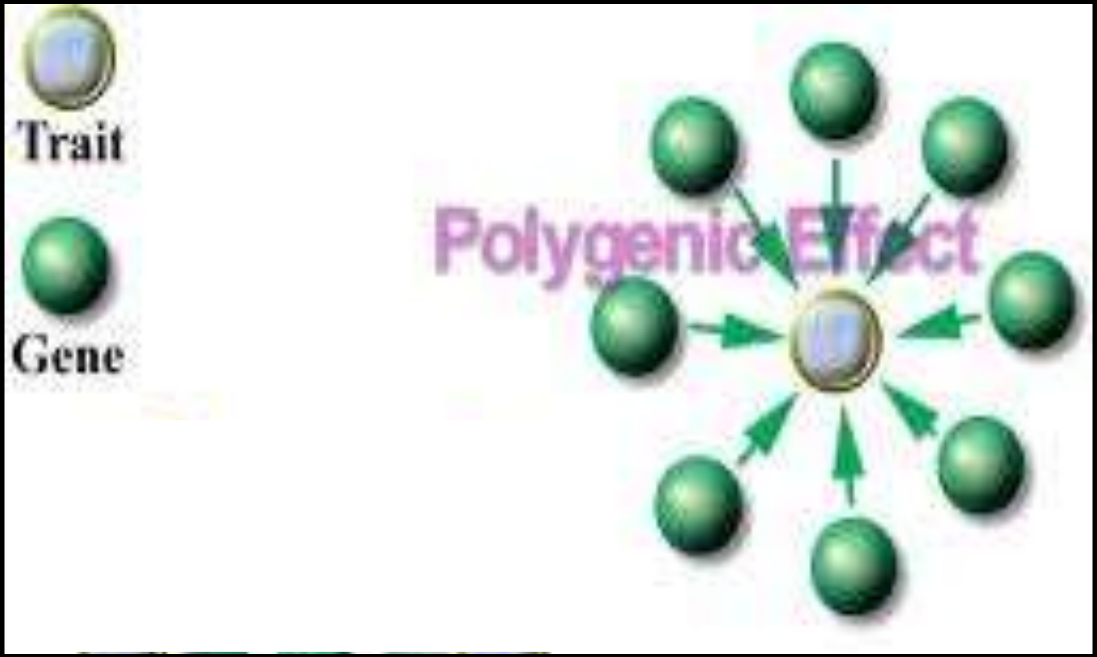
Polygenic

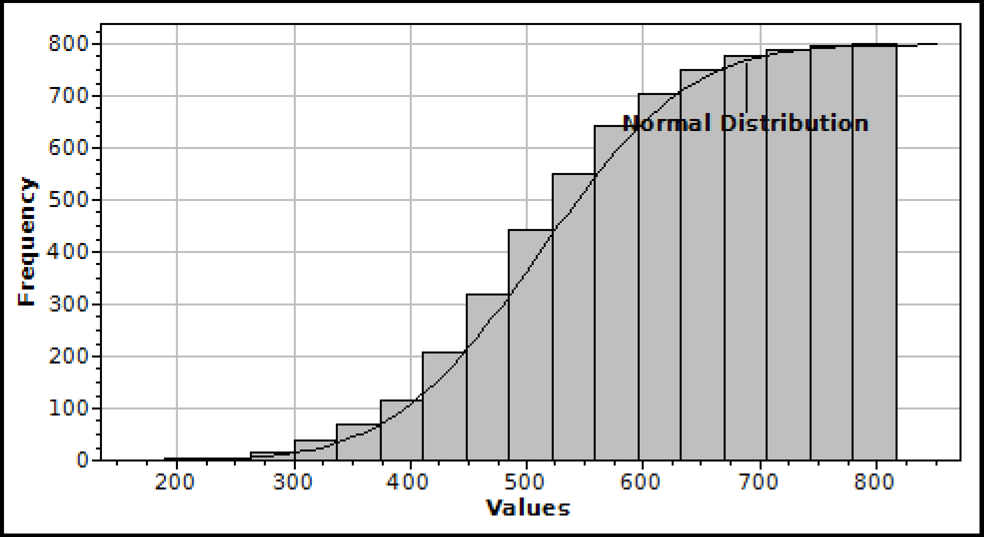


A character that is influenced by several genes

Adapted from Holt Biology 2008
Adapted from Holt Biology 2008

Distribution

An overview of the relative frequency and range of a set of values. Mathematically, a distribution is a tally or a histogram with a smooth line to show the overall pattern of the values.



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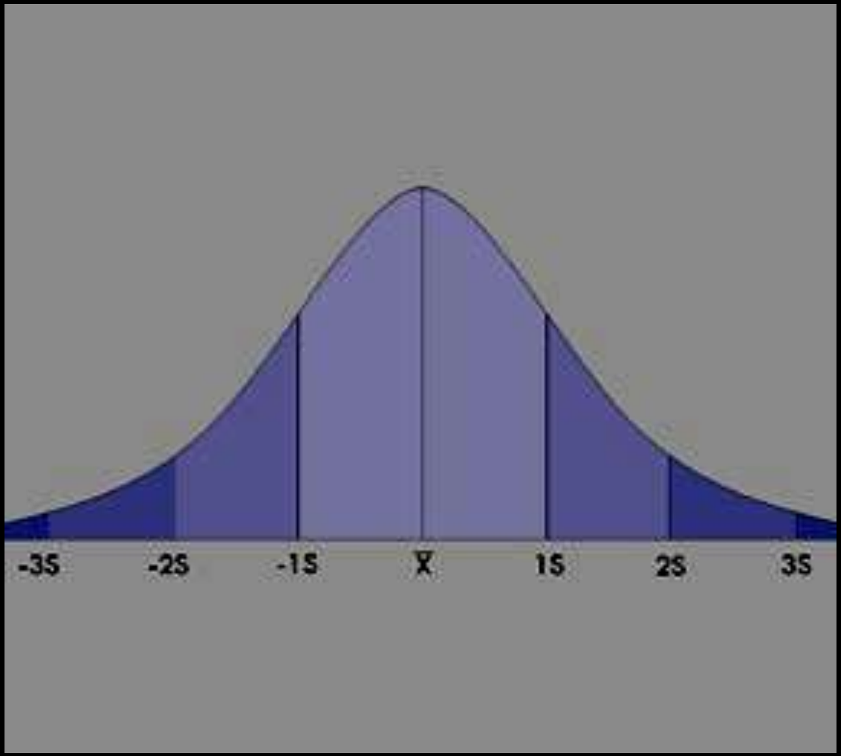
Bell curve

A symmetrical frequency curve



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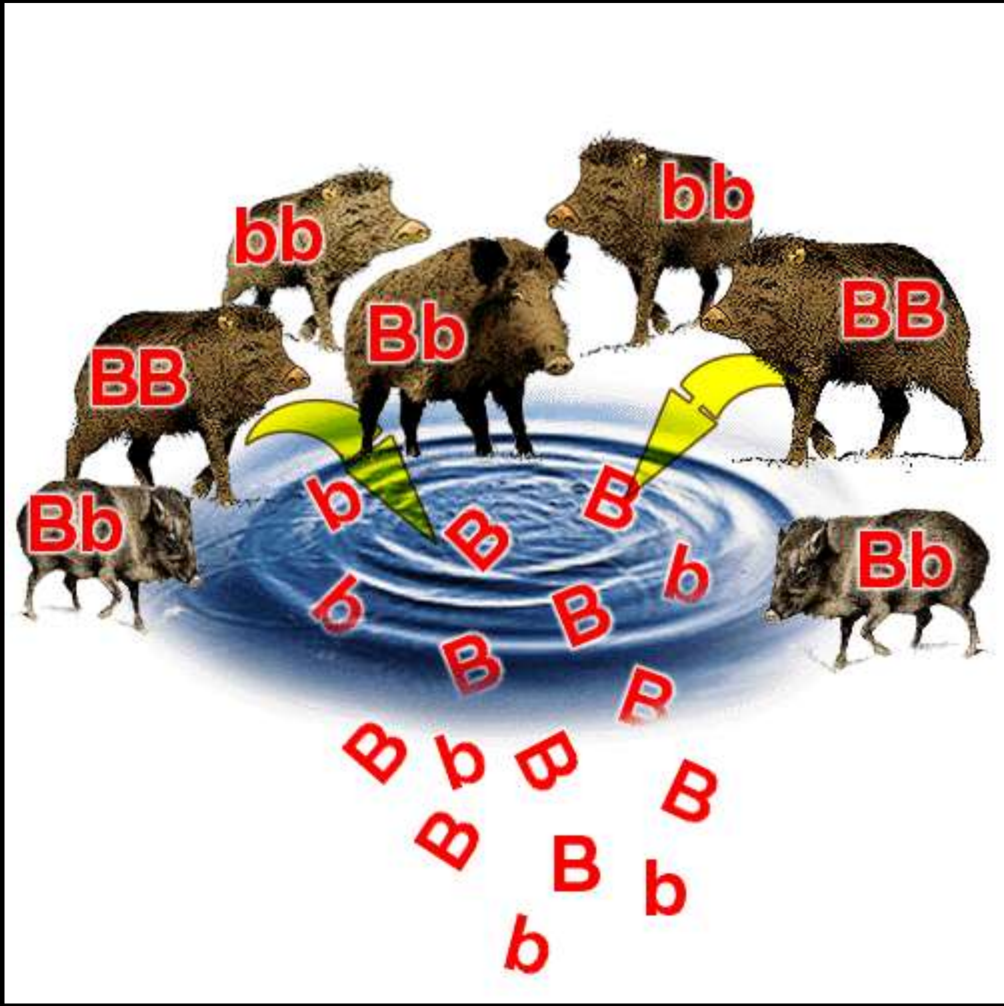
Gene pool

The particular combination of alleles in a population at any one point in time.



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Chapter 17
Section 1:
Genetic Variation

Notes

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Population Genetics

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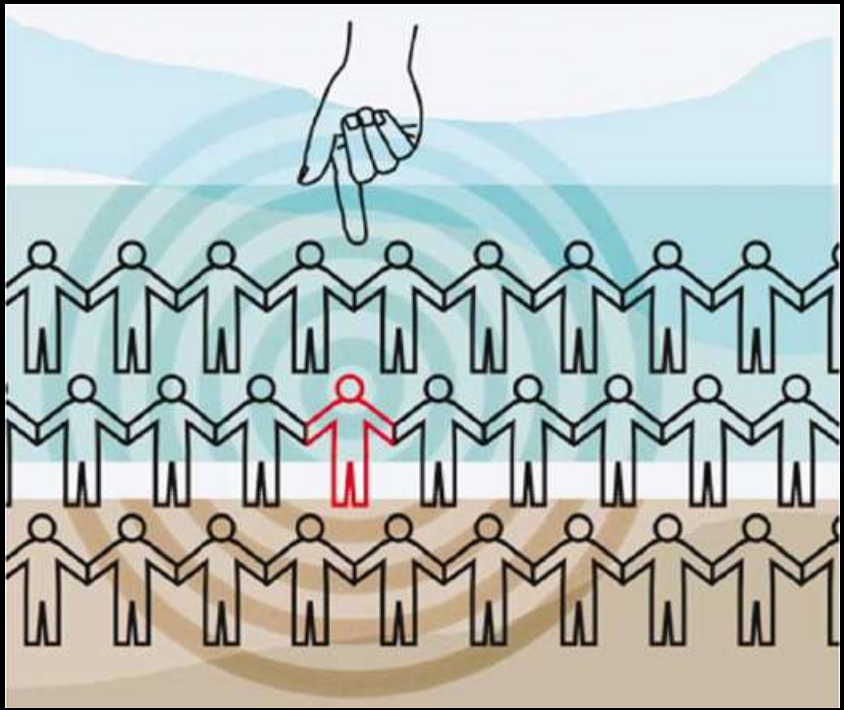
Population Genetics, *continued*

Microevolution can be studied by observing changes in the numbers and types of alleles in populations, called population genetics.



Adapted from Holt Biology 2008

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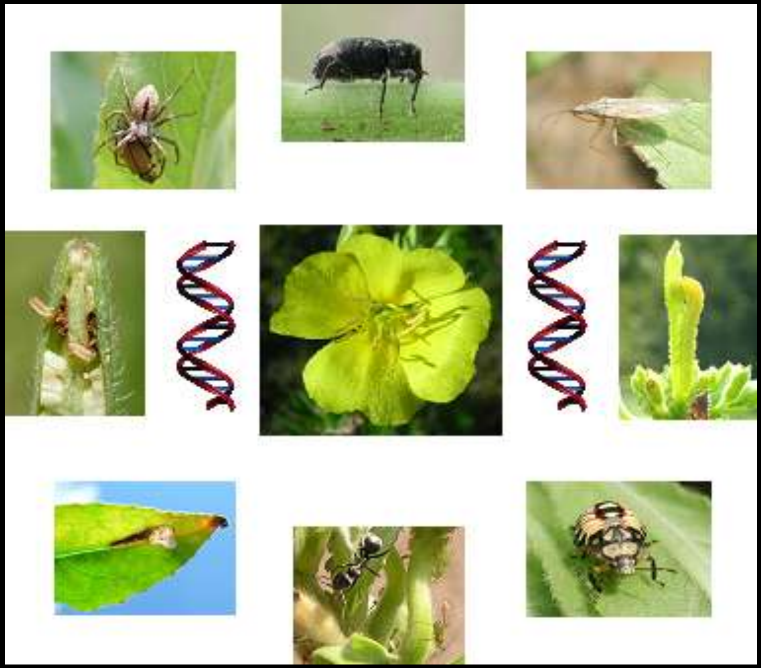
The fields of ecology, genetics, and evolutionary theory are brought together to understand how genetic changes in populations result in changes to species over time



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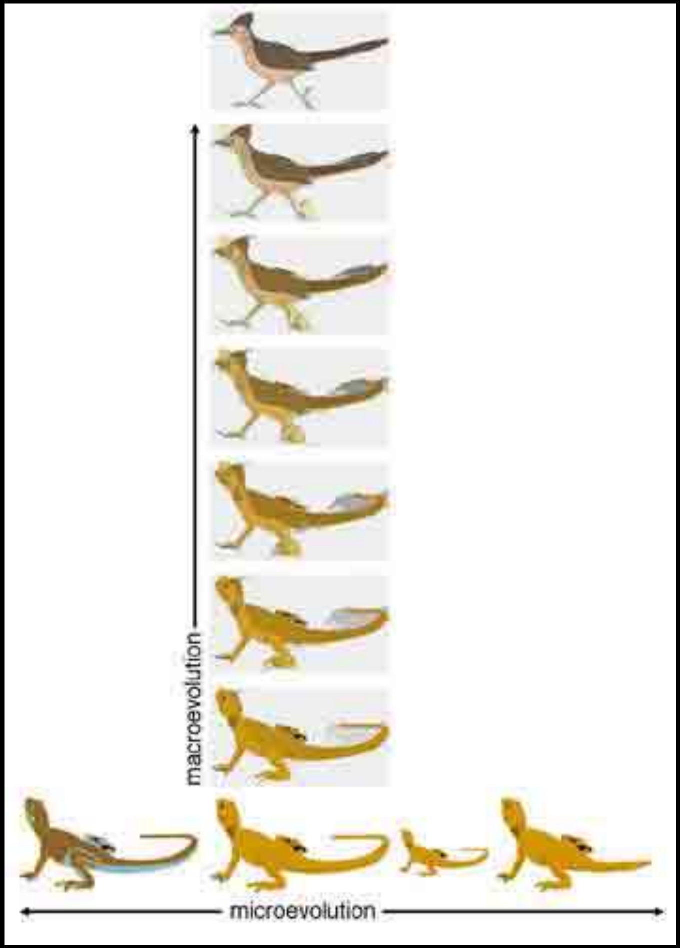
Population Genetics, *continued*

The link from microevolution to macroevolution — *speciation* — can be studied in detail.



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Adapted from Holt Biology 2008

YOUR TURN

Think, Write, Share & Re-write

What do we now know about heredity that Darwin did not know?

Adapted from Holt Biology 2008

Phenotypic Variation

Adapted from Holt Biology 2008
Adapted from Holt Biology 2008

Phenotypic Variation

The variety of phenotypes that exists for a given characteristic depend on how many genes affect it.

Adapted from Holt Biology 2008
Adapted from Holt Biology 2008

YOUR TURN

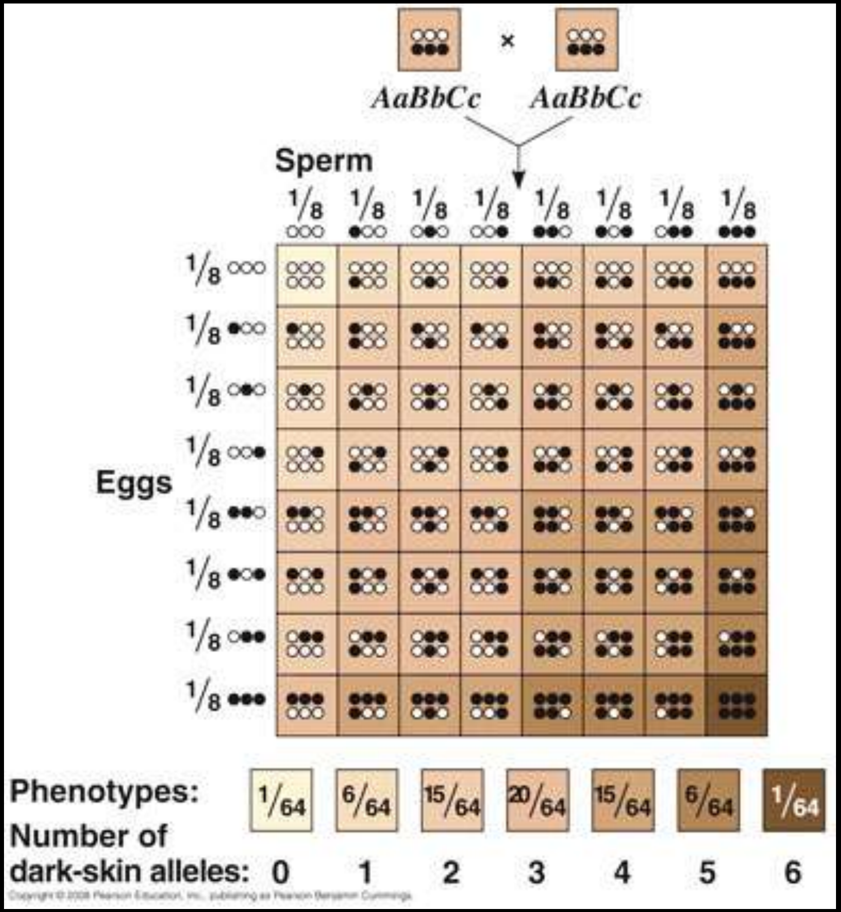
Think, Write, Share & Re-write

What kinds of variation can be seen in this classroom?

Adapted from Holt Biology 2008

Phenotypic Variation

Polygenic characters are influenced by several genes. Examples include human eye color, skin color, and height.



Adapted from Holt Biology 2008

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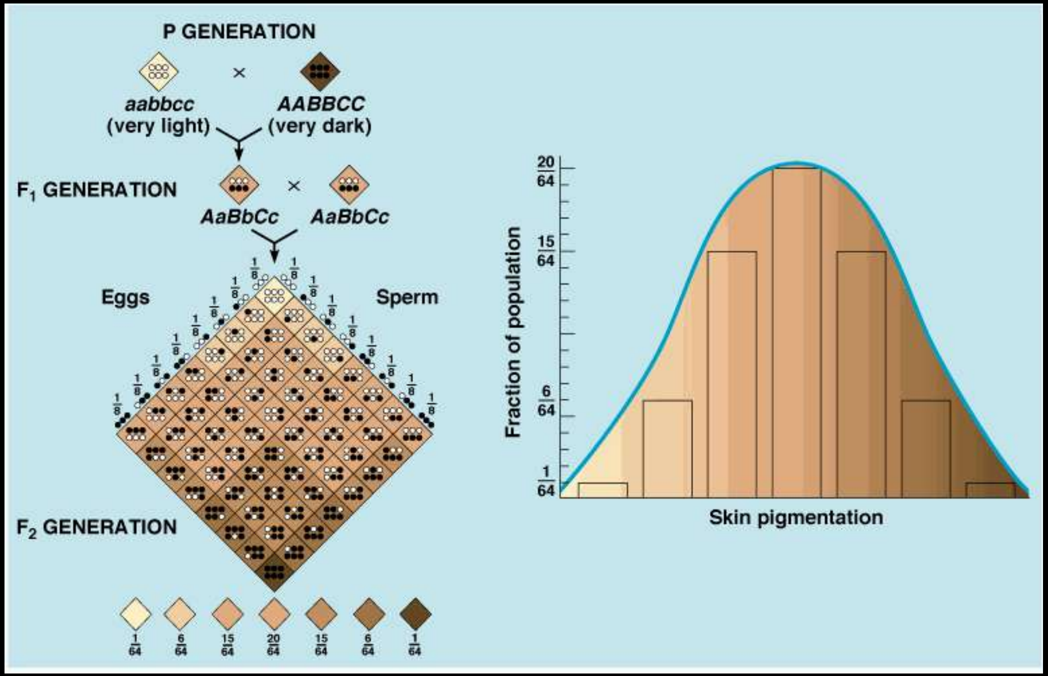
Biologists study polygenic phenotypes by measuring each individual in the population and then analyzing the distribution of the measurements.



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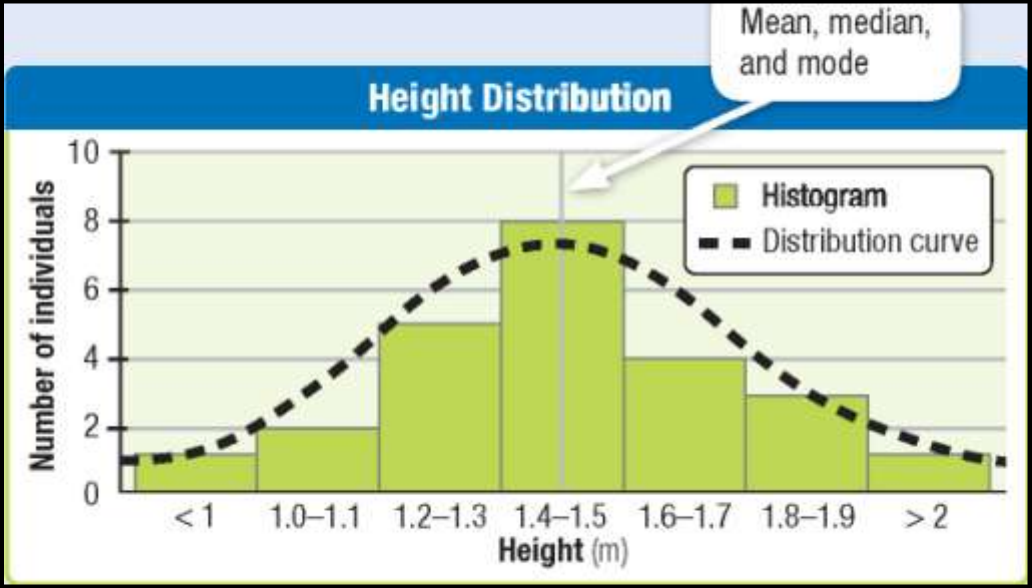
Phenotypic Variation, *continued*

A normal distribution, or *bell curve*, is one that tends to cluster around an average value in the center of the range.



Adapted from Holt Biology 2008
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YOUR TURN

Think, Write, Share & Re-write

Why do polygenic characters vary so much?

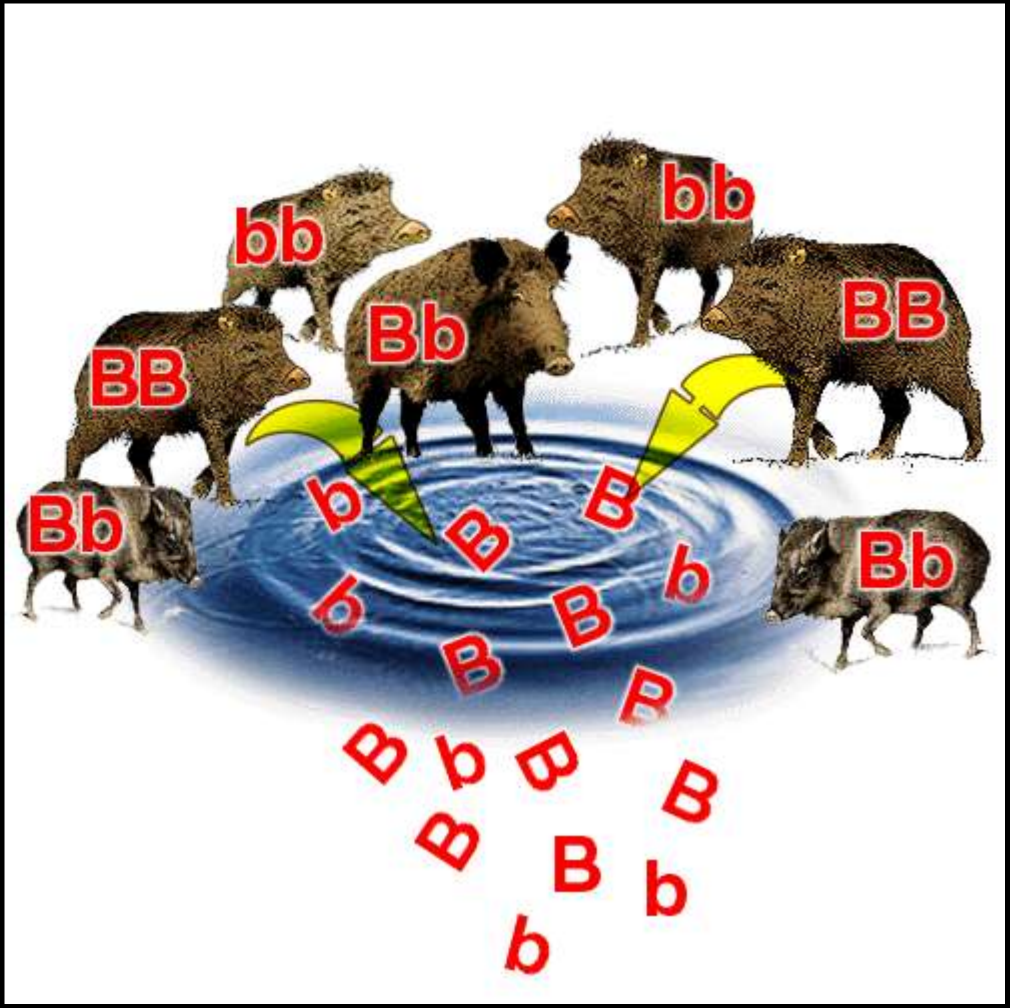
Adapted from Holt Biology 2008

Measuring Variation and Change

Adapted from Holt Biology 2008
Adapted from Holt Biology 2008

Measuring Variation and Change

The particular combination of alleles in a population at any one point in time makes up a *gene pool*.



Adapted from Holt Biology 2008
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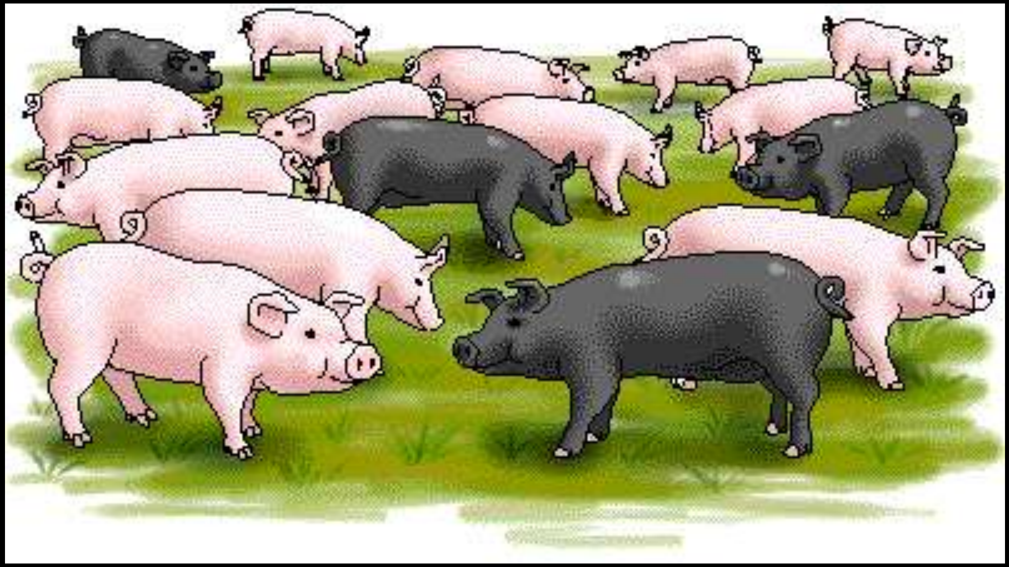
Measuring Variation and Change

Genetic variation and change are measured in terms of the frequency of alleles in the gene pool of a population.



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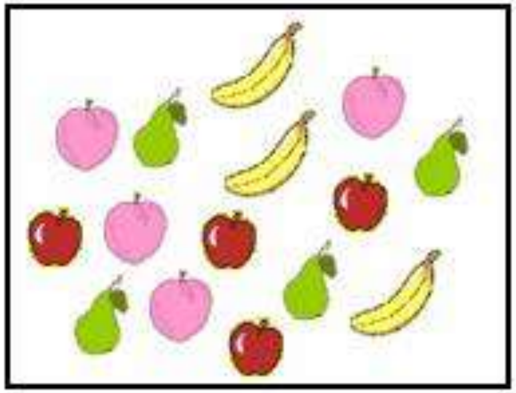
A *frequency* is the proportion or ratio of a group that is of one type. To study genetic change, the frequency of each allele in a population can be tracked over time.



Fruit	Number
Peach	4
Apple	4
Banana	4
Pear	3

Table 1

Fruit	Number
Peach	4
Apple	3
Banana	4
Pear	4

Table 2

Fruit	Number
Peach	3
Apple	4
Banana	4
Pear	4

Table 3

Fruit	Number
Peach	4
Apple	4
Banana	3
Pear	4

Table 4

Adapted from Holt Biology 2008
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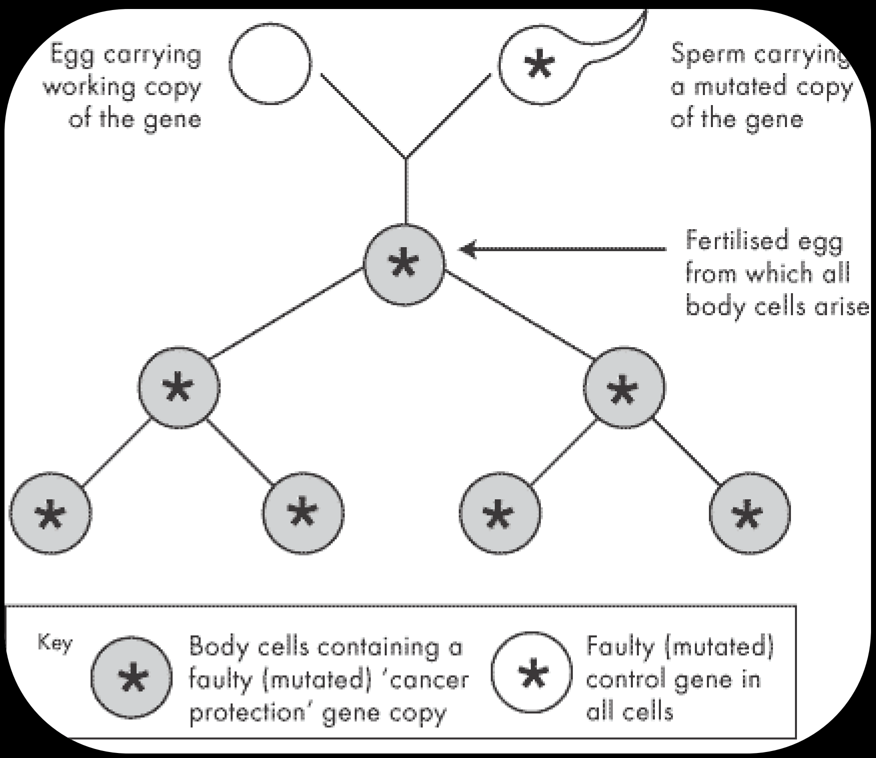
Sources of Genetic Variation

Evolution cannot proceed if there is no variation. The major source of new alleles in natural populations is mutation in germ cells.



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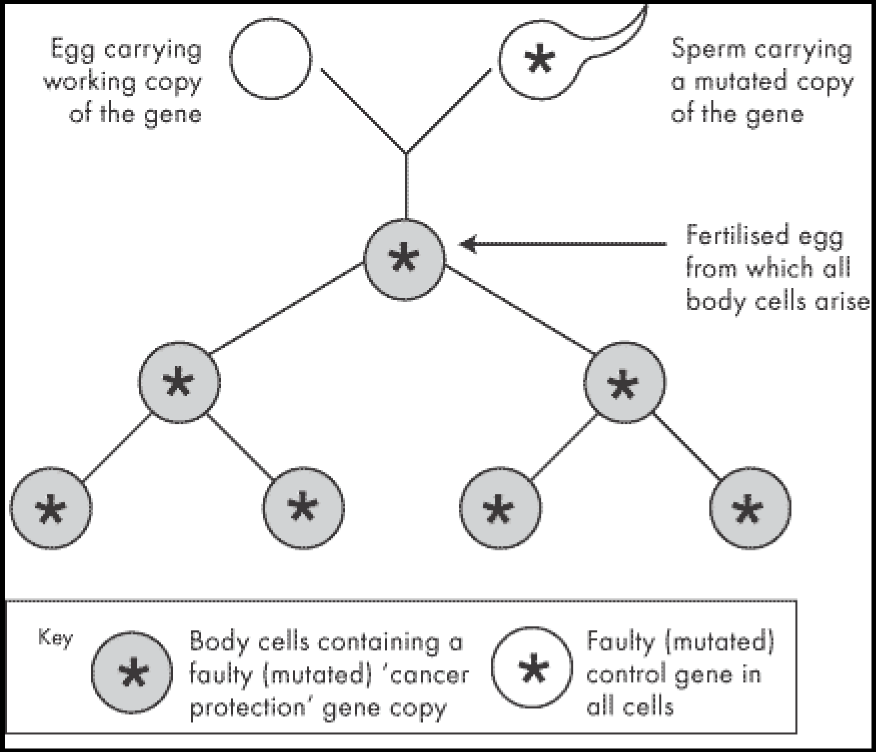
Sources of Genetic Variation

Mutation generates new alleles at a slow rate.

Only mutations in *germ* cells (egg and sperm) are passed on to offspring.



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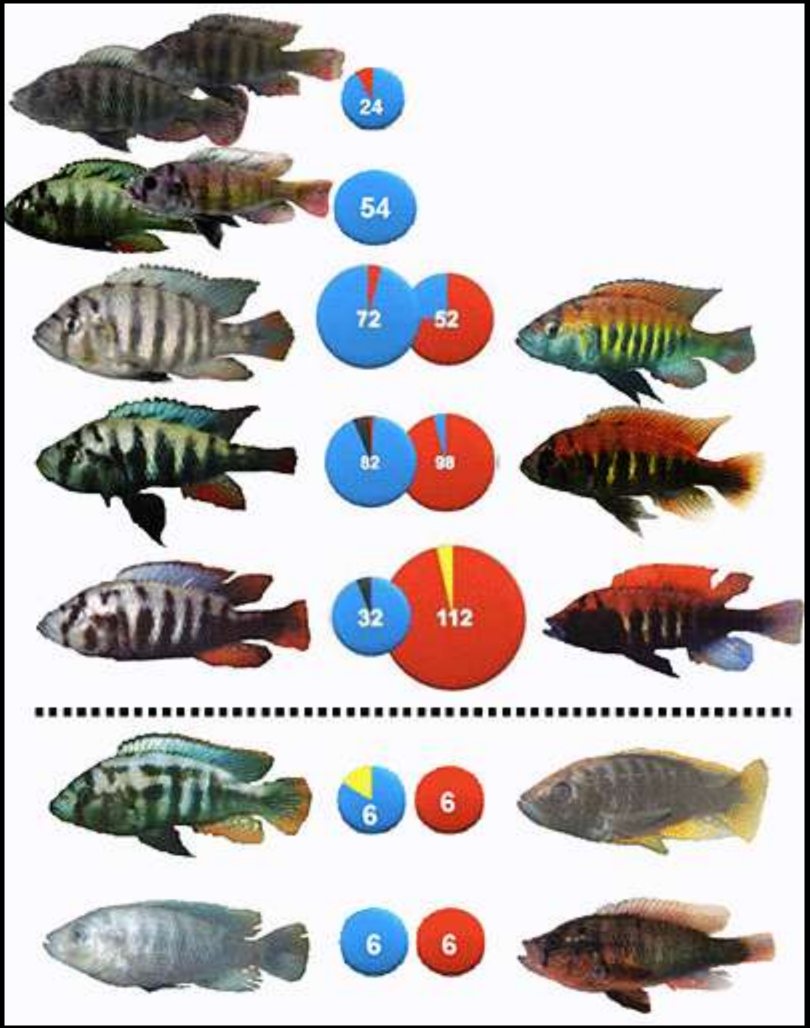
YOUR TURN

Think, Write, Share & Re-write

Why do polygenic characters vary so much?

Summary

Microevolution can be studied by observing changes in the numbers and types of alleles in populations.



Adapted from Holt Biology 2008

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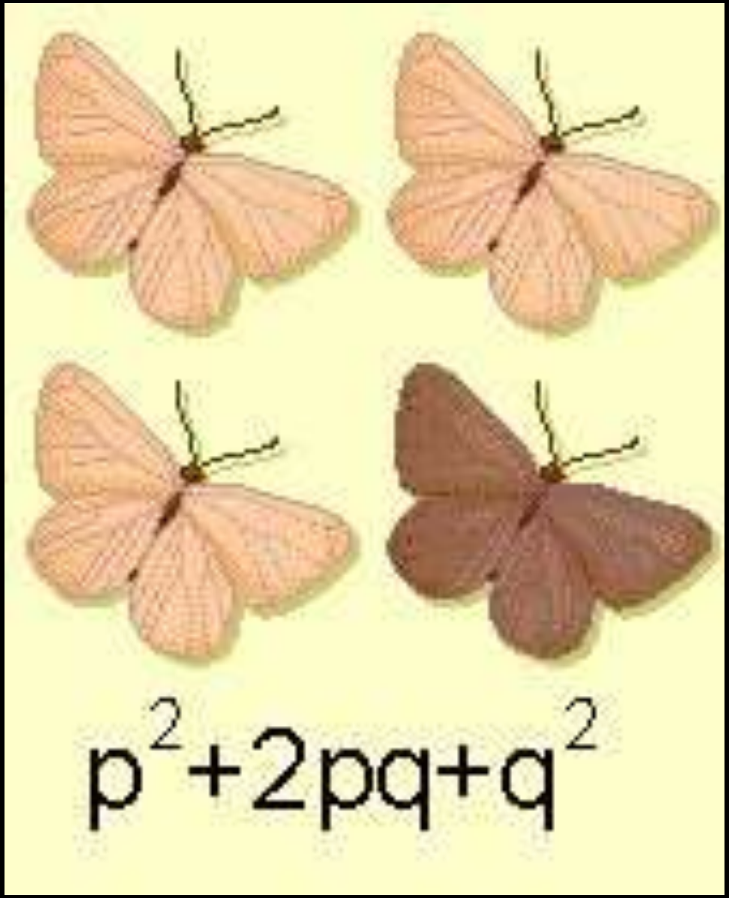
Biologists study polygenic phenotypes by measuring each individual in the population and then analyzing the distribution of the measurements.

Adapted from Holt Biology 2008
Adapted from Holt Biology 2008

Summary

Genetic variation and change are measured in terms of the frequency of alleles in the gene pool of a population.



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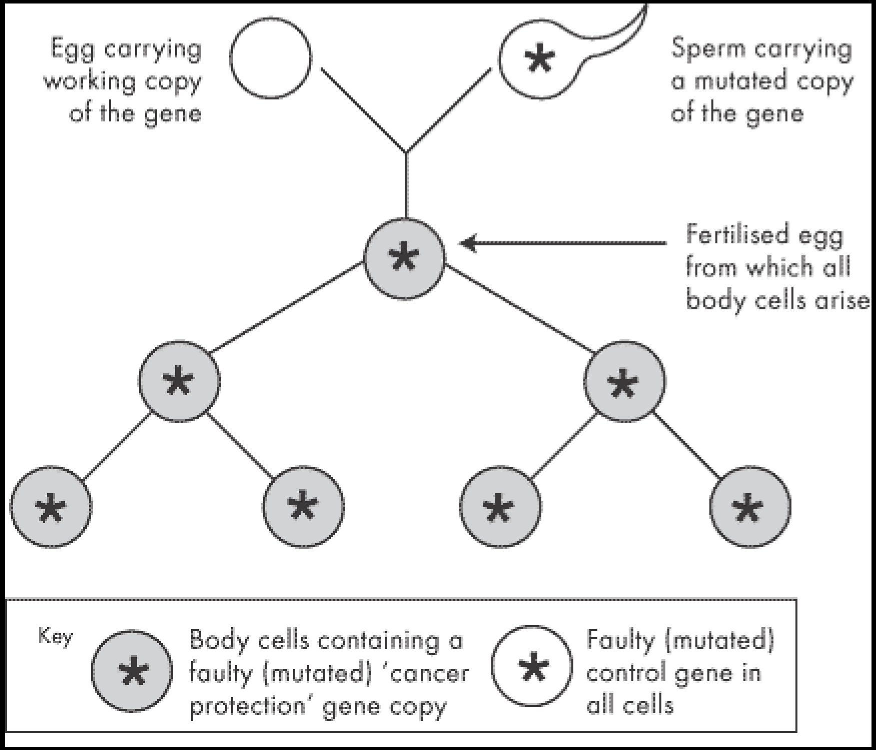
Summary

The major source of new alleles in natural populations is mutation in germ cells.



Adapted from Holt Biology 2008
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Chapter 17 Section 2: Genetic Change

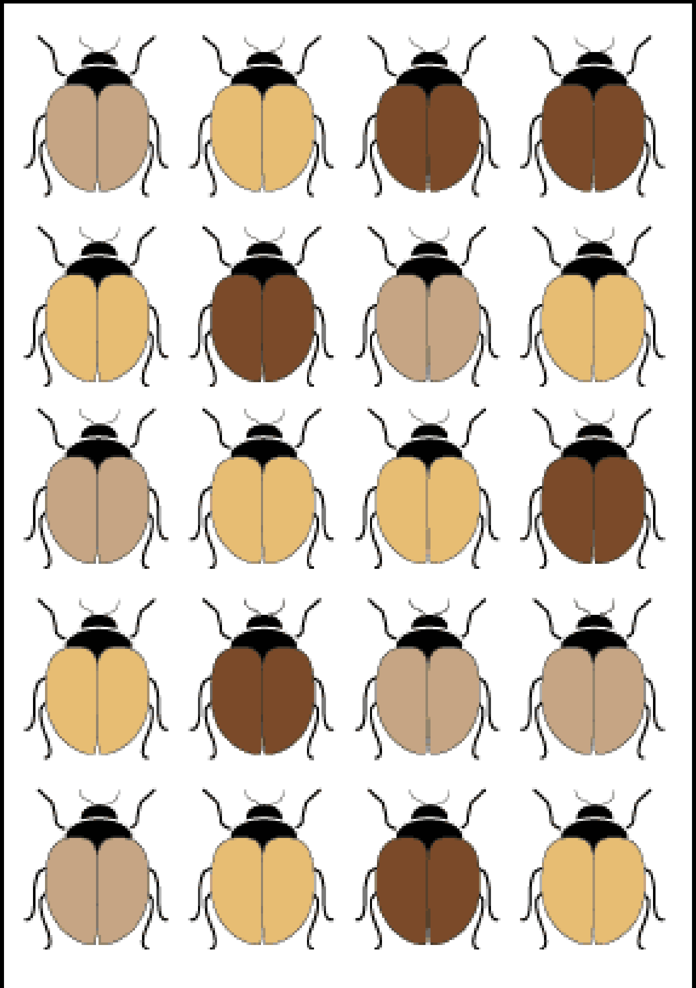
Adapted from Holt Biology 2008

Chapter 17 Section 2: Genetic Change

Key Vocabulary Terms

Genetic Equilibrium

A state in which the allele frequencies of a population remain in the same ratios from one generation to the next



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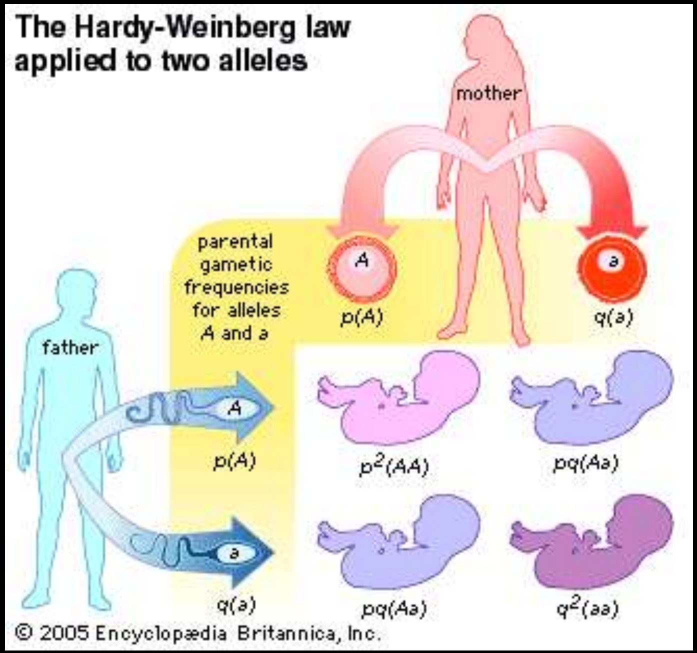
Hardy-Weinberg Principle

Predicts that the frequencies of alleles and genotypes in a population won't change unless at least 1of 5 forces acts upon the population.

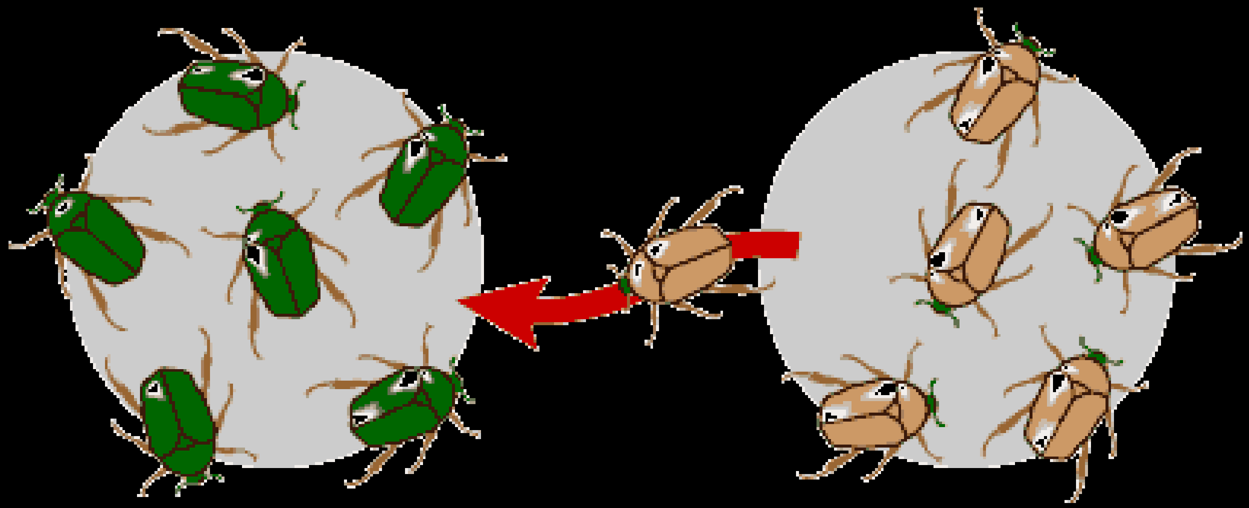


gene flow, nonrandom mating, genetic drift, mutation, and natural selection

Adapted from Holt Biology 2008

Gene flow

Occurs when genes are added to or removed from a population



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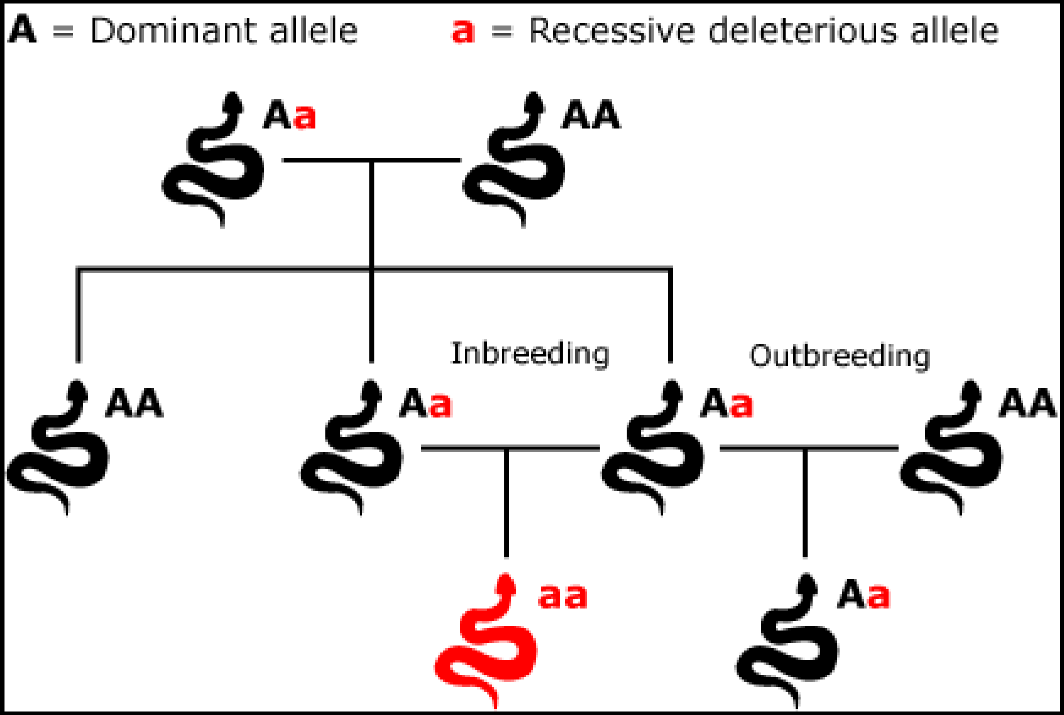
Inbreeding

Which individuals either self-fertilize or mate with others like themselves



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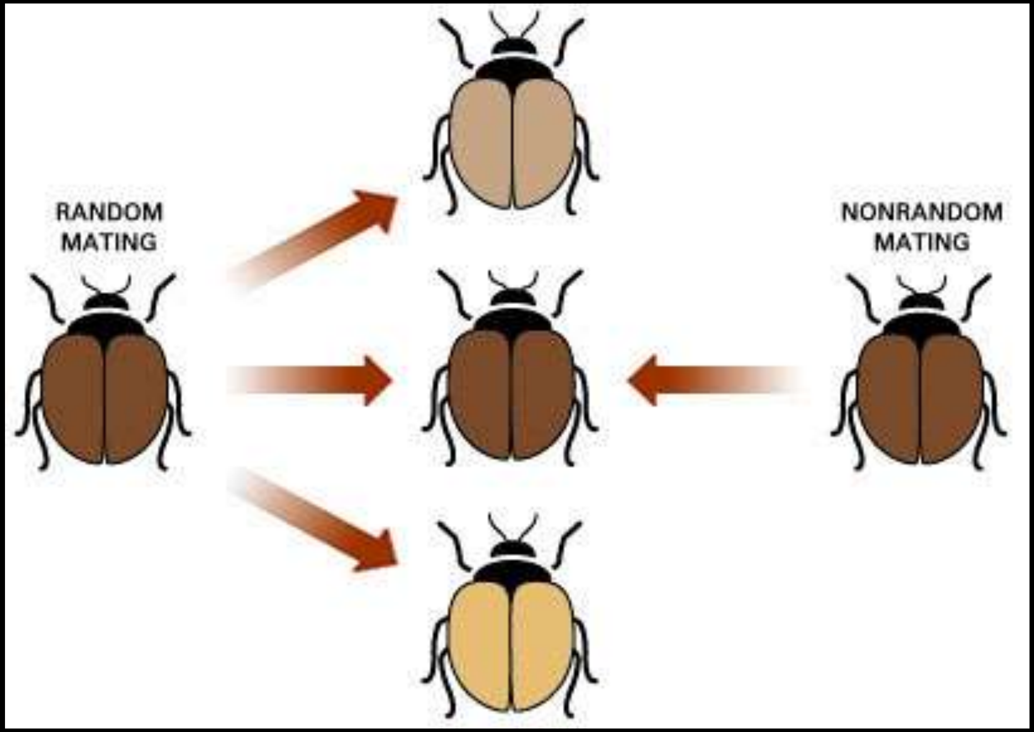
Nonrandom mating

Mating that has not occurred due to chance



Adapted from Holt Biology 2008

YOUR TURN

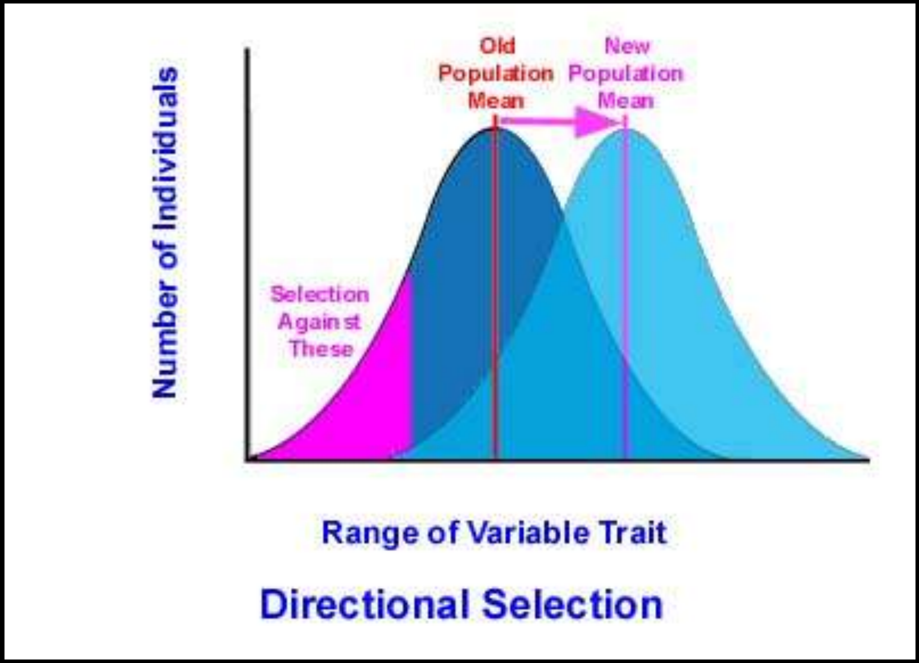
Think, Write, Share & Re-write

What can cause gene flow?

Adapted from Holt Biology 2008

Directional selection

In *directional selection,* the "peak" of a normal distribution moves in one direction along its range



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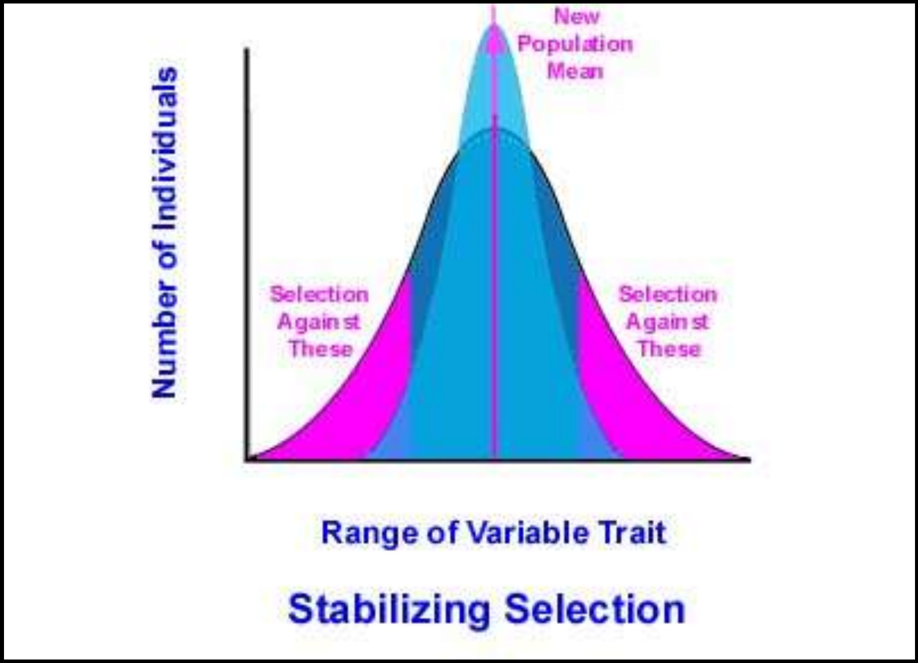
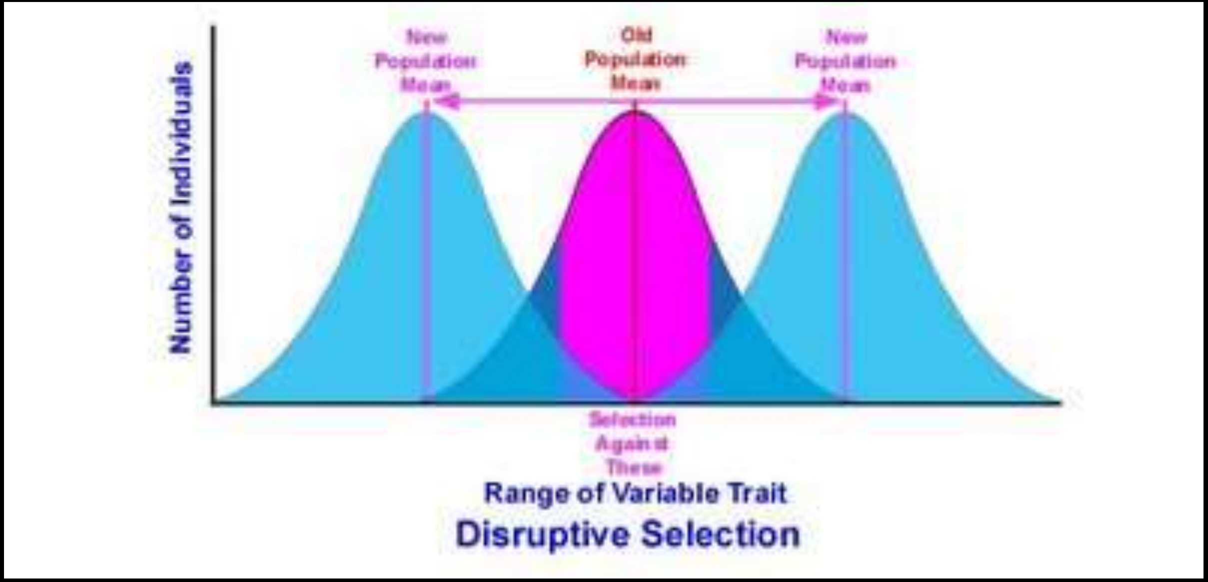
Stabilizing selection

In *stabilizing selection,* the bell-curve shape becomes narrower.



Disruptive selection

In *disruptive selection,* the bell curve is “disrupted” and pushed apart into two peaks.



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Chapter 17
Section 2:
Genetic Change

Notes

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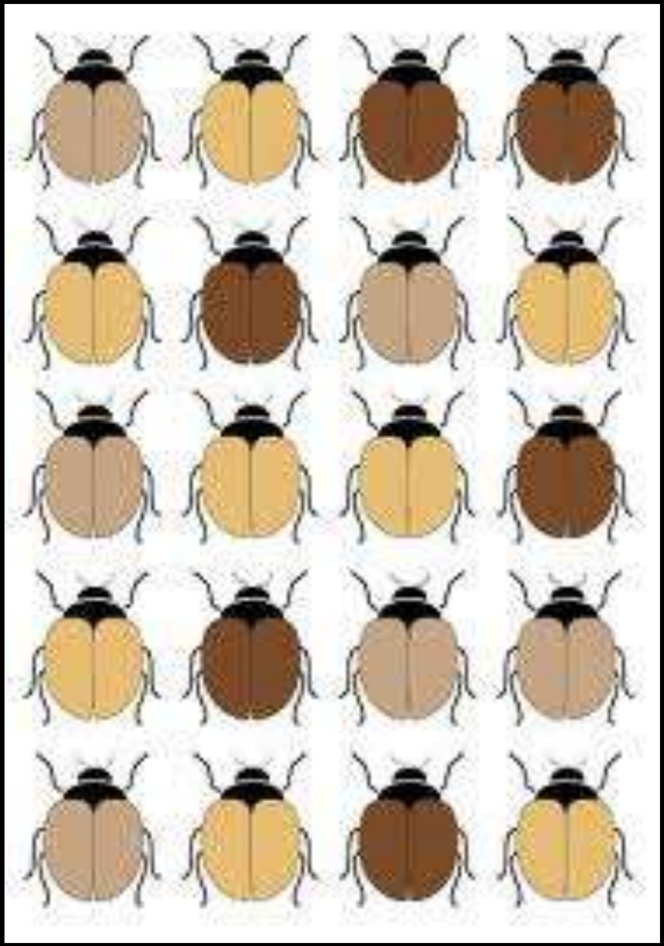
Equilibrium and Change

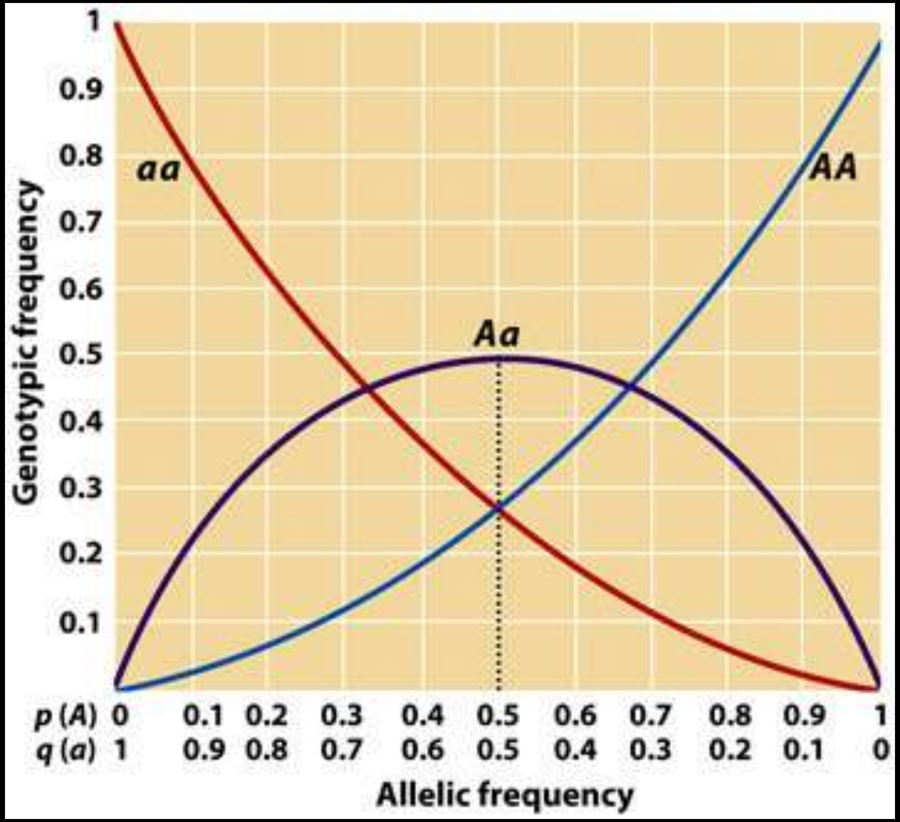
Equilibrium and Change

A population in which no genetic change occurred would be in a state of **genetic equilibrium**.



Measuring Change

Genetic change in a population can be measured as a change in genotype frequency or allele frequency.



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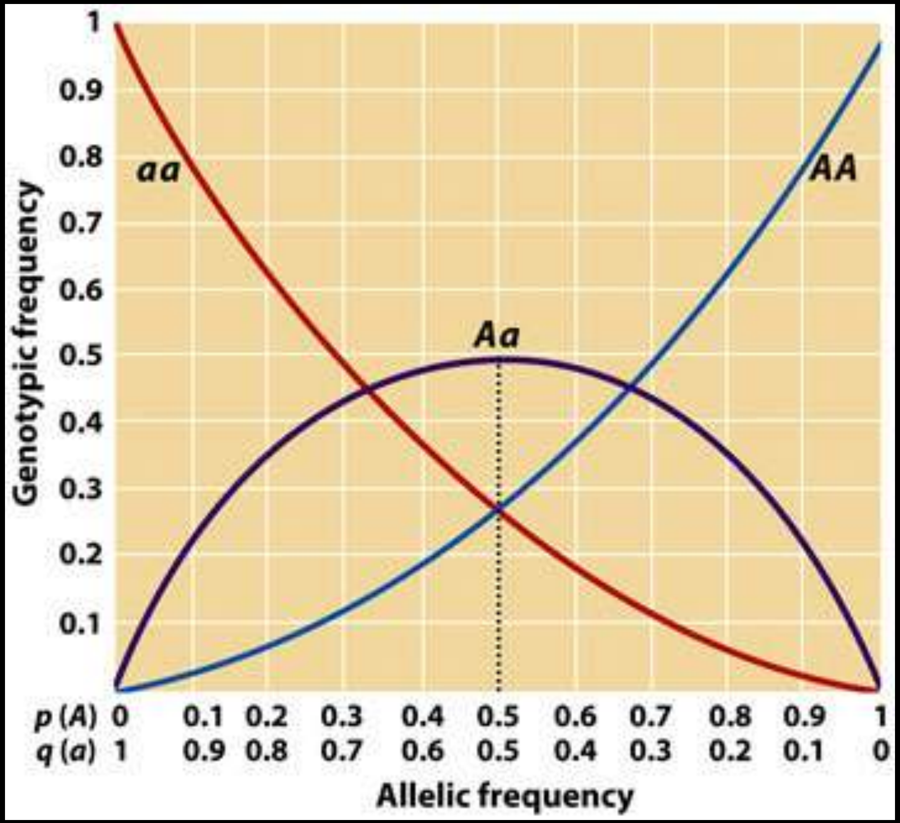
Measuring Change

A change in one doesn't necessarily mean a change in the other.



Adapted from Holt Biology 2008

The Hardy-Weinberg principle

Predicts that the frequencies of alleles and genotypes in a population will not change unless at least one of five forces acts upon the population.

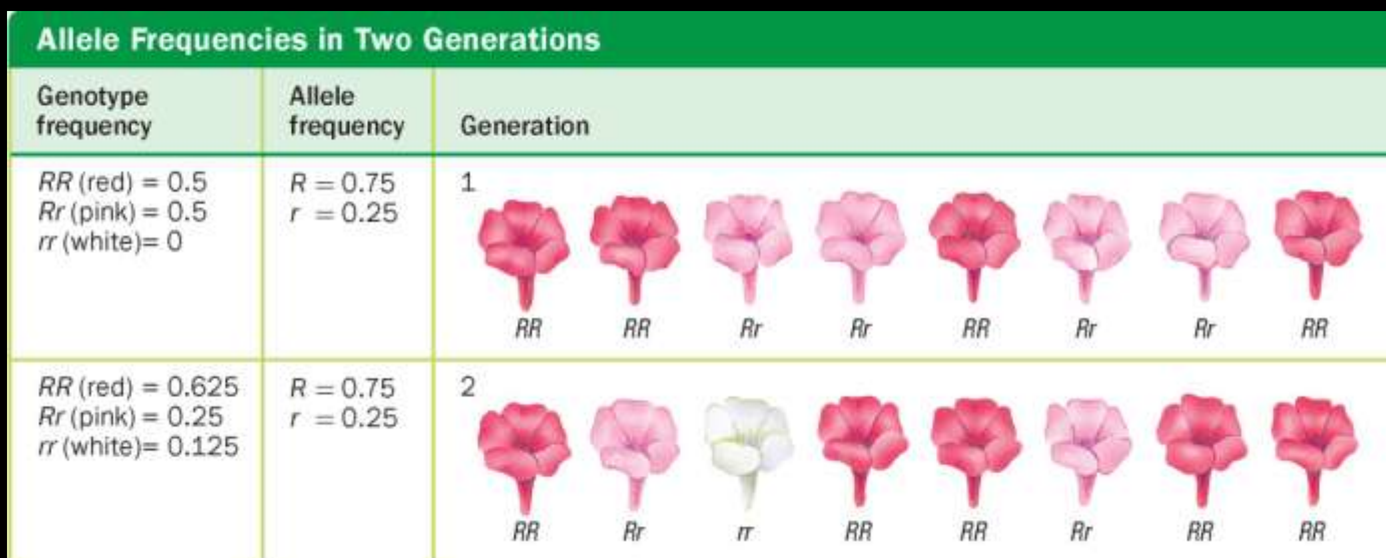
Allele Frequencies in Two Generations

Genotype frequency	Allele frequency	Generation
RR (red) = 0.5 *Rr* (pink) = 0.5 *rr* (white)= 0	*R* = 0.75 *r* = 0.25	1  *RR* *RR* *Rr* *Rr* *RR* *Rr* *Rr* *RR*
RR (red) = 0.625 *Rr* (pink) = 0.25 *rr* (white)= 0.125	*R* = 0.75 *r* = 0.25	2  *RR* *Rr* *rr* *RR* *RR* *Rr* *RR* *RR*

Adapted from Holt Biology 2008

The Hardy-Weinberg principle

The forces that can act against genetic equilibrium are gene flow, nonrandom mating, genetic drift, mutation, and natural selection.



Allele Frequencies in Two Generations

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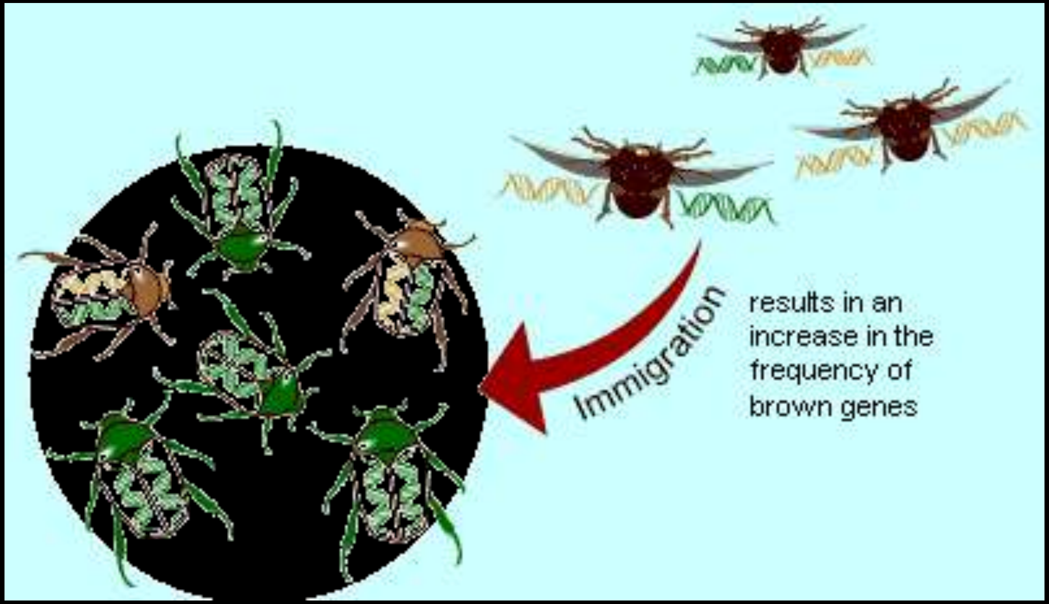
RR (red) = 0.625 *Rr* (pink) = 0.25 *rr* (white)= 0.125	*R* = 0.75 *r* = 0.25	2 *RR* *Rr* *rr* *RR* *RR* *Rr* *RR* *RR*

Adapted from Holt Biology 2008

Forces of Genetic Change

Gene Flow

Occurs when genes are added to or removed from a population.



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Forces of Genetic Change

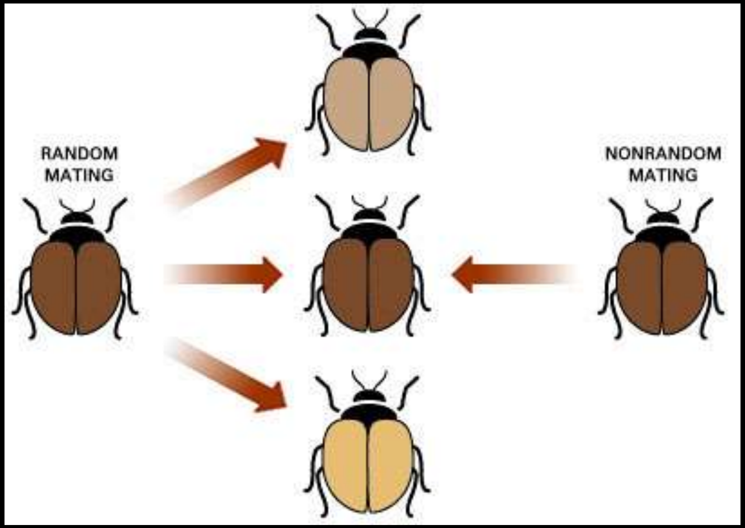
Gene Flow

Gene flow can be caused by *migration*, the movement of individuals from one population to another

Forces of Genetic Change

Nonrandom Mating

In sexually reproducing populations, any limits or preferences of mate choice will cause nonrandom mating.



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Forces of Genetic Change

Genetic Drift

Chance events can cause rare alleles to be lost from one generation to the next, especially when populations are small.

Adapted from Holt Biology 2008

Forces of Genetic Change

Genetic Drift

Such random effects on allele frequencies are called *genetic drift*.

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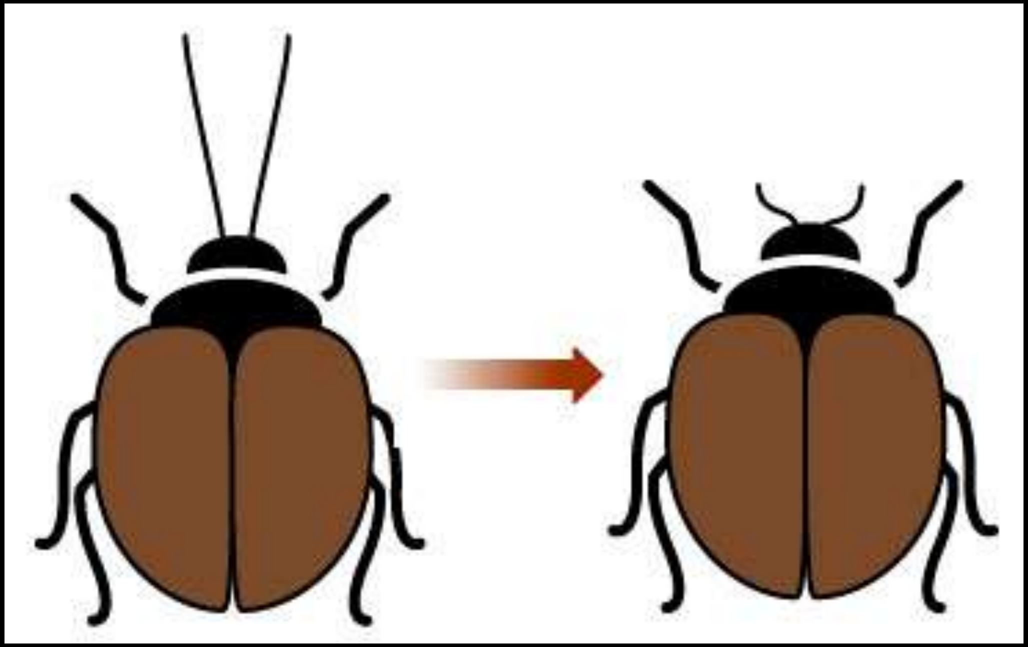
Forces of Genetic Change

Mutation

Can add a new allele to a population.



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Forces of Genetic Change

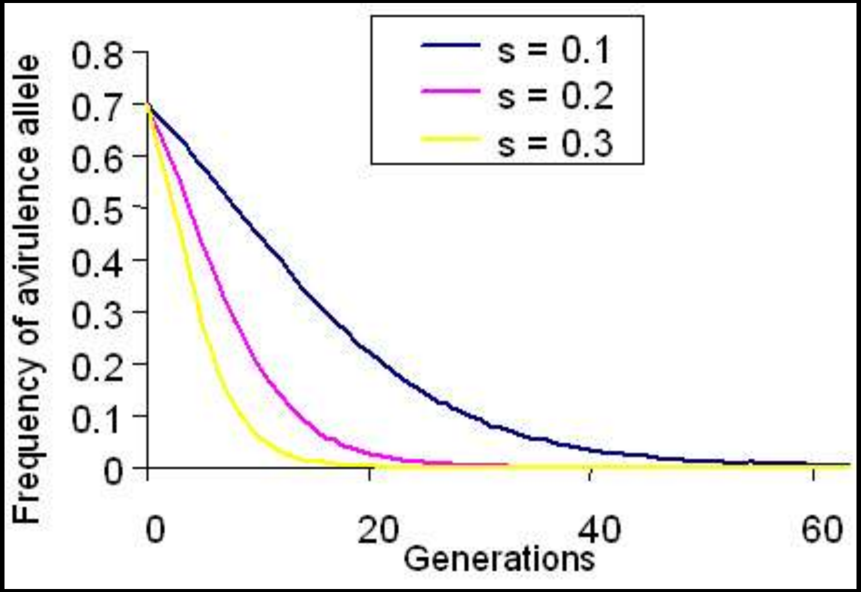
Natural Selection

Natural selection acts to eliminate individuals with certain traits from a population.

Forces of Genetic Change

Natural Selection

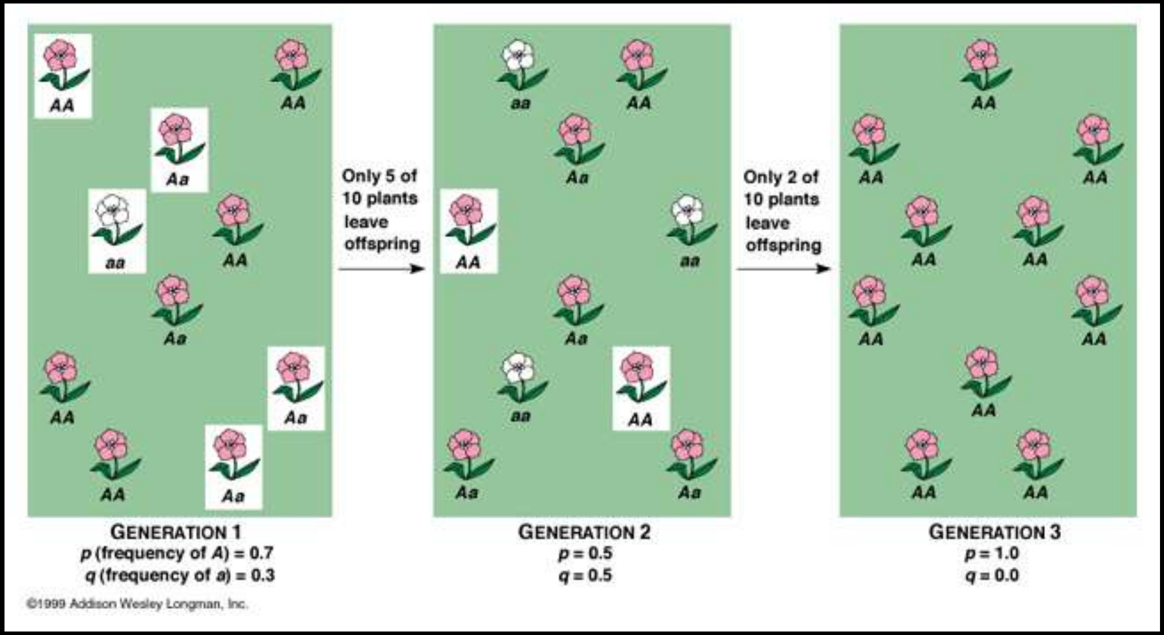
As individuals are eliminated, the alleles for those traits may become less frequent in the population.



Forces of Genetic Change

Natural Selection

Thus, both allele and genotype frequencies may change.



Adapted from Holt Biology 2008

Chapter 17 Section 2: Genetic Change

Sexual Reproduction and evolution

Adapted from Holt Biology 2008

Sexual Reproduction and Evolution

Sexual reproduction creates chances to recombine alleles and thus increase variation in a population.

Adapted from Holt Biology 2008

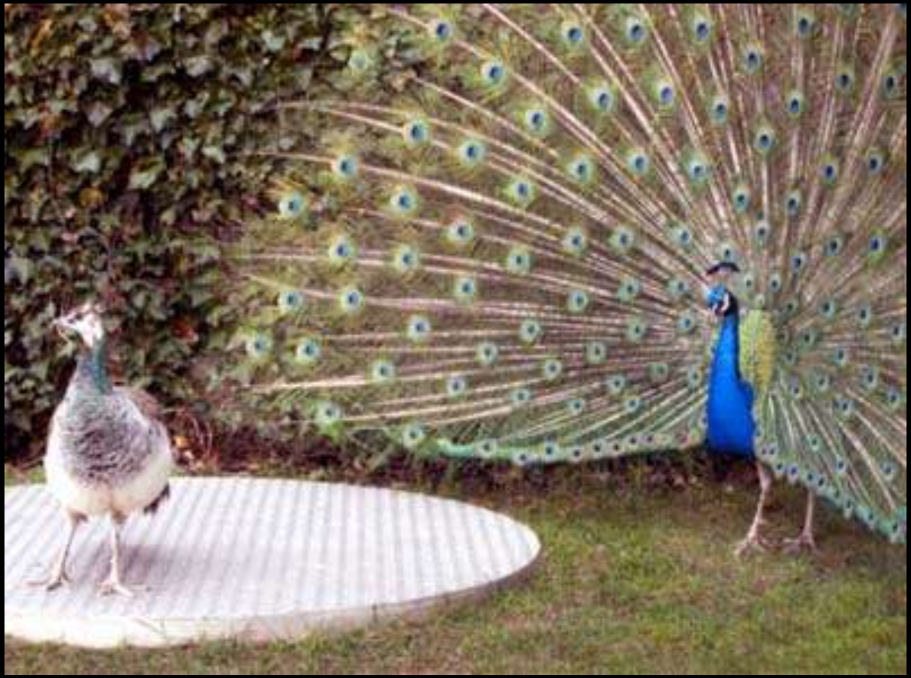
Sexual Reproduction and Evolution

Sexual reproduction creates the possibility that mating patterns or behaviors can influence the gene pool.

Adapted from Holt Biology 2008

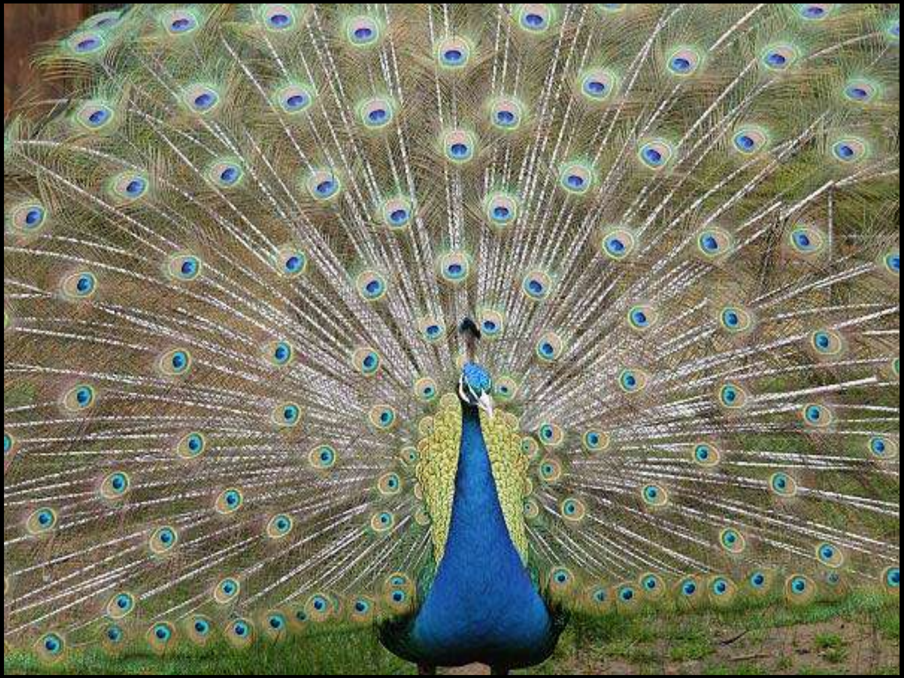
Sexual Reproduction and Evolution

For example, in animals, females sometimes select mates based on the male’s size, color, ability to gather food, or other characteristics.



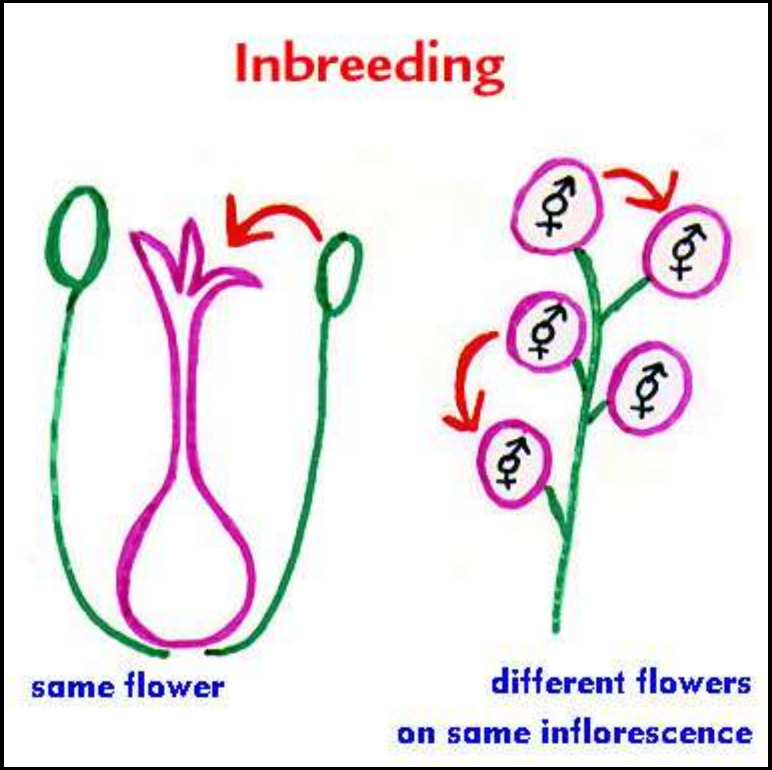
Sexual Reproduction and Evolution

This kind of behavior is called *sexual selection* and is an example of nonrandom mating.



Sexual Reproduction and Evolution

Another example of nonrandom mating is *inbreeding*, in which individuals either self-fertilize or mate with others like themselves.



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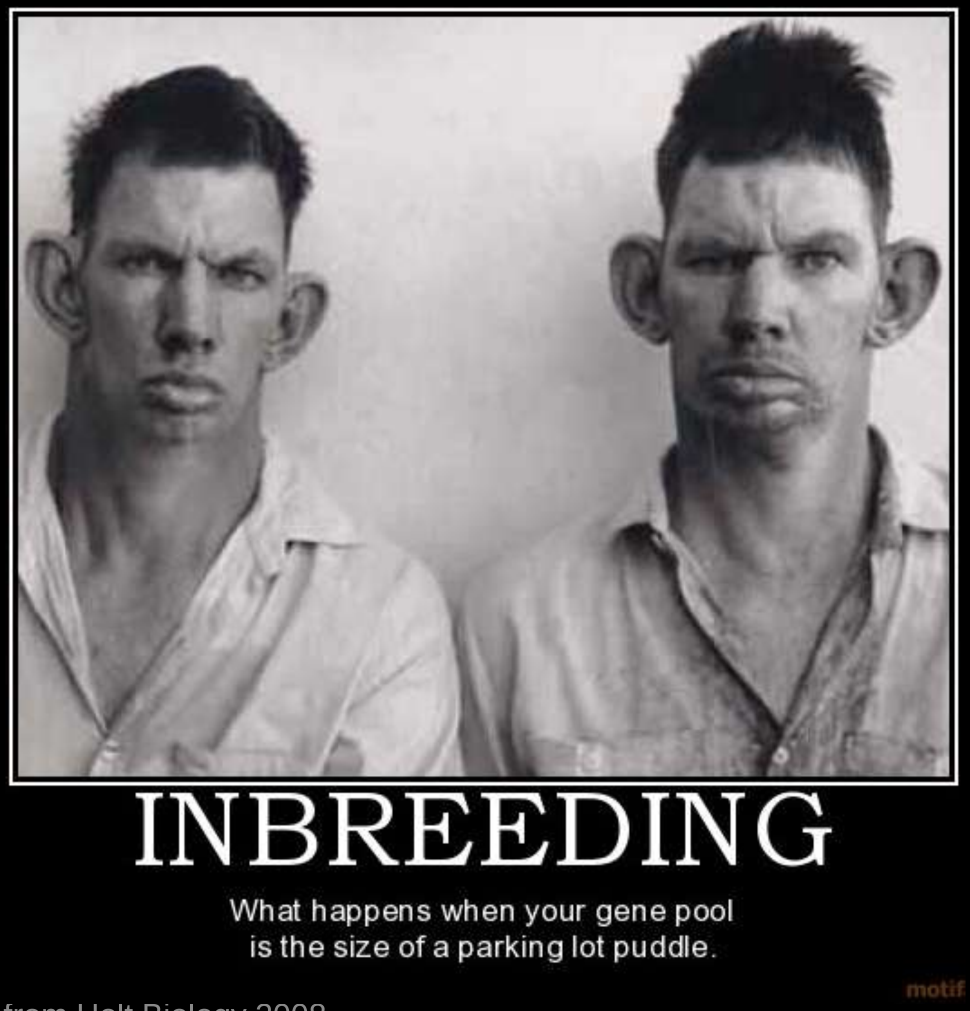
Sexual Reproduction and Evolution

Inbreeding is more likely to occur if a population is small. In a small population, all members are likely to be closely related.



Adapted from Holt Biology 2008

YOUR TURN

Think, Write, Share & Re-write

What is the genetic effect of inbreeding?

Adapted from Holt Biology 2008

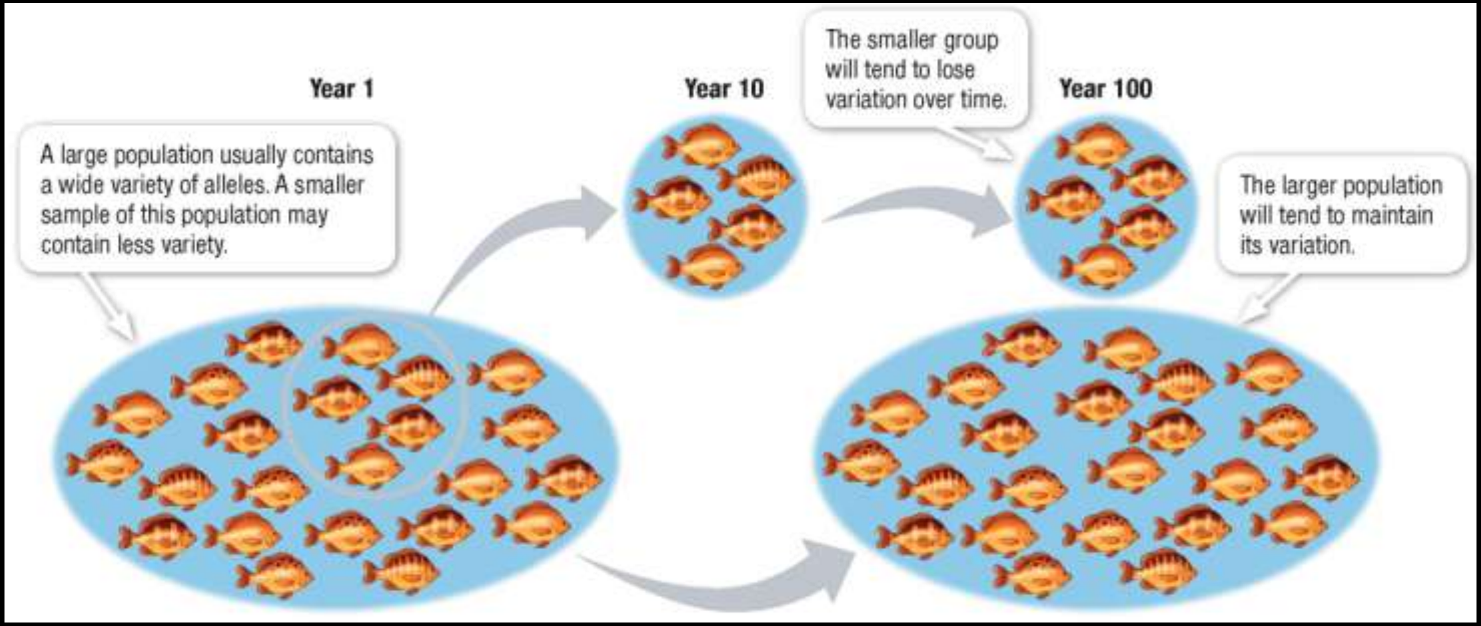
Chapter 17 Section 2: Genetic Change

Population Size and Evolution

Adapted from Holt Biology 2008

Population Size and Evolution

Population size strongly affects the probability of genetic change in a population.



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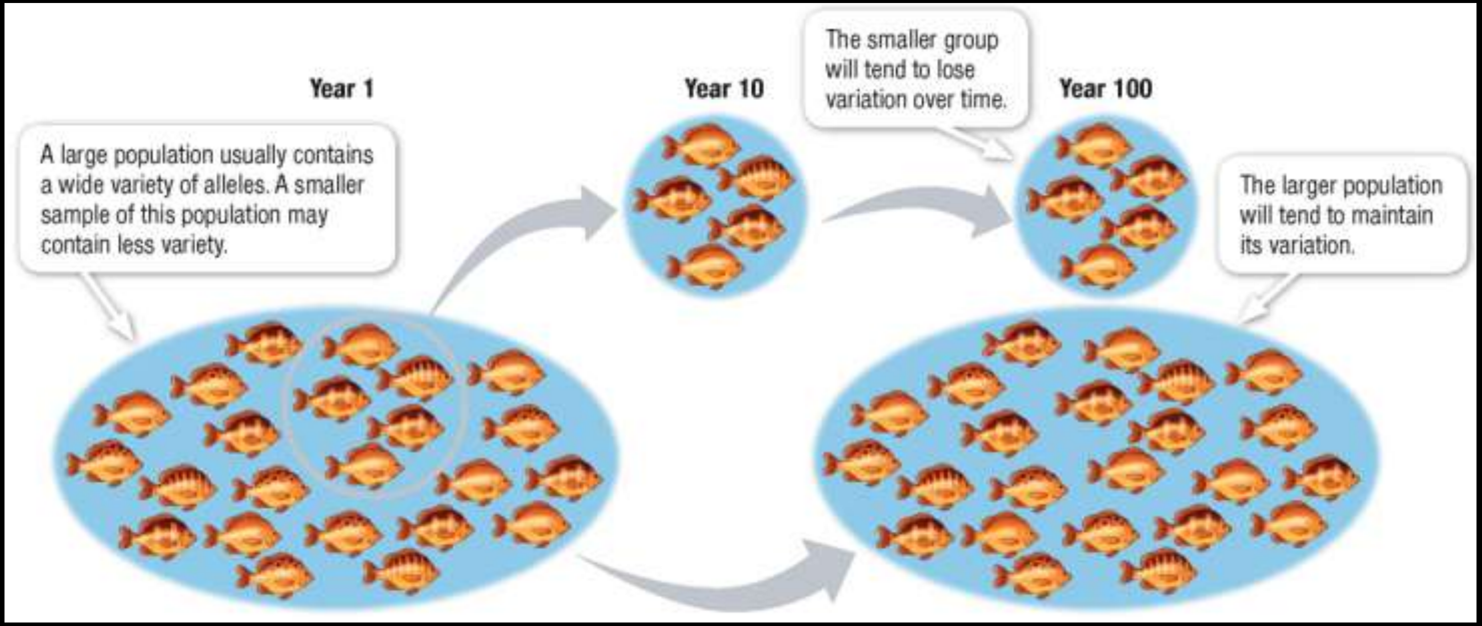
Population Size and Evolution

Allele frequencies are more likely to remain stable in large populations than in small populations.



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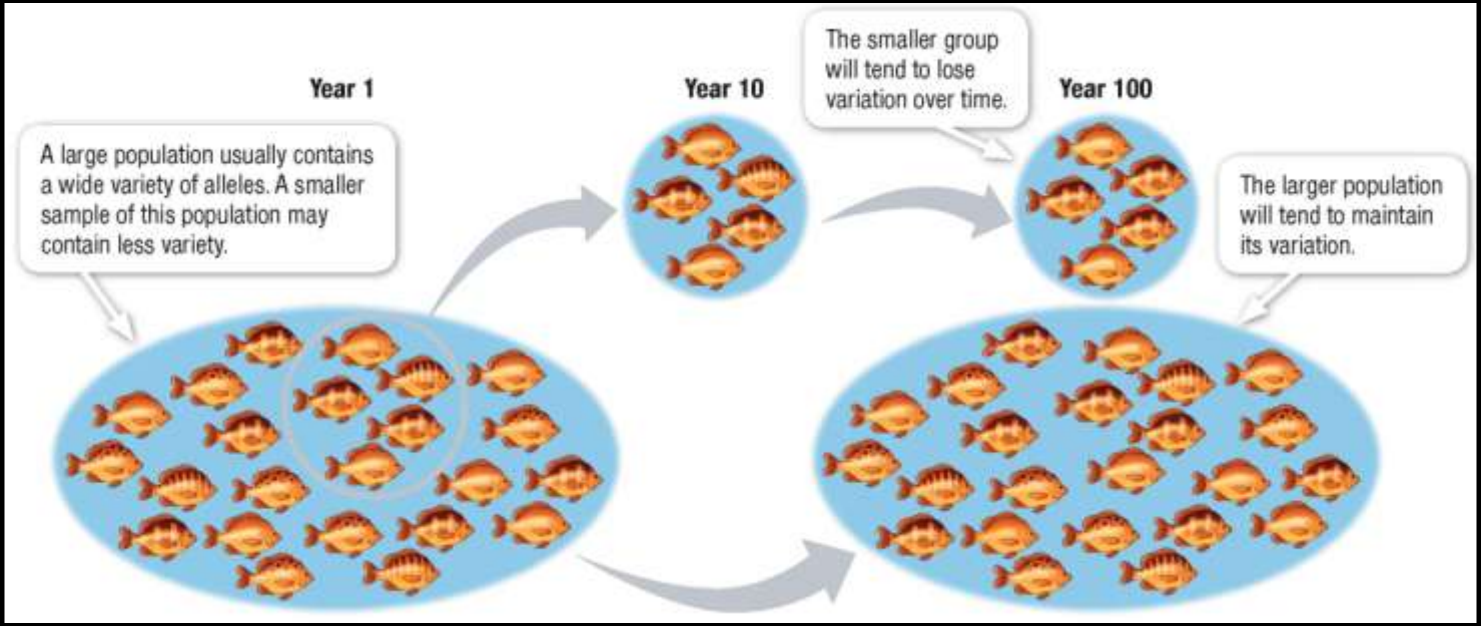
Population Size and Evolution

Genetic drift is a strong force in small populations and occurs when a particular allele disappears.



Adapted from Holt Biology 2008

Chapter 17 Section 2: Genetic Change

Natural Selection & Evolution

Adapted from Holt Biology 2008

Natural selection is a result of the following facts:

- All populations have genetic variation.
- Individuals tend to produce more offspring than the environment can support.
- Populations depend upon the reproduction of individuals.

Adapted from Holt Biology 2008

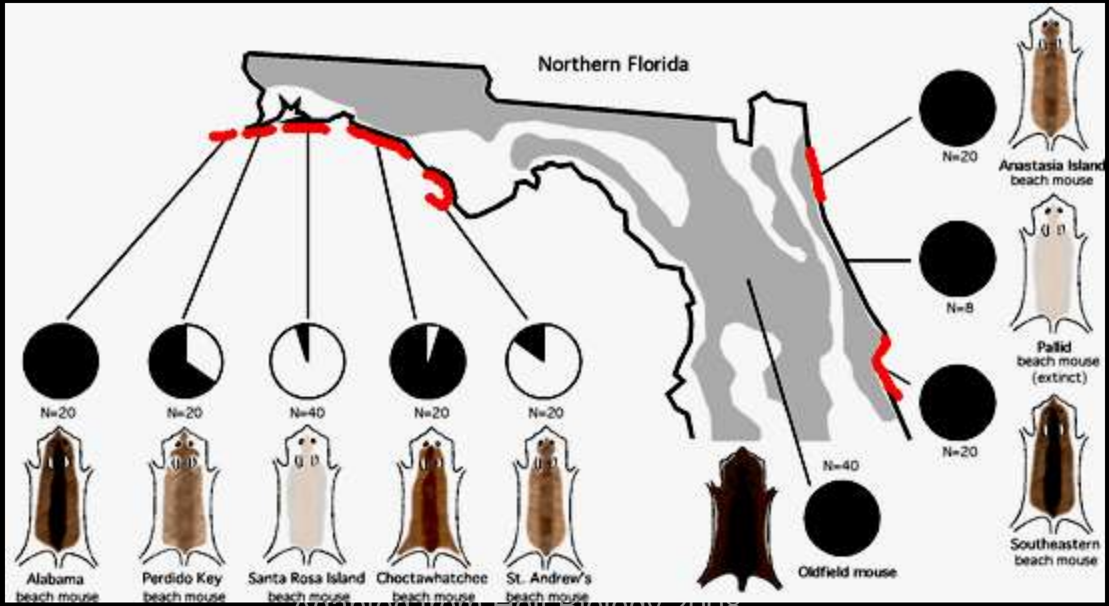
How Selection Acts

Natural selection causes evolution in populations by acting on individuals.

Adapted from Holt Biology 2008

Genetic Results of Selection

The result of natural selection is that each allele's frequency may increase or decrease depending on the allele's effects on survival and reproduction.



Adapted from Holt Biology 2008

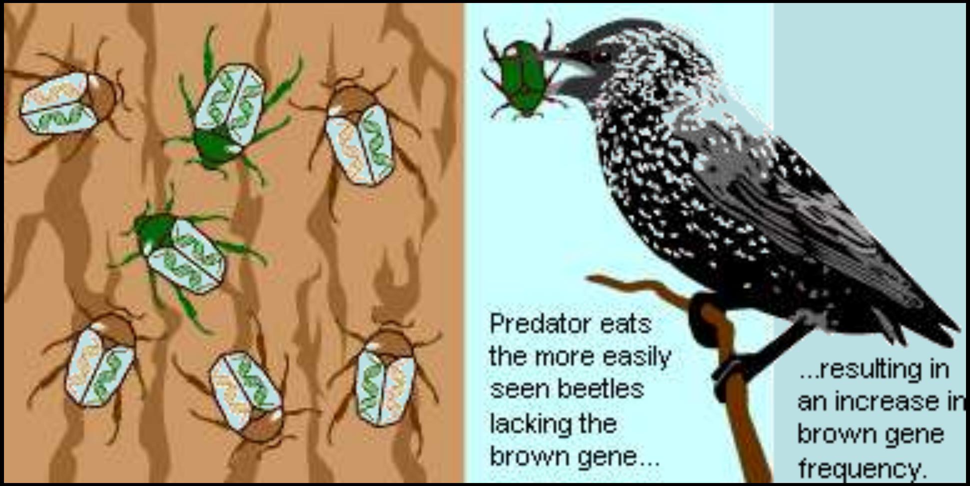
Why Selection is Limited

The key lesson that scientists have learned about evolution by natural selection is that the environment does the selecting.

Adapted from Holt Biology 2008

Natural selection is indirect

It acts on genotypes by removing unsuccessful phenotypes from a population.



Adapted from Holt Biology 2008

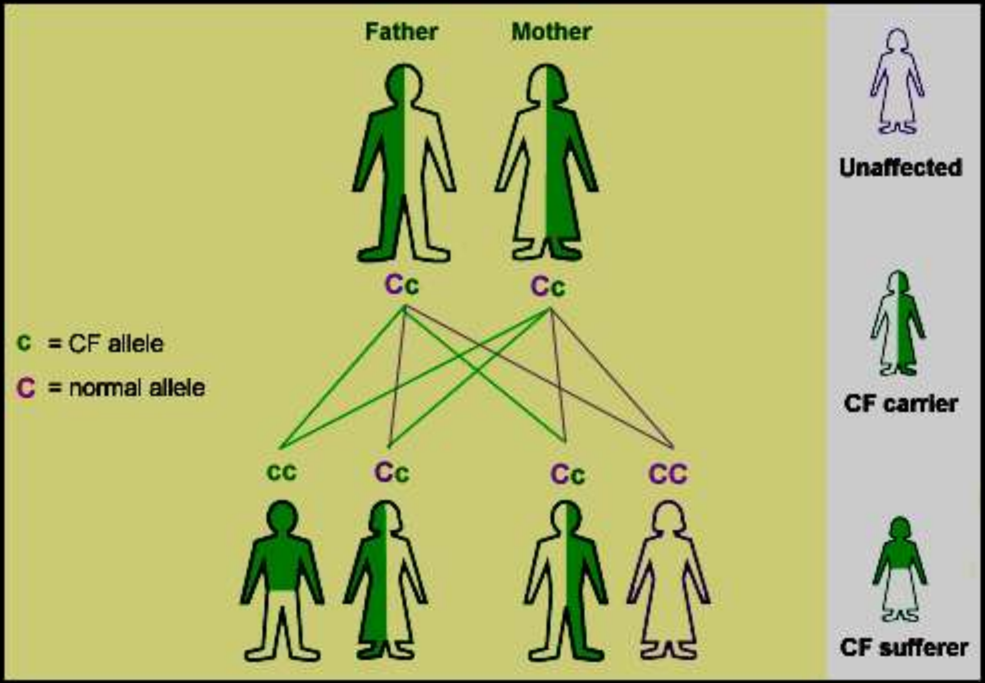
The Role of Mutation

Only characteristics that are expressed can be targets of natural selection. If a mutation results in rare recessive alleles, for example, selection cannot operate against it.

Adapted from Holt Biology 2008

The Role of Mutation

For this reason, genetic disorders (such as cystic fibrosis in humans) can persist in populations.



Adapted from Holt Biology 2008

YOUR TURN

Think, Write, Share & Re-write

How can unfavorable alleles persist?

Adapted from Holt Biology 2008

Patterns of Natural Selection

Adapted from Holt Biology 2008

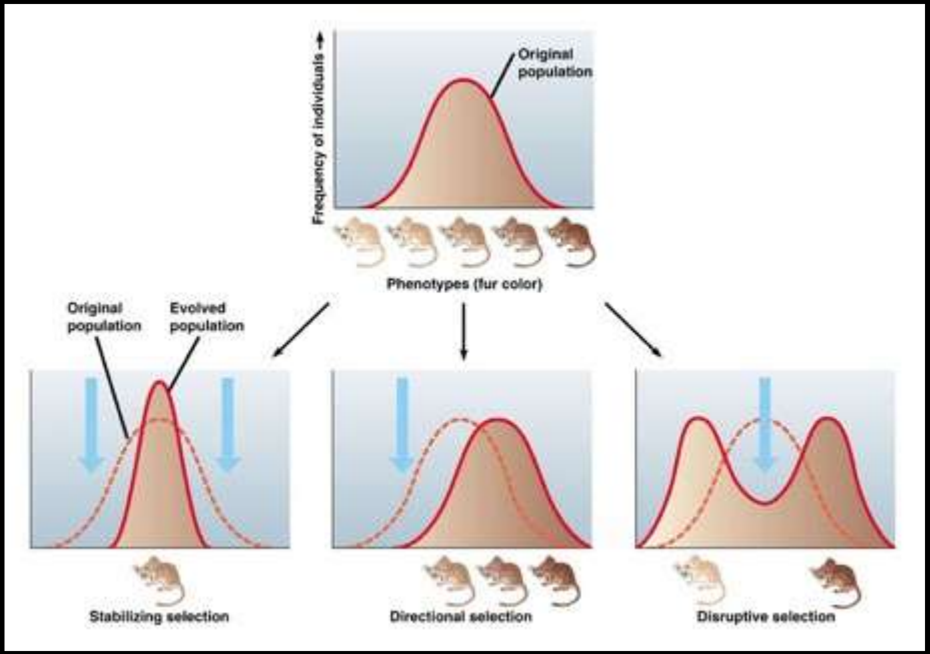
Patterns of Natural Selection

Three major patterns are possible in the way that natural selection affects the distribution of polygenic characters over time.

Adapted from Holt Biology 2008

These patterns are:

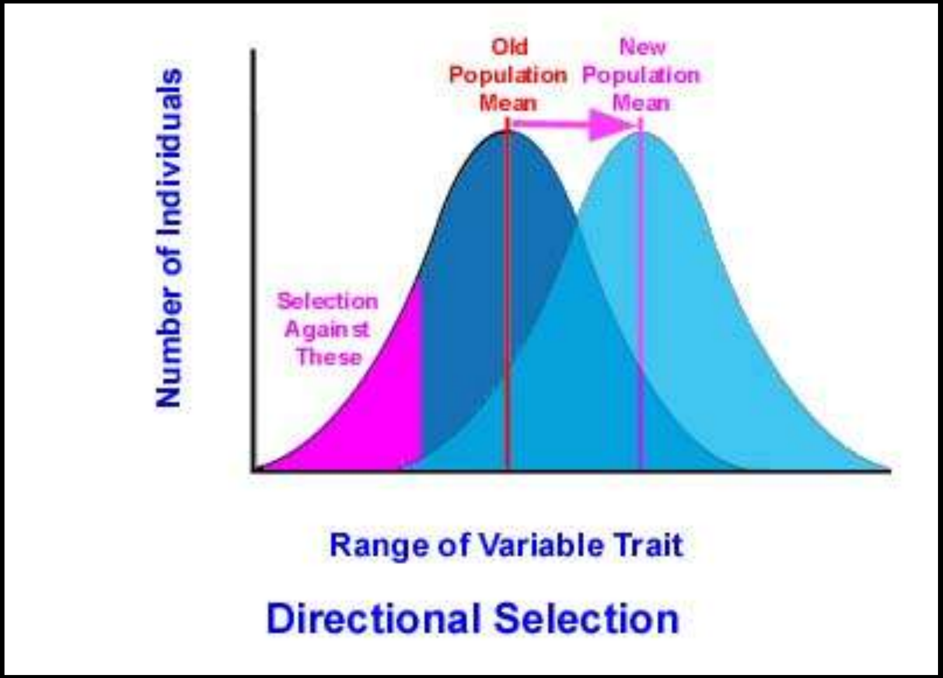
– Directional selection
– Stabilizing selection, &
– Disruptive selection.



Adapted from Holt Biology 2008

Directional Selection

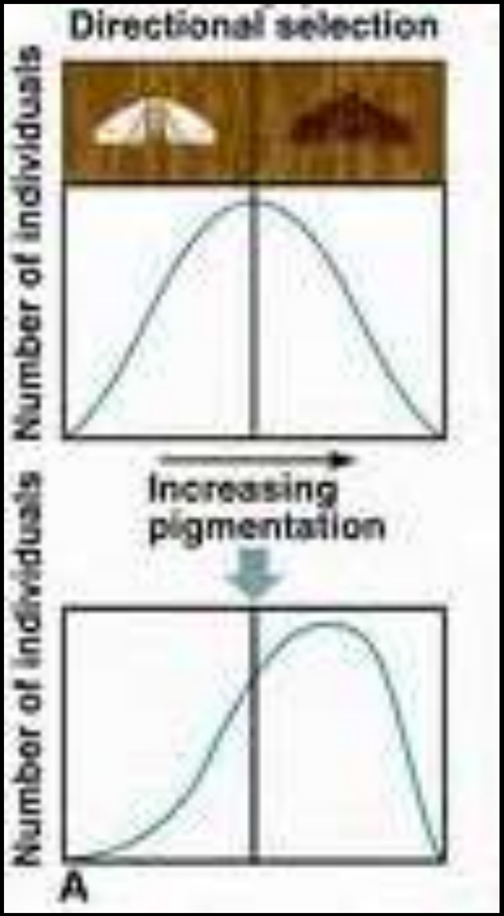
In directional selection, the "peak" of a normal distribution moves in one direction along its range.



Adapted from Holt Biology 2008

Directional Selection

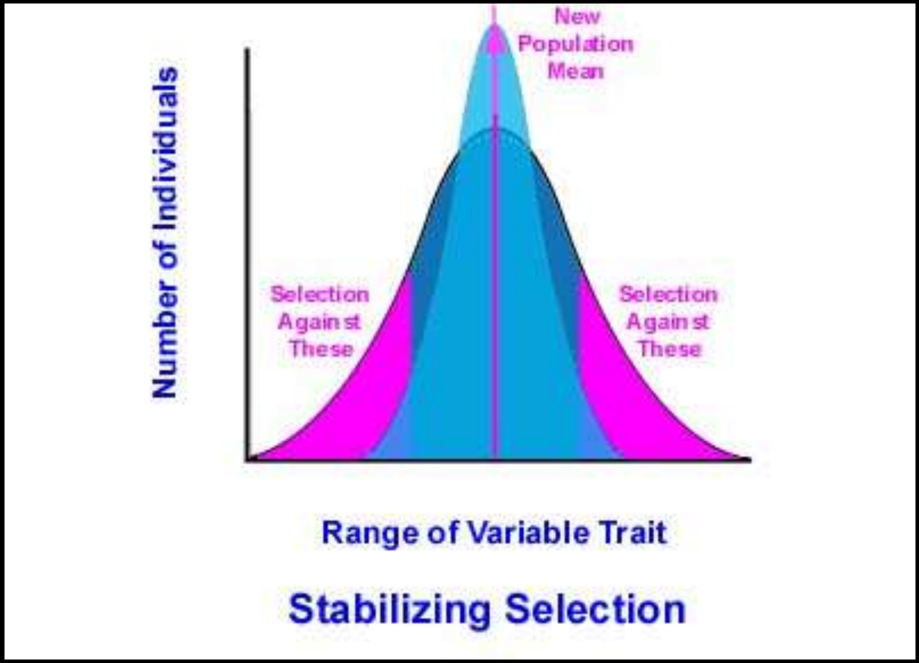
In this case, selection acts to eliminate an extreme from a range of phenotypes, making them less common.



Adapted from Holt Biology 2008

Stabilizing Selection

In stabilizing selection, the bell-curve shape becomes narrower. In this case, selection eliminates individuals that have alleles for any extreme type.



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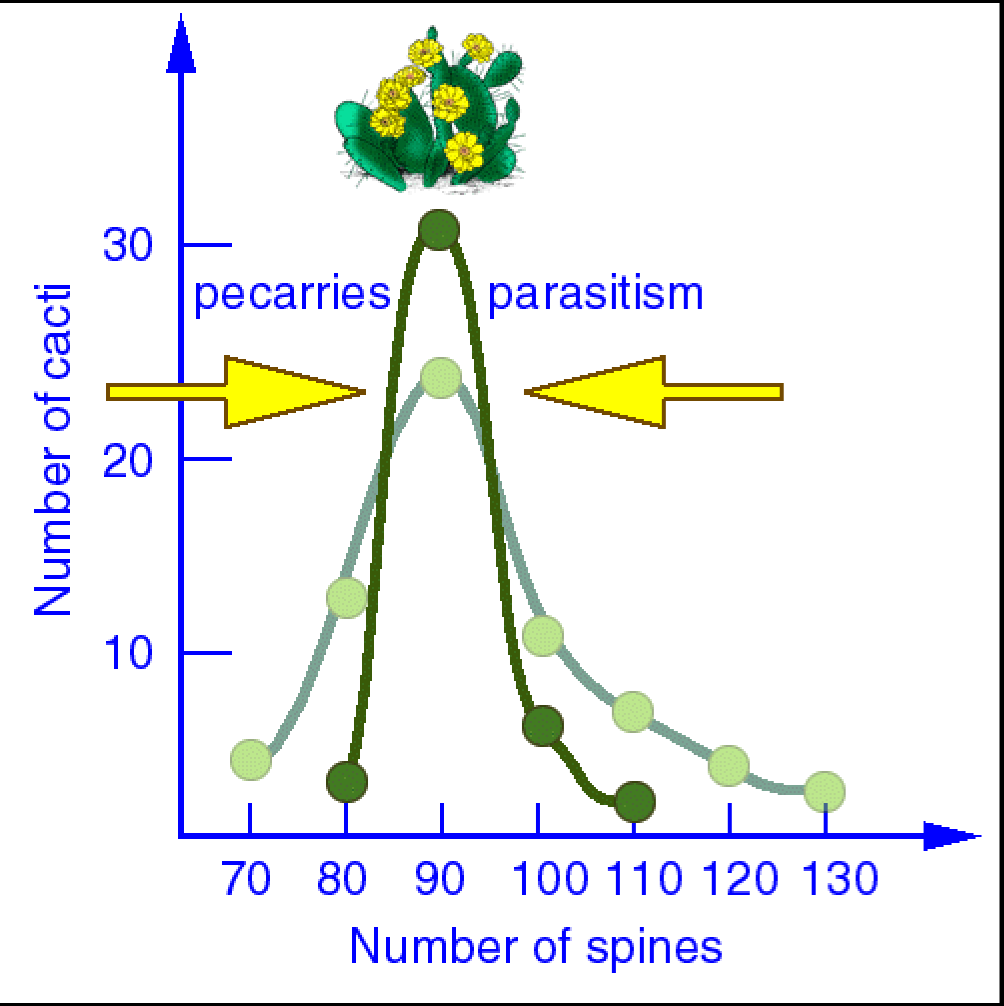
Stabilizing Selection

Stabilizing selection is very common in nature.



Adapted from Holt Biology 2008

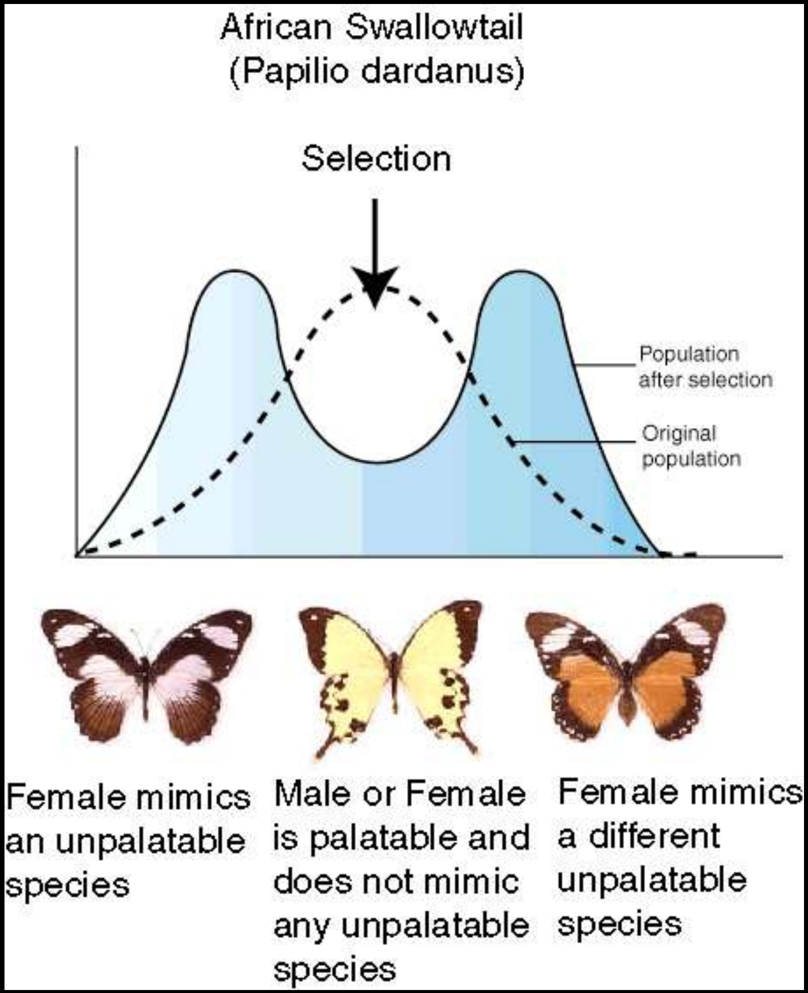
Disruptive Selection

In disruptive selection, the bell curve is "disrupted" and pushed apart into two peaks.

Adapted from Holt Biology 2008

Disruptive Selection

In this case, selection acts to eliminate individuals with average phenotype values.



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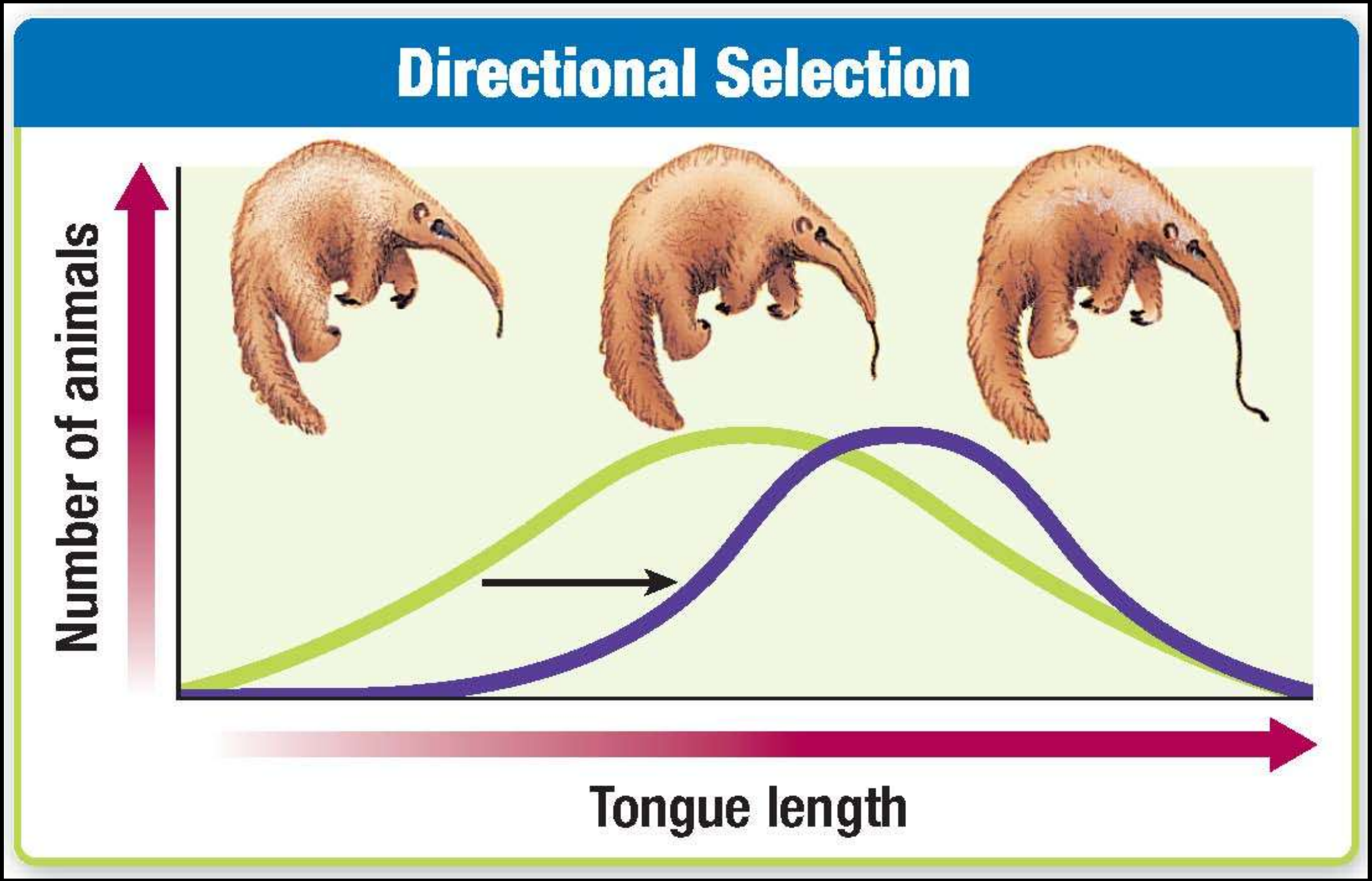
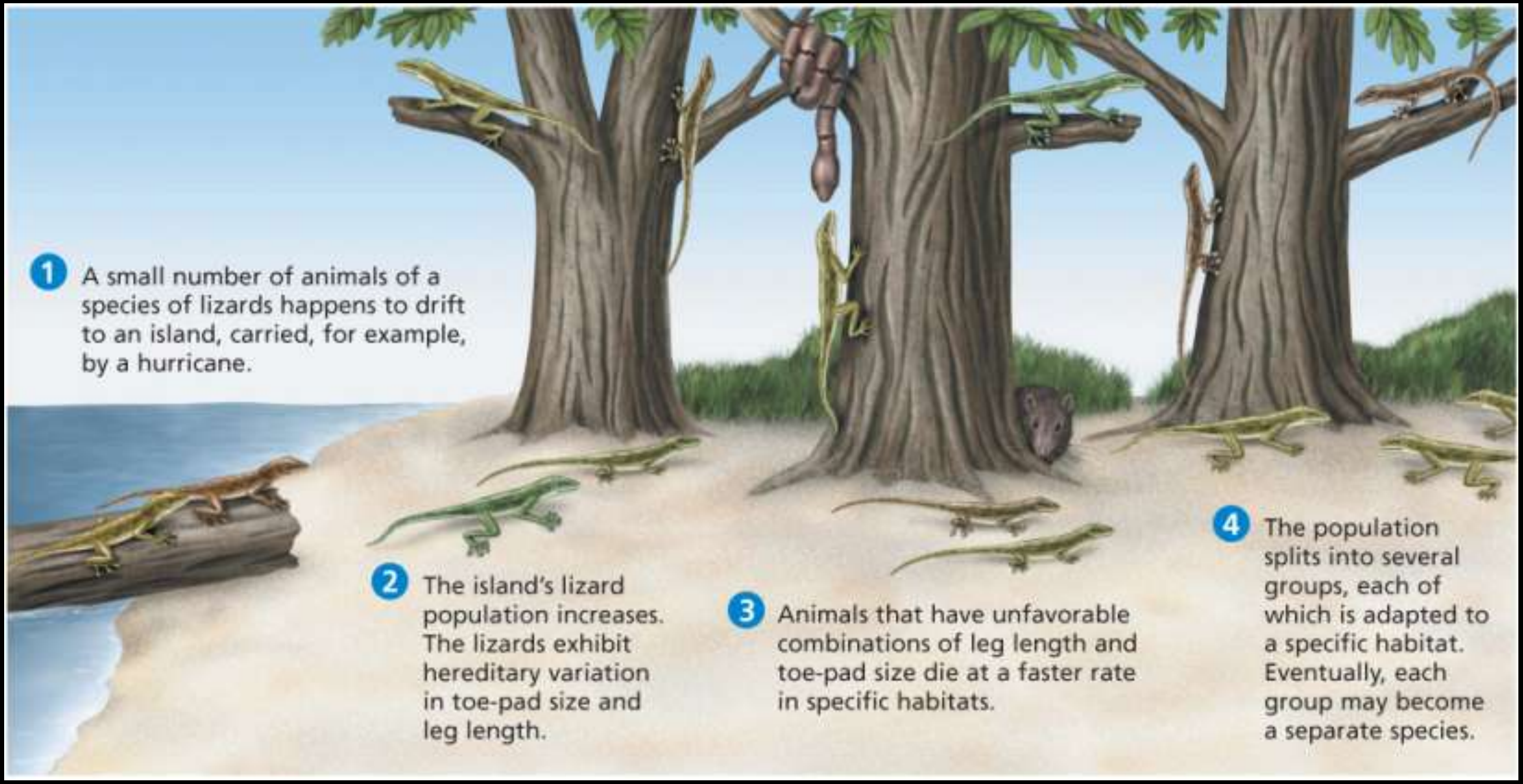
Kinds of Selection



Adapted from Holt Biology 2008

Natural Selection of Anole Lizard Species



Adapted from Holt Biology 2008

YOUR TURN

Think, Write, Share & Re-write

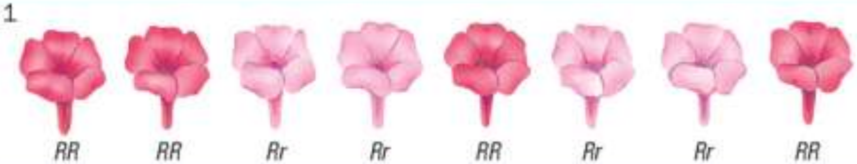
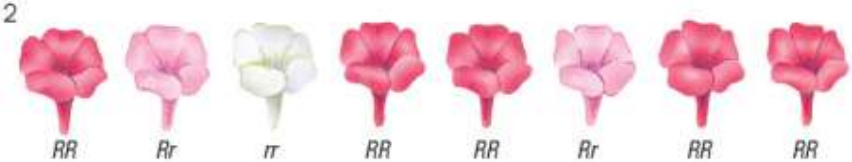
Which form of selection increases the range of variation in a distribution?

Adapted from Holt Biology 2008

Summary

The **Hardy-Weinberg principle** predicts that the **frequencies of alleles** and **genotypes** in a population will not change unless at least one of five forces acts upon the population.

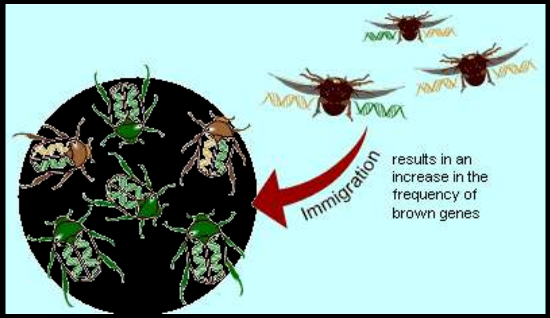
Allele Frequencies in Two Generations

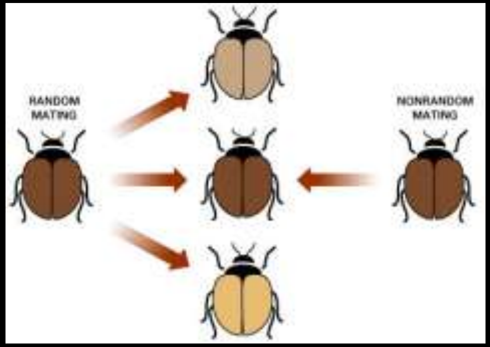
Genotype frequency	Allele frequency	Generation
RR (red) = 0.5 *Rr* (pink) = 0.5 *rr* (white)= 0	*R* = 0.75 *r* = 0.25	1  *RR* *RR* *Rr* *Rr* *RR* *Rr* *Rr* *RR*
RR (red) = 0.625 *Rr* (pink) = 0.25 *rr* (white)= 0.125	*R* = 0.75 *r* = 0.25	2  *RR* *Rr* *rr* *RR* *RR* *Rr* *RR* *RR*

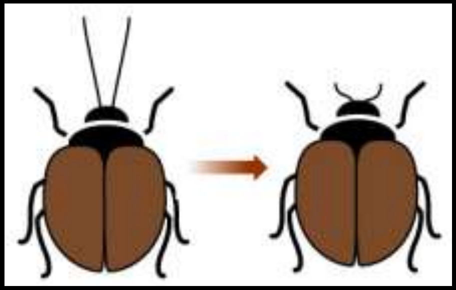
Adapted from Holt Biology 2008

Summary

The forces that can act against genetic equilibrium are gene flow, nonrandom mating, genetic drift, mutation, and natural selection.



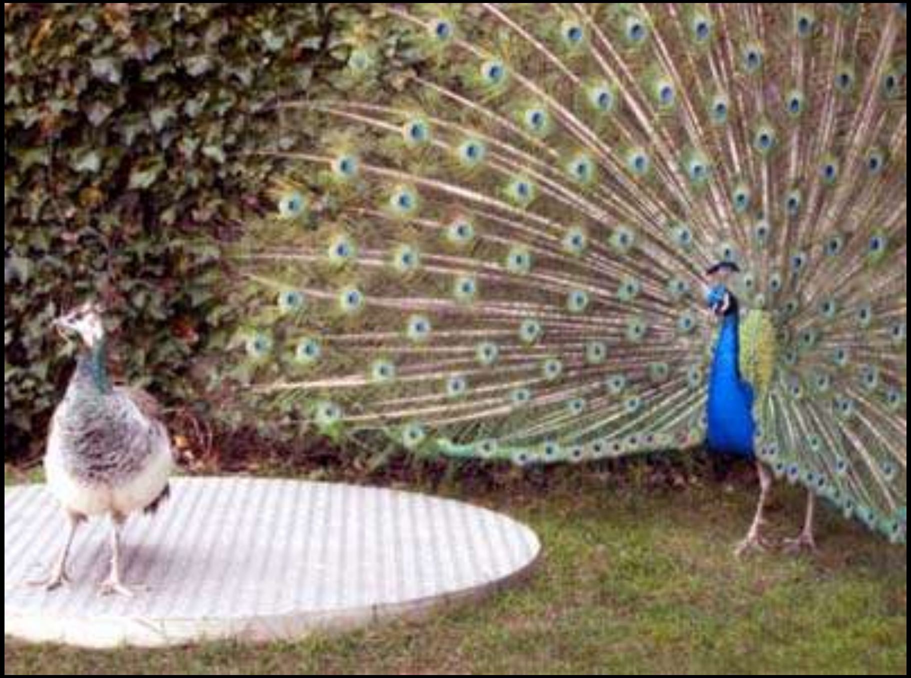




Adapted from Holt Biology 2008

Summary

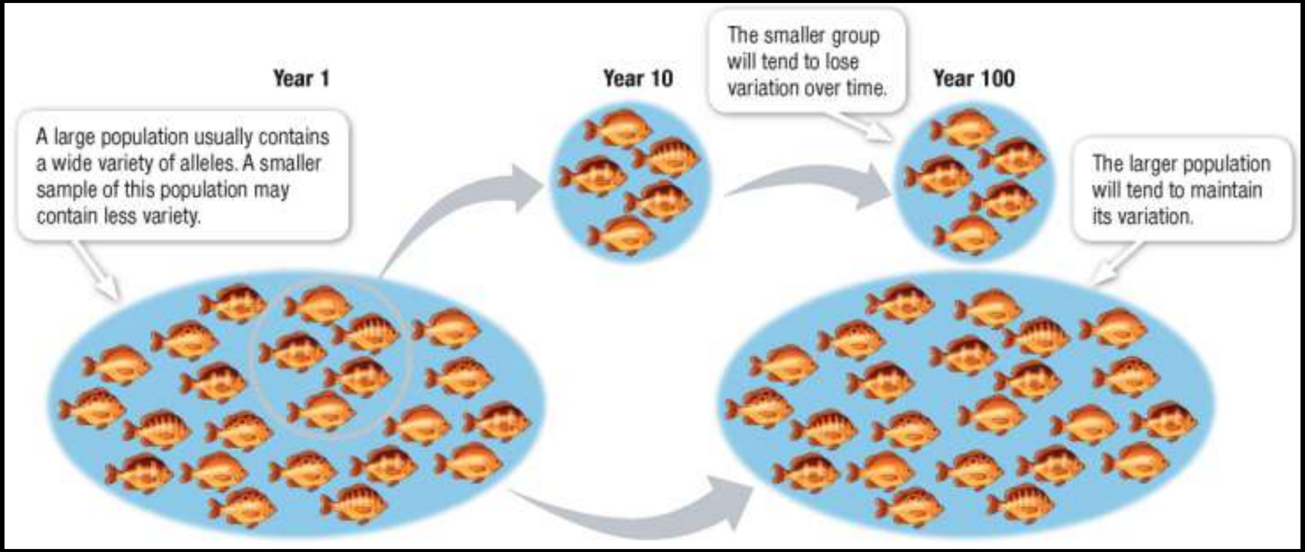
Sexual reproduction creates the possibility that mating patterns or behaviors can influence the gene pool of a population.



Adapted from Holt Biology 2008

Summary

Allele frequencies are more likely to remain stable in large populations than in small populations.



Adapted from Holt Biology 2008

Summary

Natural selection acts only to change the relative frequency of alleles that exist in a population. Natural selection acts on genotypes by removing unsuccessful phenotypes from a population.

Adapted from Holt Biology 2008

Summary

Three major patterns are possible in the way that natural selection affects a distribution of polygenic characters over time. These patterns are directional selection, stabilizing selection, and disruptive selection.

Chapter 17 Section 3: Population Genetics and Speciation

Adapted from Holt Biology 2008

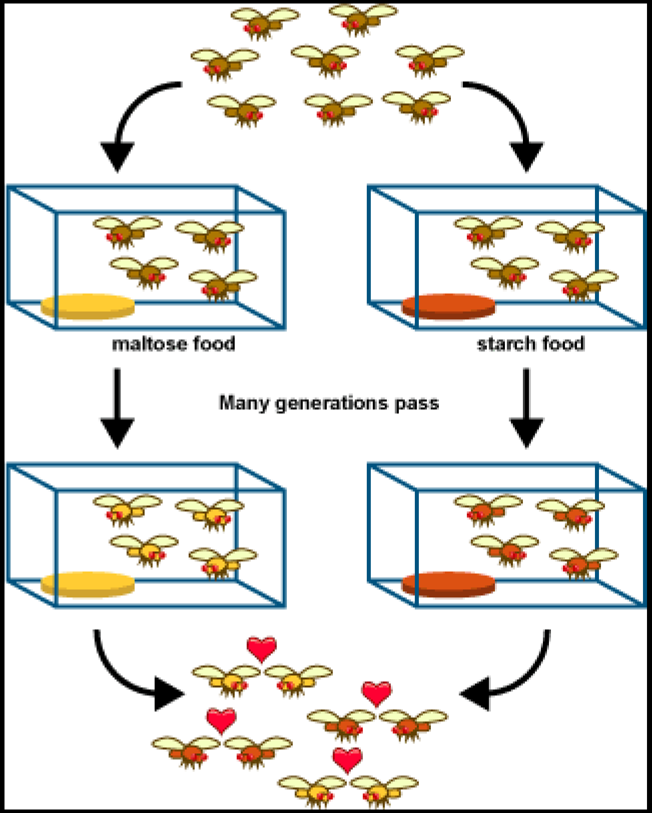
Chapter 17 Section 3: Population Genetics and Speciation

Key Vocabulary Terms

Adapted from Holt Biology 2008

Reproductive Isolation

A state in which a particular set of populations can no longer interbreed to produce future generations of offspring



Adapted from Holt Biology 2008

Subspecies

A taxonomic classification below species that groups organisms that live in different geographical areas, differ morphologically from other populations of the species, but can interbreed with other populations of the species

Adapted from Holt Biology 2008

Chapter 17 Section 3: Population Genetics and Speciation

Notes

Adapted from Holt Biology 2008

Defining Species

Scientists may use more than one definition for *species*. The definition used depends on the organisms and field of science being studied.

Adapted from Holt Biology 2008

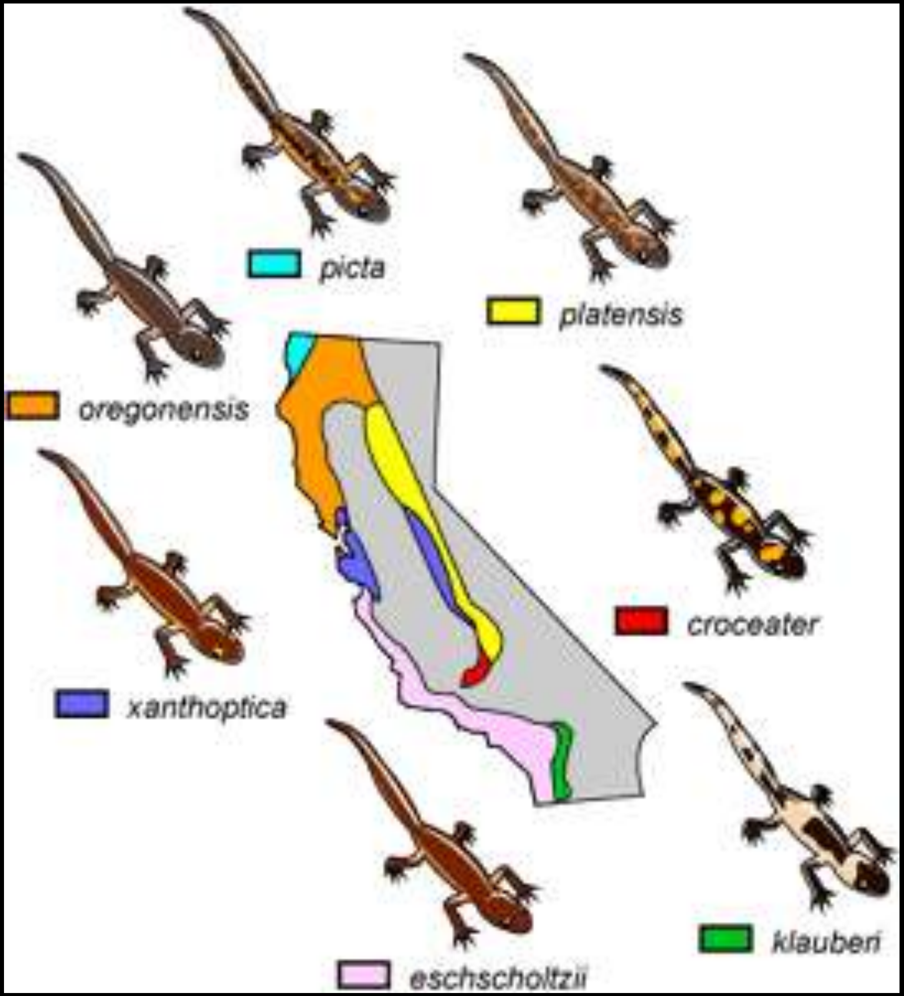
Defining Species

A *species* is generally defined as a group of natural populations that can interbreed and usually produce fertile offspring.

Adapted from Holt Biology 2008

Defining Species

This definition is based on the *biological species concept*.



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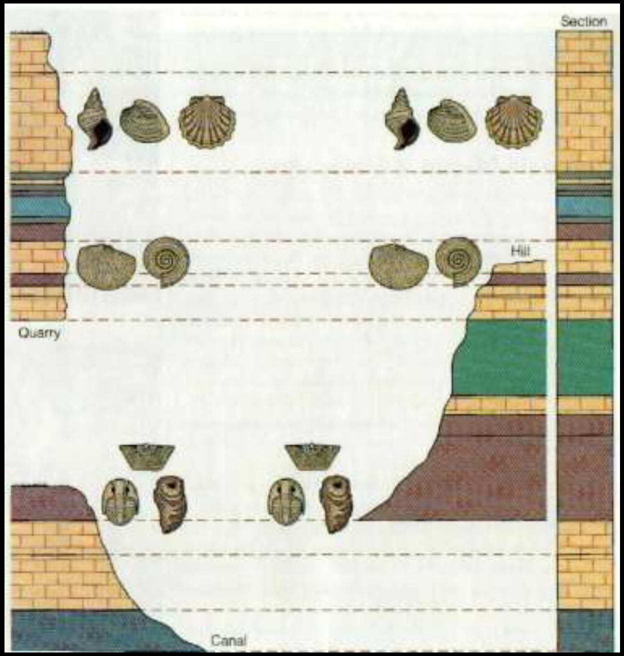
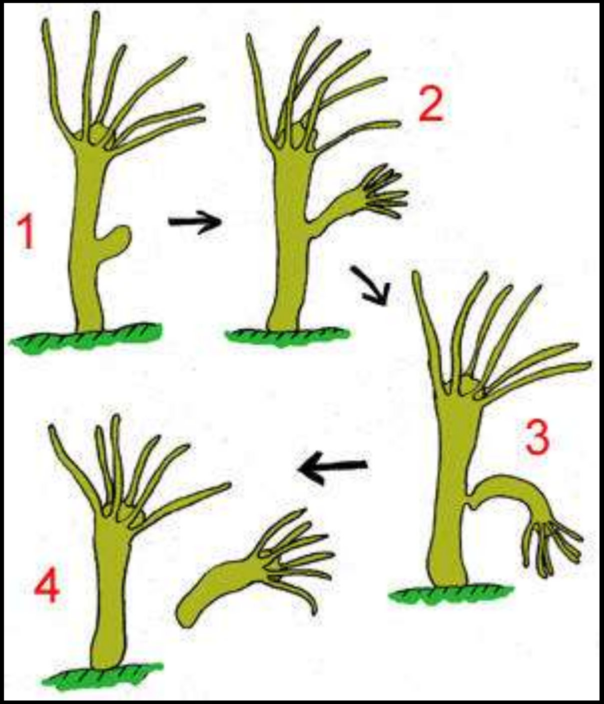
Defining Species

Other definitions for species may be used for fossils or for organisms that reproduce asexually.





Adapted from Holt Biology 2008

Defining Species

Instead of, or in addition to, the biological species concept, species may be defined based on:

- their physical features,
- their ecological roles, or
- their genetic relatedness.

Adapted from Holt Biology 2008

YOUR TURN

Think, Write, Share & Re-write

Why is a species hard to define?

Adapted from Holt Biology 2008

Forming New Species

Adapted from Holt Biology 2008

Forming New Species

Each population of a single species lives in a different place.

Adapted from Holt Biology 2008

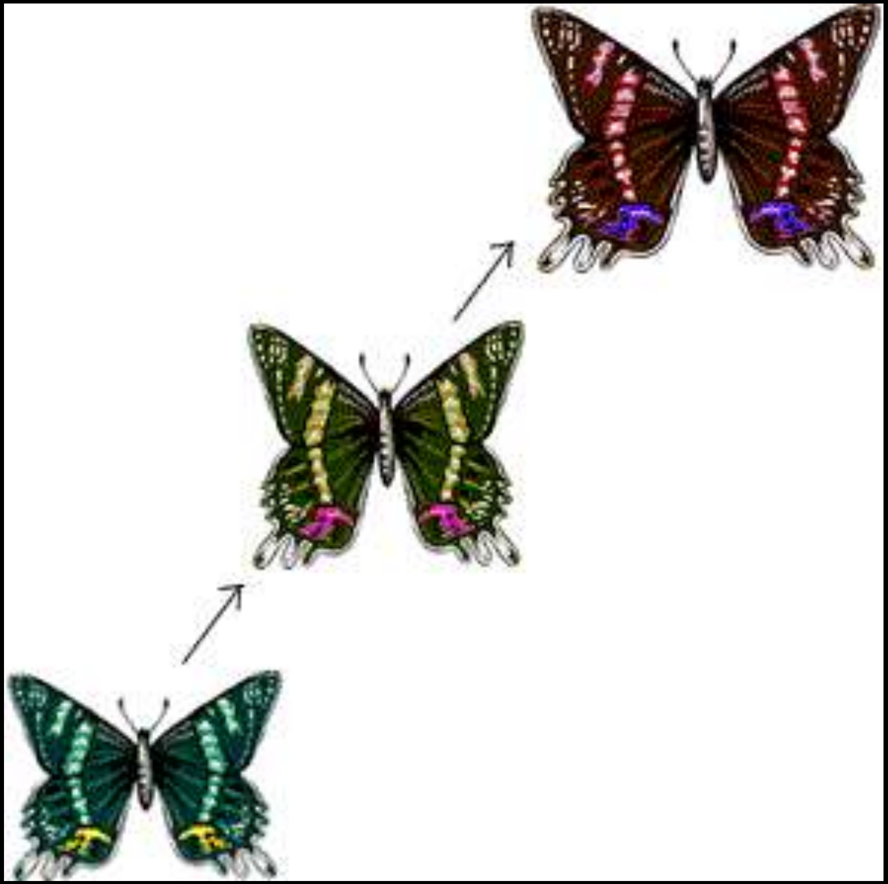
Forming New Species

In each place, natural selection acts upon each population and tends to result in offspring that are better adapted to each specific environment.

Adapted from Holt Biology 2008

Forming New Species

If the environments differ, the adaptations may differ. This is called *divergence* and can lead to the formation of new species.



Adapted from Holt Biology 2008

Forming New Species

Speciation is the process of forming new species by evolution from preexisting species.

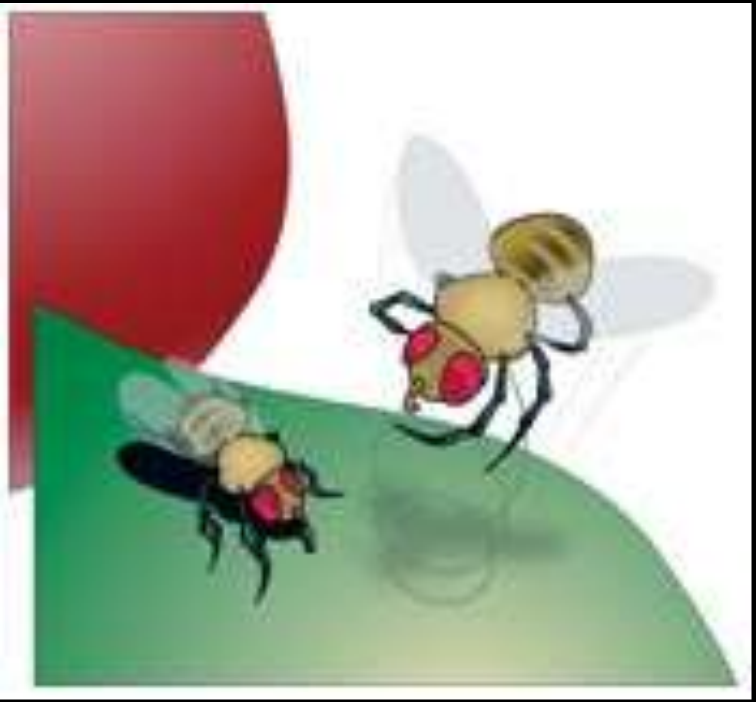
Adapted from Holt Biology 2008

Speciation has occurred when the net effects of evolutionary forces result in a population that has unique features and is reproductively isolated.

Adapted from Holt Biology 2008

Reproductive Isolation

Reproductive isolation is a state in which two populations can no longer interbreed to produce future offspring.



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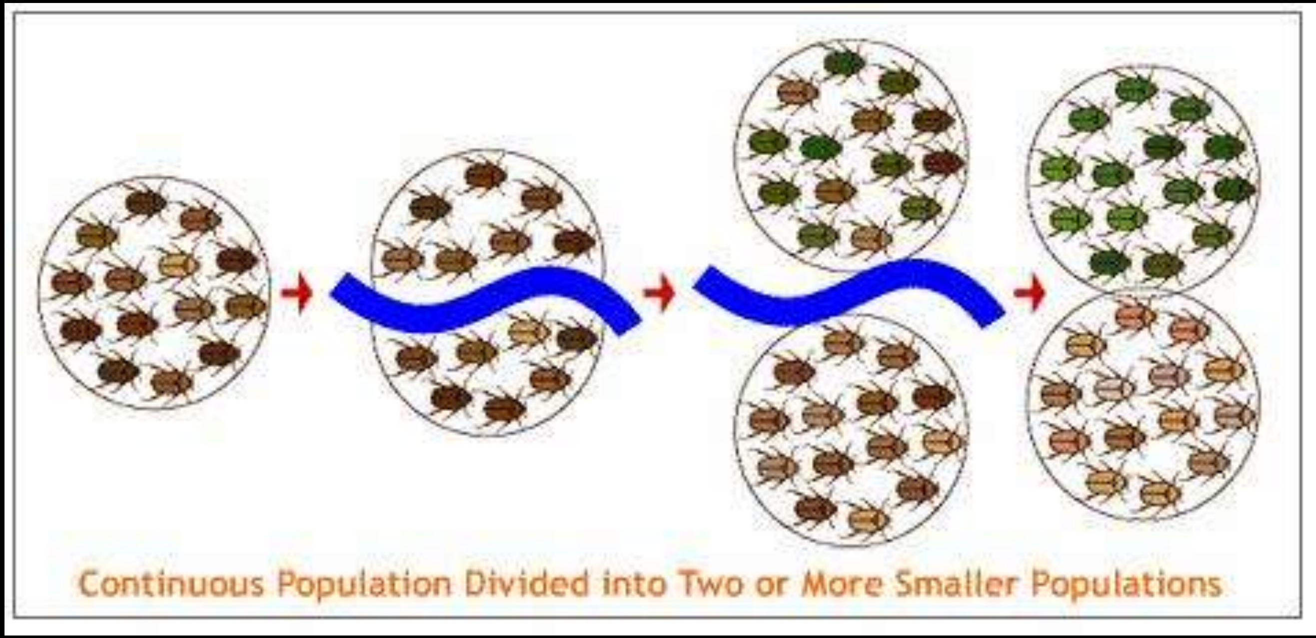
Forming New Species

From this point on, the groups may be subject to different forces, so they will tend to diverge over time.



Adapted from Holt Biology 2008

Forming New Species

Through divergence over time, populations of the same species may differ enough to be considered subspecies.

Adapted from Holt Biology 2008

Forming New Species

Subspecies are simply populations that have taken a step toward speciation by diverging in some detectable way. This may only be apparent after the passage of time.

Adapted from Holt Biology 2008

Mechanisms of Isolation

Any of the following mechanisms may contribute to the reproductive isolation of populations:

- Geography
- Ecological Niche
- Mating Behavior and Timing
- Polyploidy
- Hybridization

Adapted from Holt Biology 2008

YOUR TURN

Think, Write, Share & Re-write

What mechanisms can isolate species?

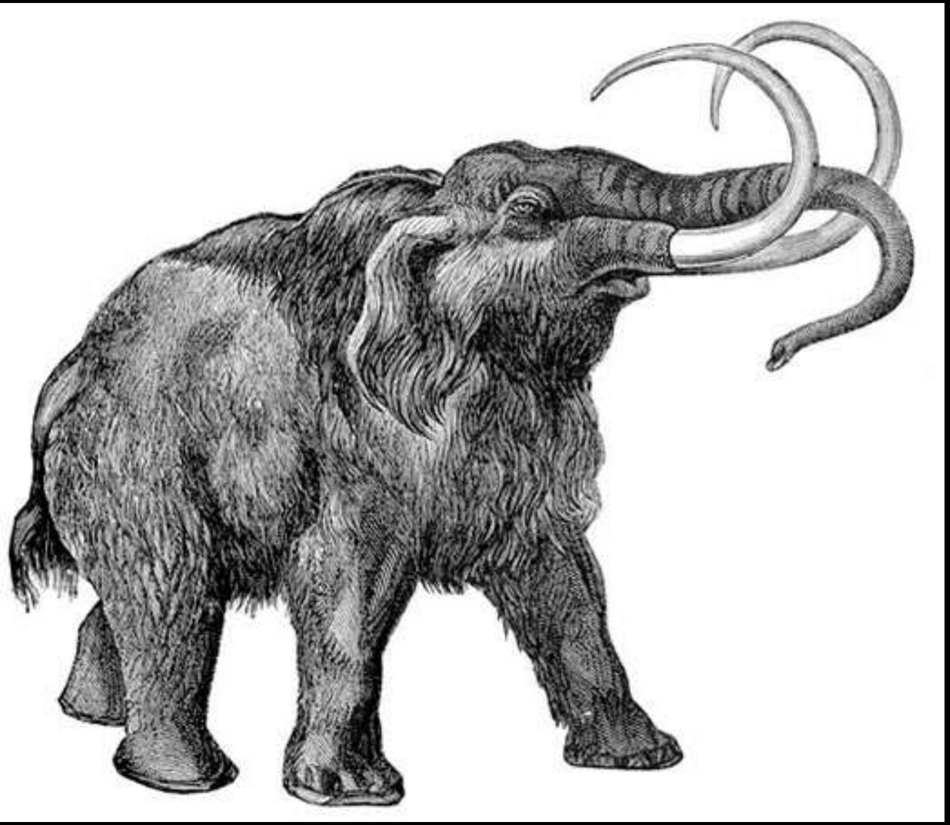
Adapted from Holt Biology 2008

Extinction:
The End of Species

Adapted from Holt Biology 2008

Extinction: The End of Species

Extinction occurs when a species fails to produce any more descendants. Extinction, like speciation, can only be detected after it is complete.



Adapted from Holt Biology 2008

Extinction: The End of Species

More than 99% of all of the species that have ever lived on earth have become extinct.

Adapted from Holt Biology 2008

Extinction: The End of Species

Many cases of extinction are the result of environmental change.

Adapted from Holt Biology 2008

Extinction: The End of Species

If a species cannot adapt fast enough to changes, the species may be driven to extinction.

Adapted from Holt Biology 2008

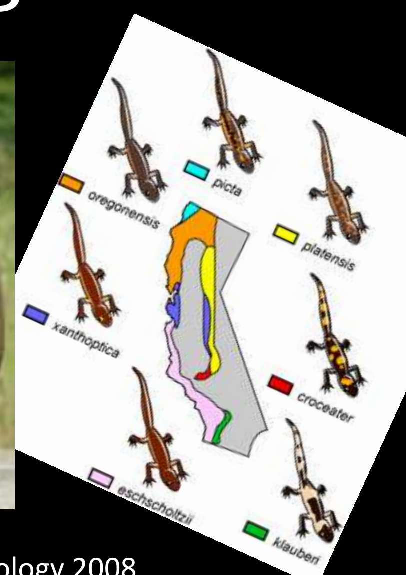
YOUR TURN

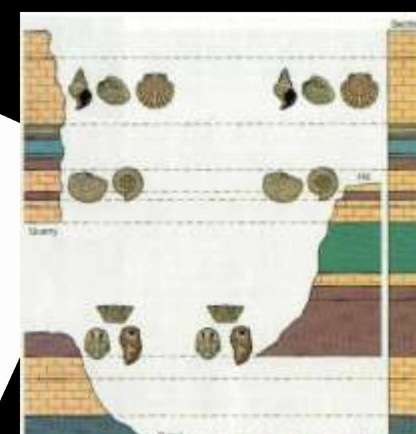
Think, Write, Share & Re-write

When do we know that extinction has happened?

Summary

Today, scientists may use more than one definition for species. The definition used depends on the organisms and field of science being studied.





Adapted from Holt Biology 2008

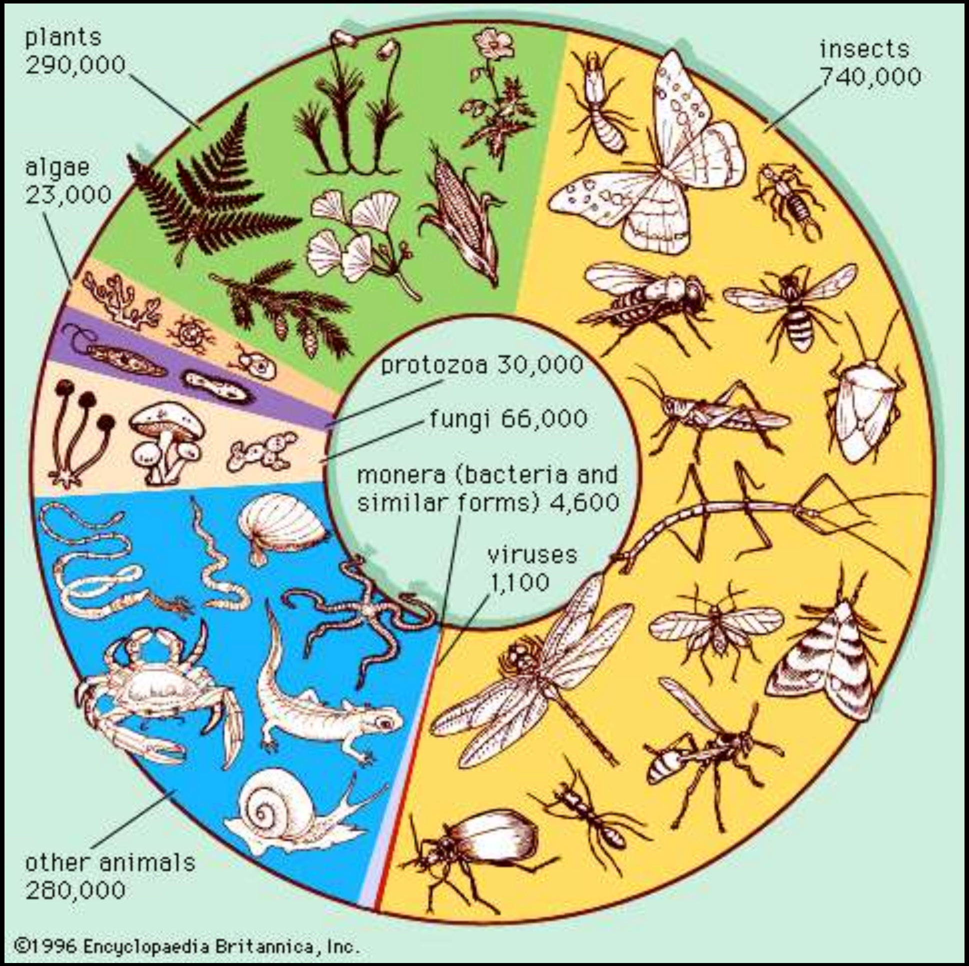
Summary

Speciation has occurred when the net effects of evolutionary forces result in a population that has unique features and is reproductively isolated.

Adapted from Holt Biology 2008

Summary

The species that exist at any time are the net result of both speciation and extinction.



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