16-2 Evolution as Genetic Change

Natural selection affects which individuals survive and reproduce and which do not.

If an individual dies without reproducing, it does not contribute its alleles to the population's gene pool.

If an individual produces many offspring, its alleles stay in the gene pool and may increase in frequency.

Evolution is any change over time in the relative frequencies of alleles in a population.

Populations, not individual organisms, can evolve over time.

Natural selection on single-gene traits can lead to changes in allele frequencies and thus to evolution.

Organisms of one color may produce fewer offspring than organisms of other colors.

For example, a lizard population is normally brown, but has mutations that produce red and black forms.

Red lizards are more visible to predators, so they will be less likely to survive and reproduce. Therefore, the allele for red color will become rare.

Black lizards may warm up faster on cold days. This may give them energy to avoid predators. In turn, they may produce more offspring.

The allele for black color will increase in relative frequency.

Natural Selection on Single-Gene Traits

Effect of Color Mutations on Lizard Survival

Initial Population	Generation 10	Generation 20	Generation 30
80%	80%	70%	40%
10%	0%	0%	0%
10%	20%	30%	60%

Natural selection can affect the distributions of phenotypes in any of three ways:

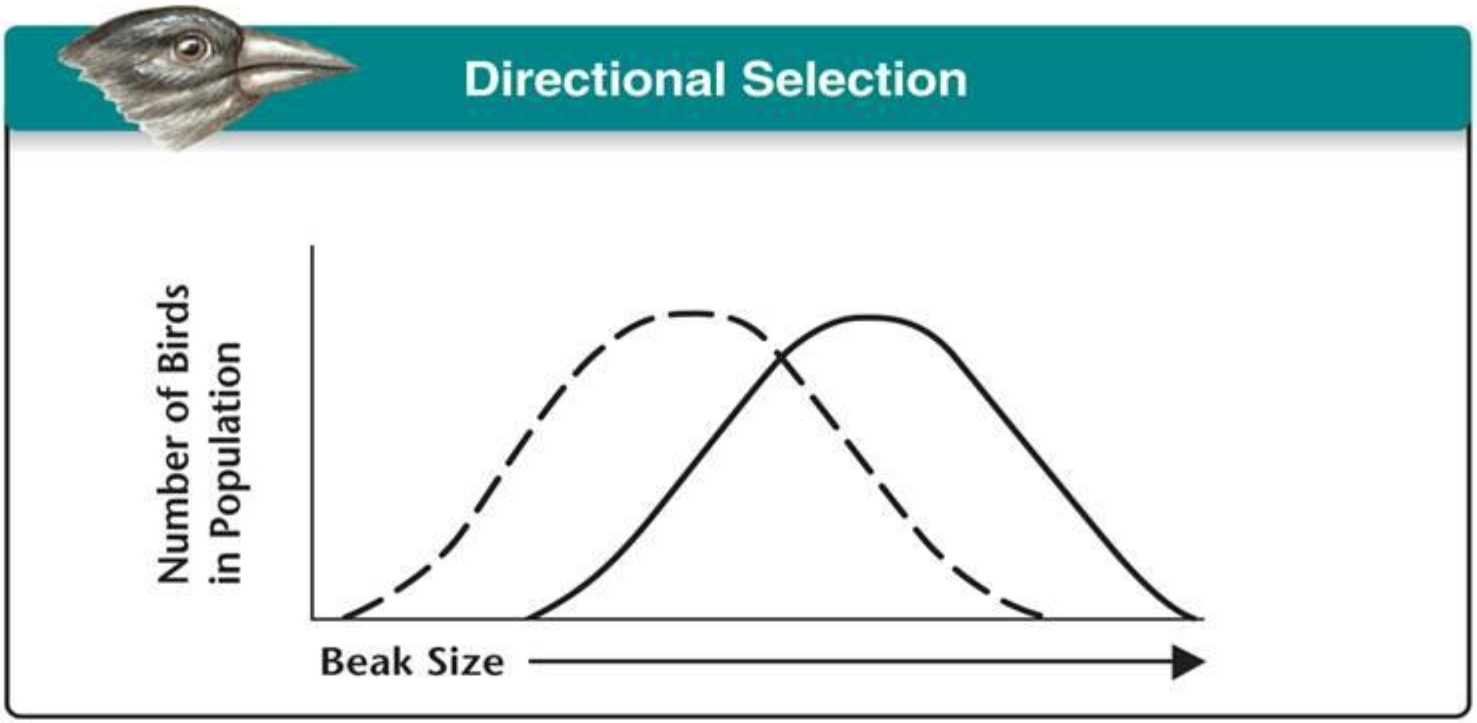
- **directional selection**
- **stabilizing selection**
- **disruptive selection**

Directional Selection

When individuals at one end of the curve have higher fitness than individuals in the middle or at the other end, **directional selection** takes place.

The range of phenotypes shifts as some individuals survive and reproduce while others do not.

In this case, birds with larger beaks have higher fitness. Therefore, the average beak size increases.

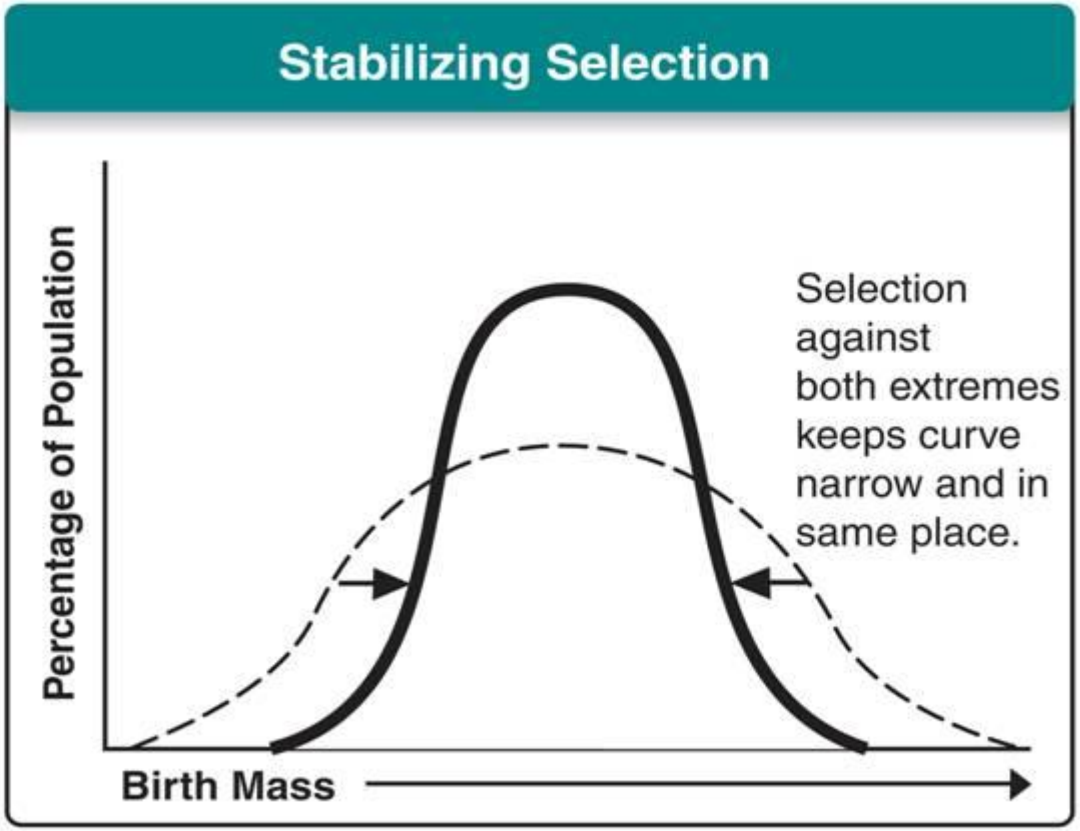


Stabilizing Selection

When individuals near the center of the curve have higher fitness than individuals at either end of the curve, **stabilizing selection** takes place.

This keeps the center of the curve at its current position, but it narrows the overall graph.

Human babies born at an average mass are more likely to survive than babies born either much smaller or much larger than average.

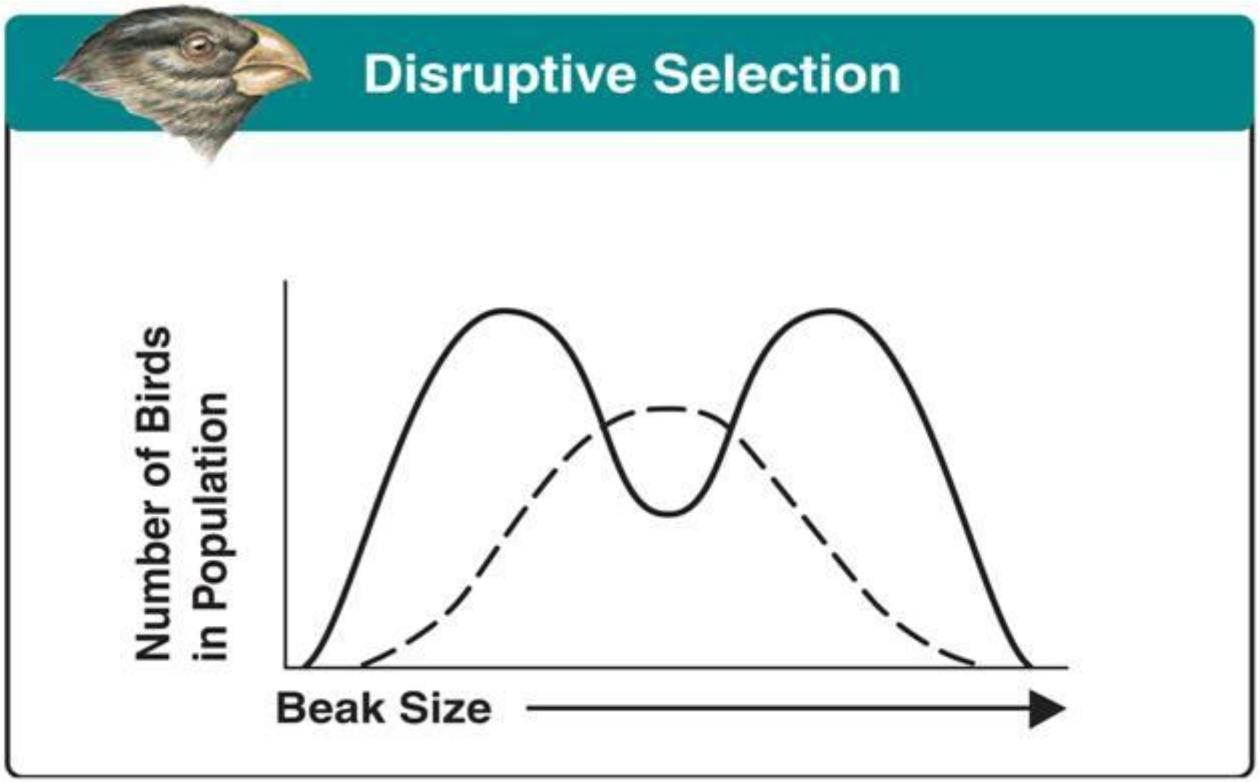


Disruptive Selection

When individuals at the upper and lower ends of the curve have higher fitness than individuals near the middle, **disruptive selection** takes place.

If the pressure of natural selection is strong enough and long enough, the curve will split, creating two distinct phenotypes.

If average-sized seeds become scarce, a bird population will split into two groups: one that eats small seeds and one that eats large seeds.



In small populations, individuals that carry a particular allele may leave more descendants than other individuals do, just by chance.

Over time, a series of chance occurrences of this type can cause an allele to become common in a population.

Genetic drift may occur when a small group of individuals colonizes a new habitat.

Individuals may carry alleles in different relative frequencies than did the larger population from which they came.

The new population will be genetically different from the parent population.

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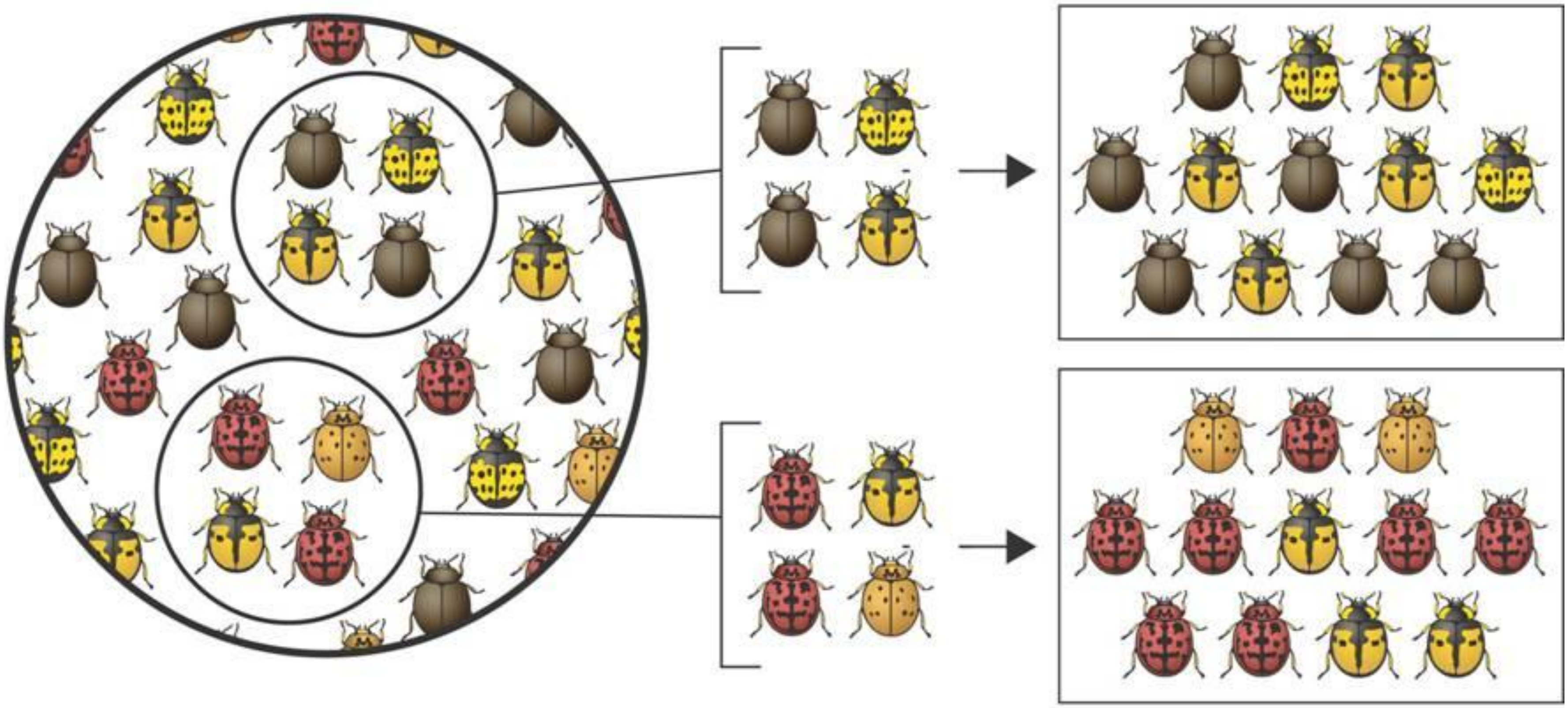
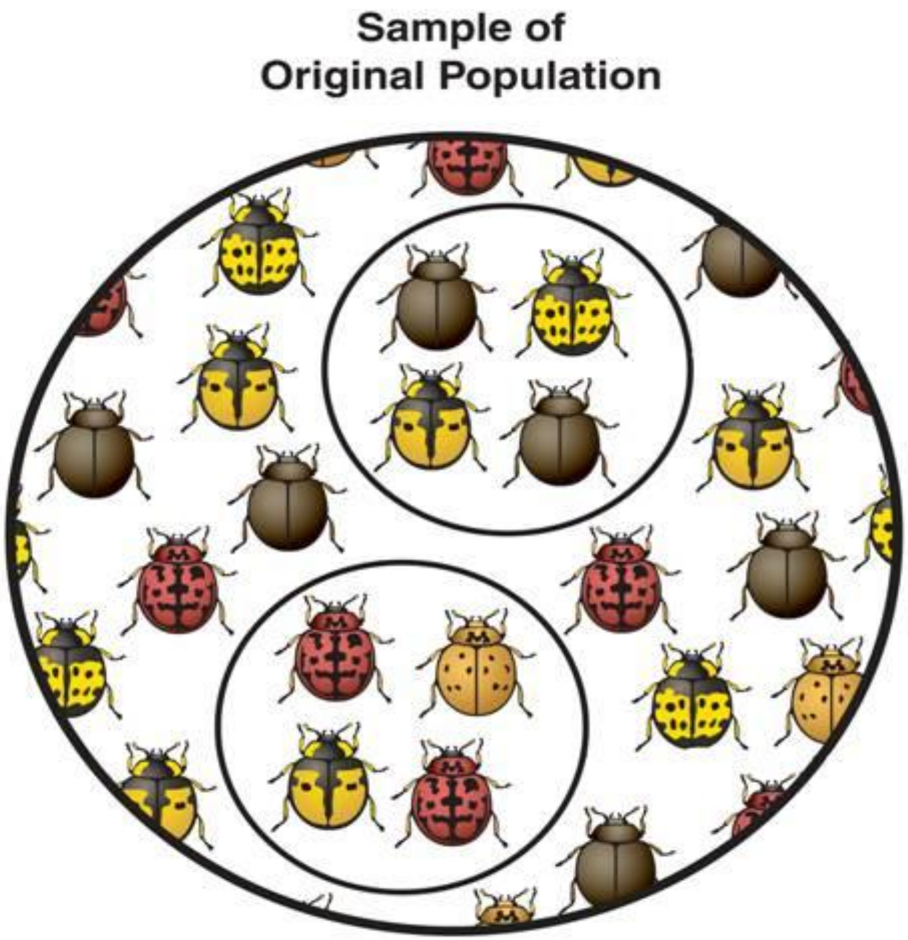
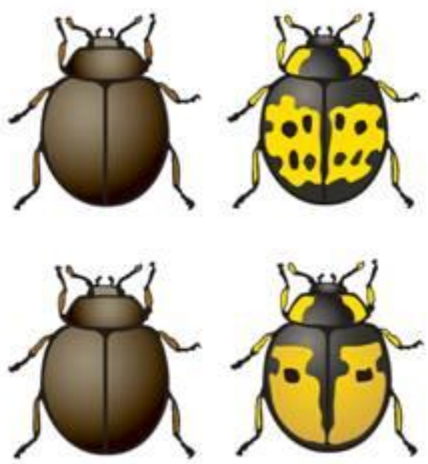
Genetic Drift



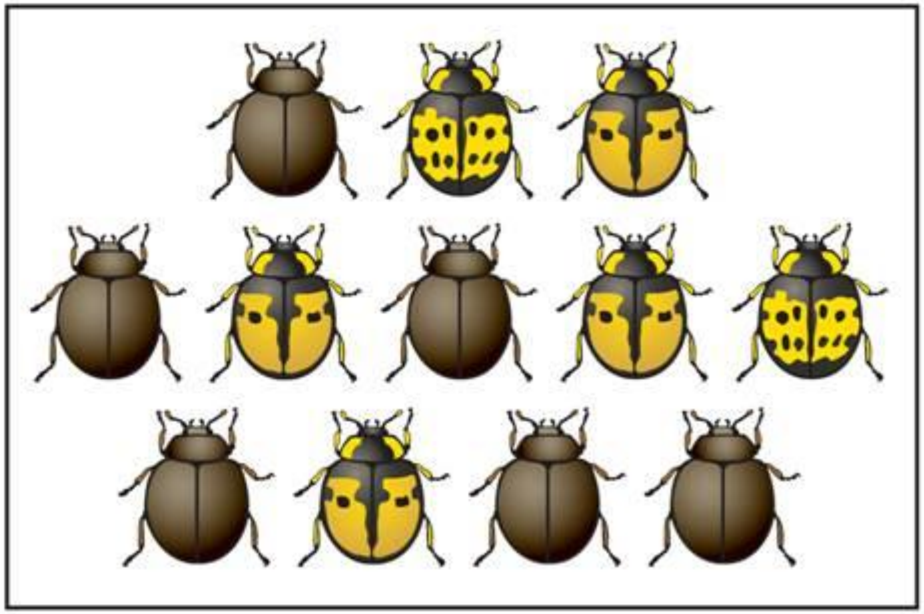

Sample of
Original Population

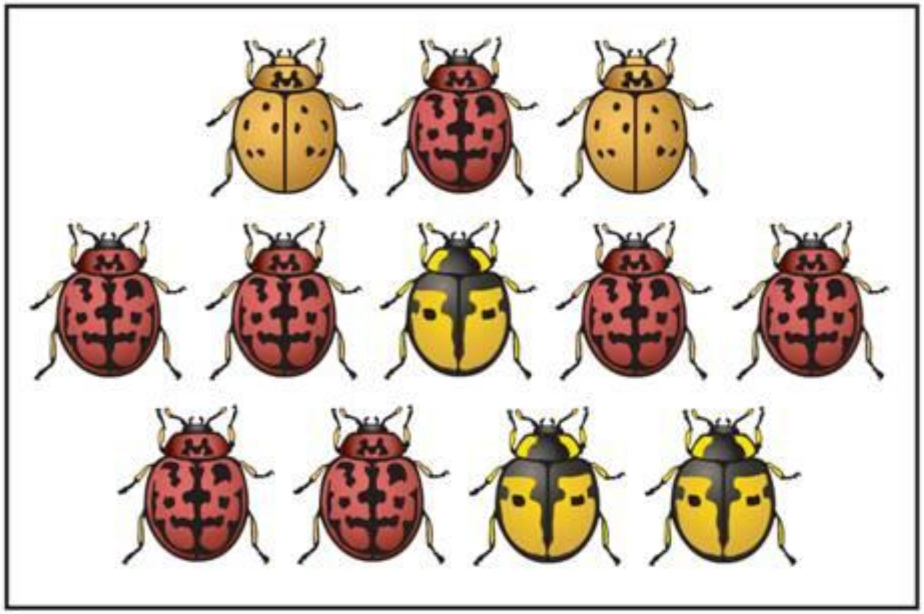
Founding Population A



Founding Population B

Descendants





Population A **Population B**

When allele frequencies change due to migration of a small subgroup of a population it is known as the **founder effect.**

Evolution Versus Genetic Equilibrium

The **Hardy-Weinberg principle** states that allele frequencies in a population will remain constant unless one or more factors cause those frequencies to change.

When allele frequencies remain constant it is called **genetic equilibrium**.

Five conditions are required to maintain genetic equilibrium from generation to generation:

- **there must be random mating,**
- **the population must be very large,**
- **there can be no movement into or out of the population,**
- **there can be no mutations, and**
- **there can be no natural selection.**

Random Mating

Random mating ensures that each individual has an equal chance of passing on its alleles to offspring.

In natural populations, mating is rarely completely random. Many species select mates based on particular heritable traits.

Large Population

Genetic drift has less effect on large populations than on small ones.

Allele frequencies of large populations are less likely to be changed through the process of genetic drift.

No Movement Into or Out of the Population

Because individuals may bring new alleles into a population, there must be no movement of individuals into or out of a population.

The population's gene pool must be kept together and kept separate from the gene pools of other populations.

No Mutations

If genes mutate, new alleles may be introduced into the population, and allele frequencies will change.

No Natural Selection

All genotypes in the population must have equal probabilities of survival and reproduction.

No phenotype can have a selective advantage over another.

There can be no natural selection operating on the population.

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1 Which of the following patterns of natural selection on polygenic traits favors both extremes of a bell curve?

a. stabilizing selection

A b. disruptive selection

c. directional selection

d. genetic drift

2 Which of the following events could lead to genetic drift?

a. A few new individuals move into a large, diverse population.

A b. A few individuals from a large, diverse population leave and establish a new population.

c. Two large populations come back together after a few years of separation.

d. The mutation rate in a large population increases due to pollution.

3 The situation in which allele frequencies remain constant in a population is known as

a. genetic drift.

b. the founder effect.

A c. genetic equilibrium.

d. natural selection.

4 Which of the following conditions is required to maintain genetic equilibrium in a population?

a. movement in or out of the population

A b. random mating

c. natural selection

d. small population

5 According to the Hardy-Weinberg principle, no evolution will take place if

A

a. all five of the Hardy-Weinberg conditions are met.

b. any one of the Hardy-Weinberg conditions is met.

c. at least three of the Hardy-Weinberg conditions are met.

d. none of the Hardy-Weinberg conditions are met.

END OF SECTION

16-3 The Process of Speciation

Natural selection and chance events can change the relative frequencies of alleles in a population and lead to speciation.

Speciation is the formation of new species.

A species is a group of organisms that breed with one another and produce fertile offspring.

What factors are involved in the formation of new species?

The gene pools of two populations must become separated for them to become new species.

Isolating Mechanisms

As new species evolve, populations become reproductively isolated from each other.

When the members of two populations cannot interbreed and produce fertile offspring, **reproductive isolation** has occurred.

Reproductive isolation can develop in a variety of ways, including:

- behavioral isolation
- geographic isolation
- temporal isolation

Behavioral Isolation

Behavioral isolation occurs when two populations are capable of interbreeding but have differences in courtship rituals or other reproductive strategies that involve behavior.

Geographic Isolation

Geographic isolation occurs when two populations are separated by geographic barriers such as rivers or mountains.

Geographic barriers do not guarantee the formation of new species.

If two formerly separated populations can still interbreed, they remain a single species.

Potential geographic barriers may separate certain types of organisms but not others.

Temporal Isolation

Temporal isolation occurs when two or more species reproduce at different times.

Galápagos Islands Finches

Shape of Head and Beak			
Common Name of Finch Species	Vegetarian tree finch	Large insectivorous tree finch	Woodpecker finch
Main Food	Fruits	Insects	Insects
Feeding Adaptation	Parrotlike beak	Grasping beak	Uses cactus spines
Habitat	Trees	Trees	Trees

Galápagos Islands Finches

Shape of Head and Beak			
Common Name of Finch Species	Cactus ground finch	Sharp-beaked ground finch	Large ground finch
Main Food	Cacti	Seeds	Seeds
Feeding Adaptation	Large crushing beak	Pointed crushing beak	Large crushing beak
Habitat	Ground	Ground	Ground

When food was scarce, individuals with large beaks were more likely to survive.

Speciation in Darwin's Finches

Speciation in the Galápagos finches occurred by:

- founding of a new population
- geographic isolation
- changes in new population's gene pool
- reproductive isolation
- ecological competition

Founders Arrive

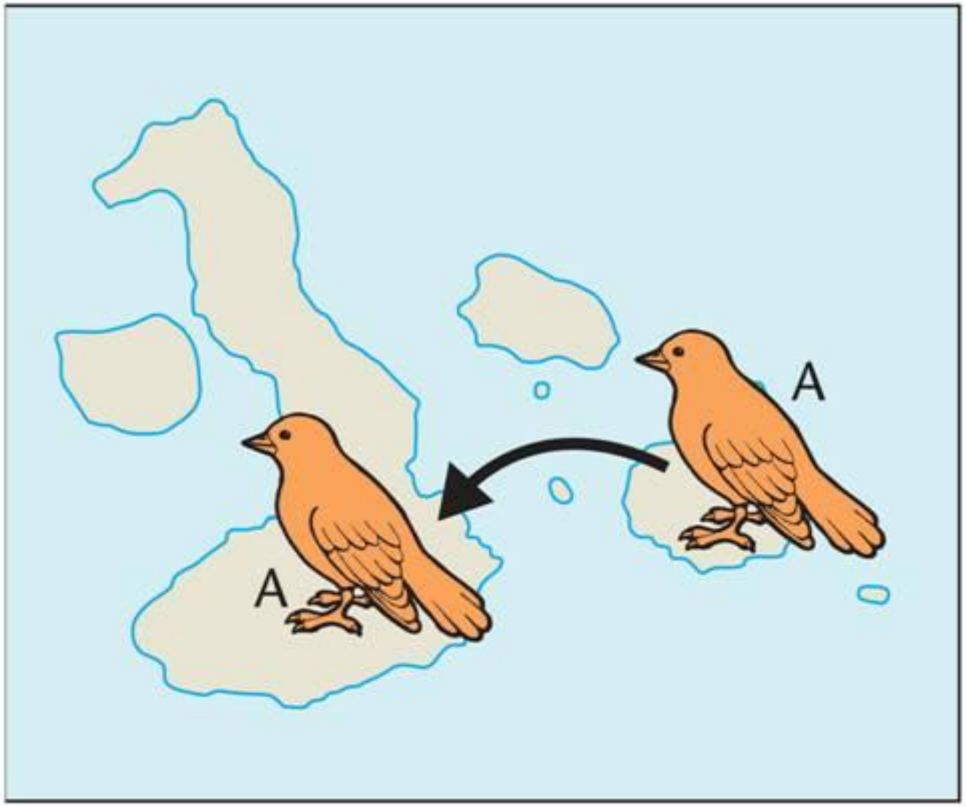
A few finches—species A—travel from South America to one of the Galápagos Islands.

There, they survive and reproduce.

Geographic Isolation

Some birds from species A cross to a second island.

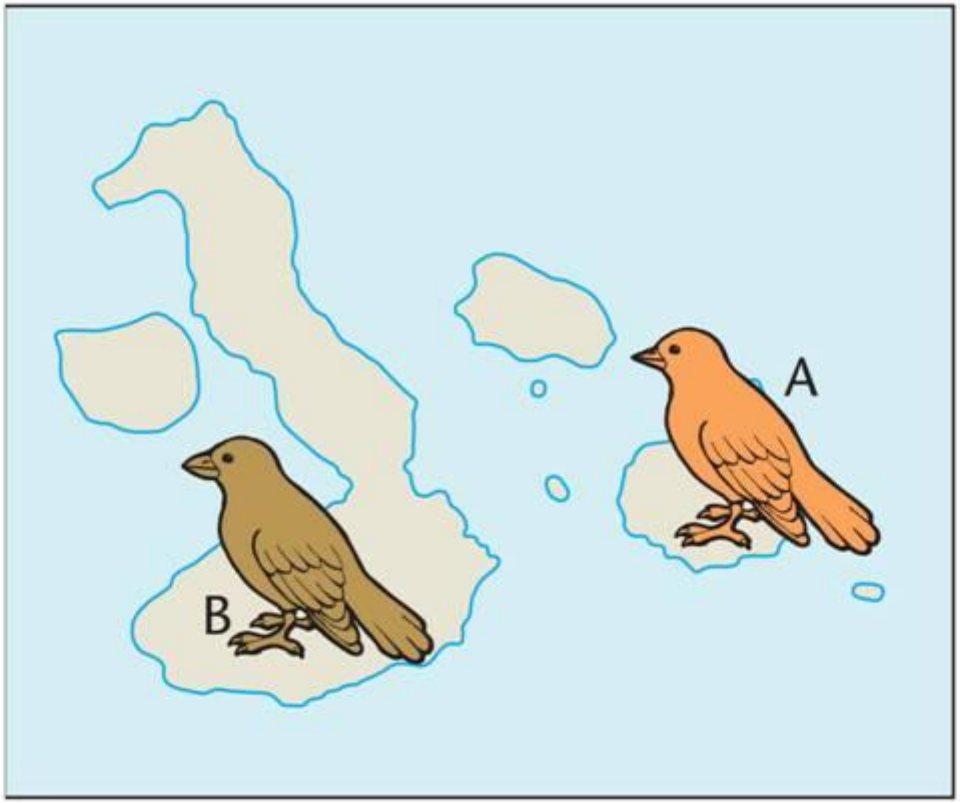
The two populations no longer share a gene pool.



Changes in the Gene Pool

Seed sizes on the second island favor birds with large beaks.

The population on the second island evolves into population B, with larger beaks.



Reproductive Isolation

If population B birds cross back to the first island, they will not mate with birds from population A.

Populations A and B are separate species.

Ecological Competition

As species A and B compete for available seeds on the first island, they continue to evolve in a way that increases the differences between them.

A new species—C—may evolve.

Continued Evolution

This process of isolation, genetic change, and reproductive isolation probably repeated itself often across the entire Galápagos island chain.

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1 When two species do not reproduce because of differences in mating rituals, the situation is referred to as

a. temporal isolation.

b. geographic isolation.

A c. behavioral isolation.

d. reproductive isolation.

2 The most important factor involved in the evolution of the Kaibab and Abert squirrels of the American Southwest appears to be

a. temporal isolation.

A b. geographic isolation.

c. behavioral isolation.

d. different food sources.

3 One finding of the Grants' research on generations of Galápagos finches was that

a. natural selection did not occur in the finches.

A b. natural selection can take place often and very rapidly.

c. beak size had no effect on survival rate of the finches.

d. natural selection was slow and permanent.

4 All of the following played a role in speciation of Galápagos finches EXCEPT

A

a. no changes in the gene pool.

b. separation of populations.

c. reproductive isolation.

d. natural selection.

5 Beak size in the various groups of Galápagos finches changed primarily in response to

a. climate.

b. mating preference.

A c. food source.

d. availability of water.

END OF SECTION