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Objectives

- **Distinguish** among the three patterns of dispersion in a population.
- **Contrast** exponential growth and logistic growth.
- **Differentiate** *r*-strategists from *K*-strategists.

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What Is a Population?

- A **population** consists of all the individuals of a species that live together in one place at one time.
- Every population tends to grow because individuals tend to have multiple offspring over their lifetime. But eventually, limited resources in an environment limit the growth of a population.
- The statistical study of all populations is called demography.

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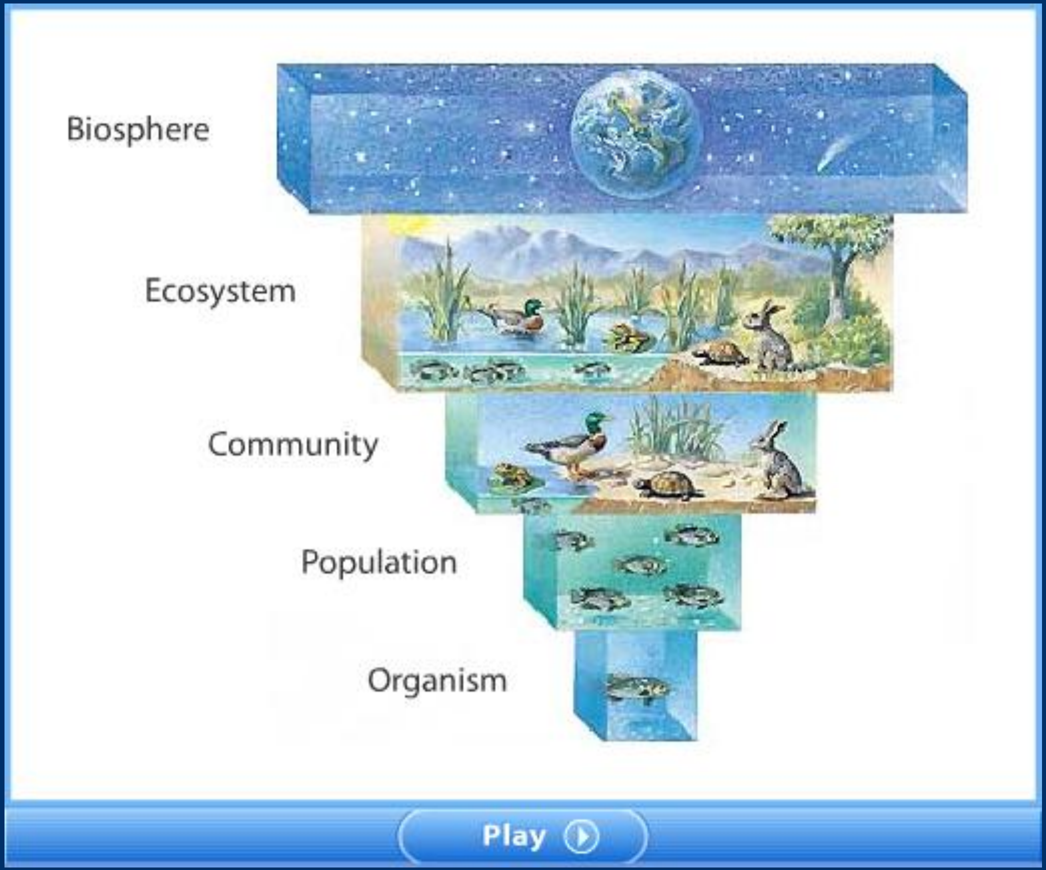
Population



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What Is a Population?, *continued*

Three Key Features of Populations

- The number of individuals in a population, or **population size,** can affect the population's ability to survive.
- **Population density** is the number of individuals that live in a given area.
- A third feature of a population is the way the individuals of the population are arranged in space. This feature is called **dispersion.**

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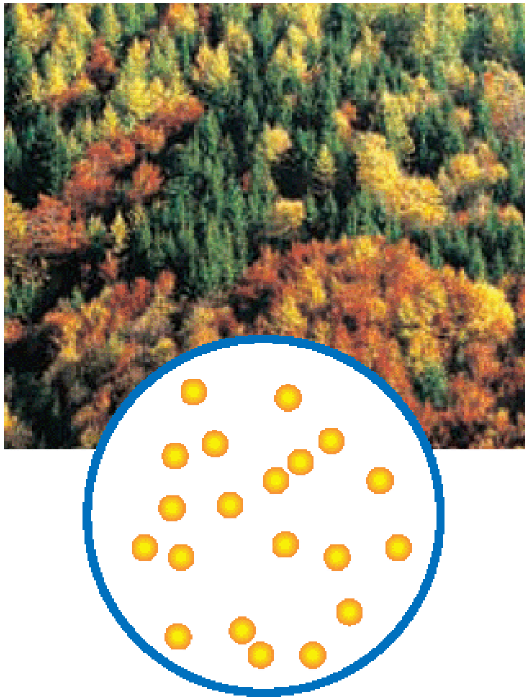
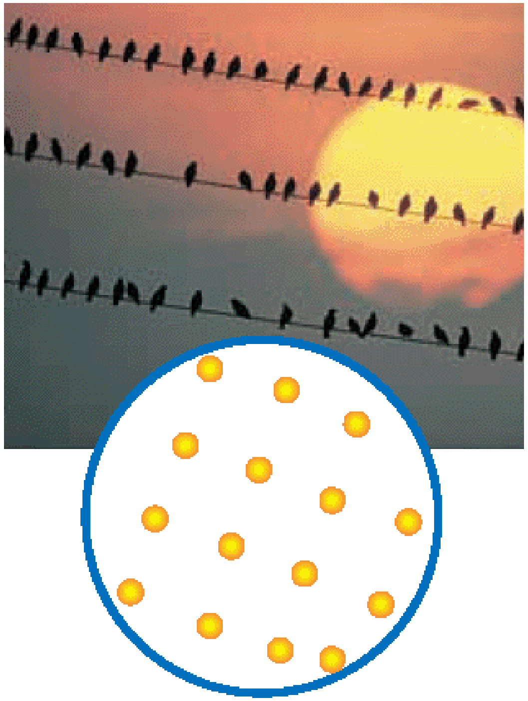
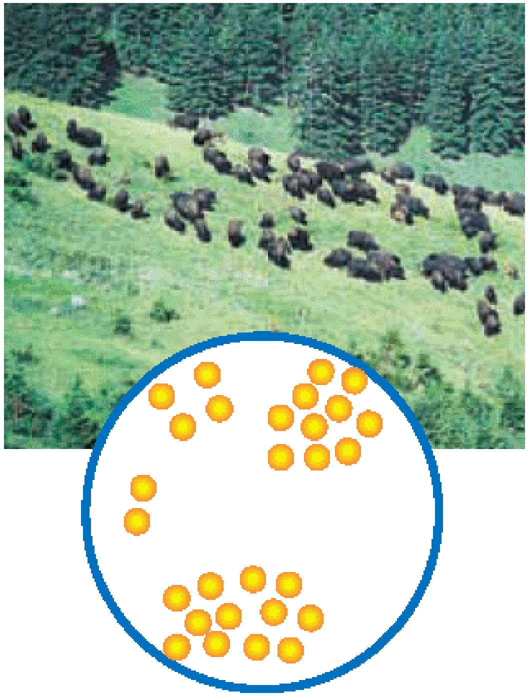
Three Patterns of Population Dispersion



Pine trees in a *random distribution*



Birds in an *even distribution*



Buffalo in a *clumped distribution*

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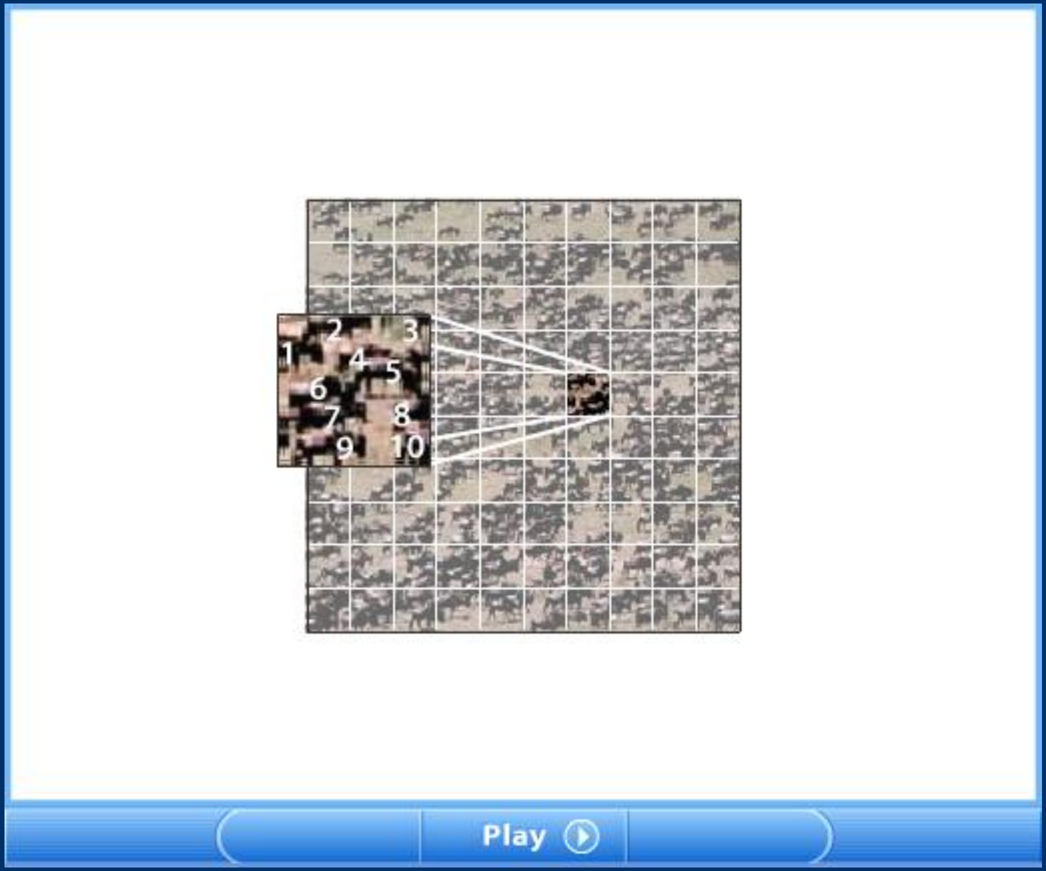
Characteristics of Populations



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Modeling Population Growth

- When demographers try to predict how a population will grow, they make a model of the population.
- A **population model** is a hypothetical population that attempts to exhibit the key characteristics of a real population.
- By making a change in the model and observing the outcome, demographers can predict what might occur in a real population.

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Modeling Population Growth, *continued*

Growth Rate

- A population grows when more individuals are born than die in a given period.
- So a simple population model describes the rate of population growth as the difference between the birthrate and the death rate.
- For human populations, birth and death rates are usually expressed as the number of births and deaths per thousand people per year.

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Modeling Population Growth, *continued*

Growth Rate and Population Size

- When population size is plotted against time on a graph, the population growth curve resembles a J-shaped curve and is called an exponential growth curve.
- An **exponential growth curve** is a curve in which the rate of population growth stays the same, as a result the population size increases steadily.
- The population size that an environment can sustain is called the **carrying capacity** (K).

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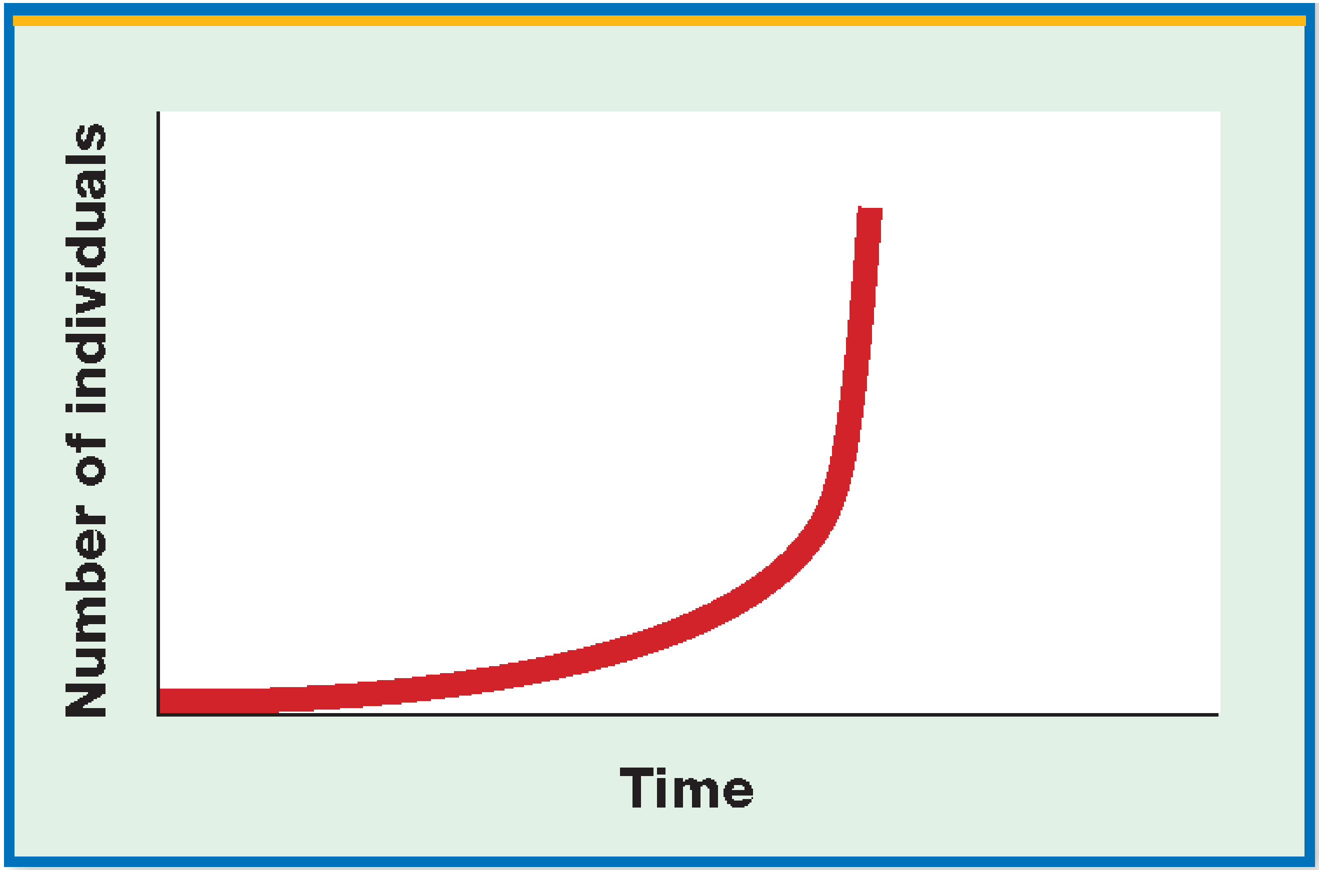
Exponential Growth Curve



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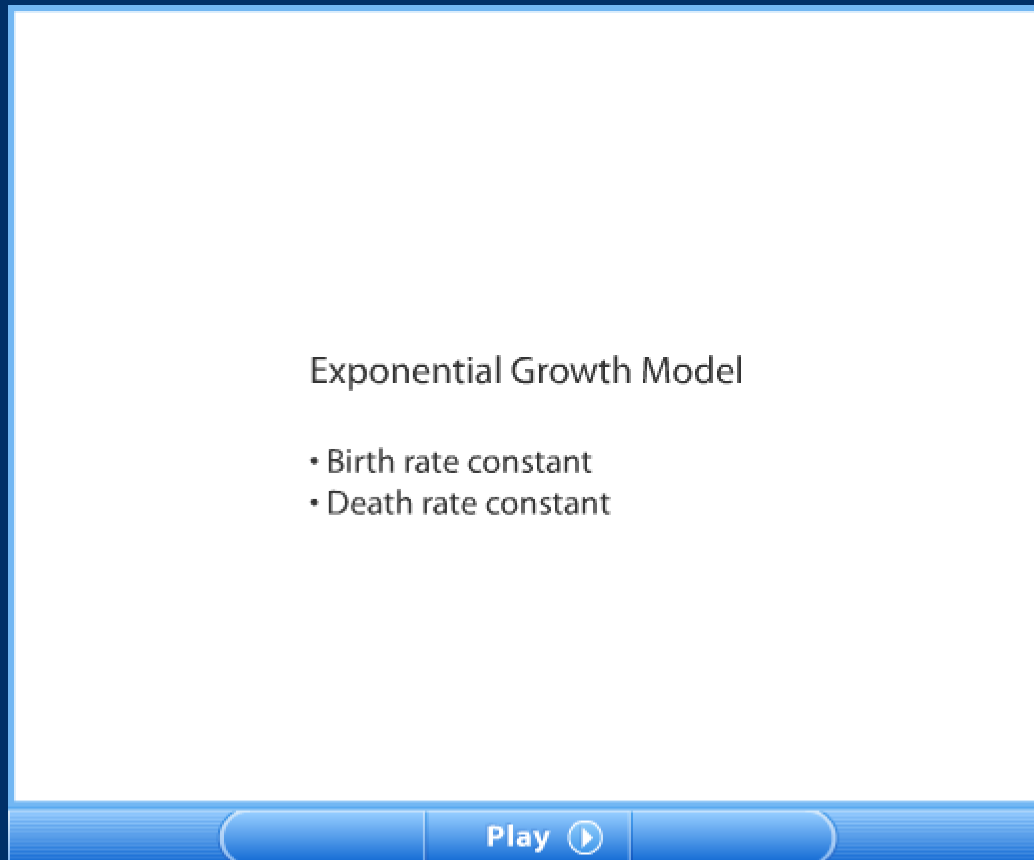
Exponential Growth



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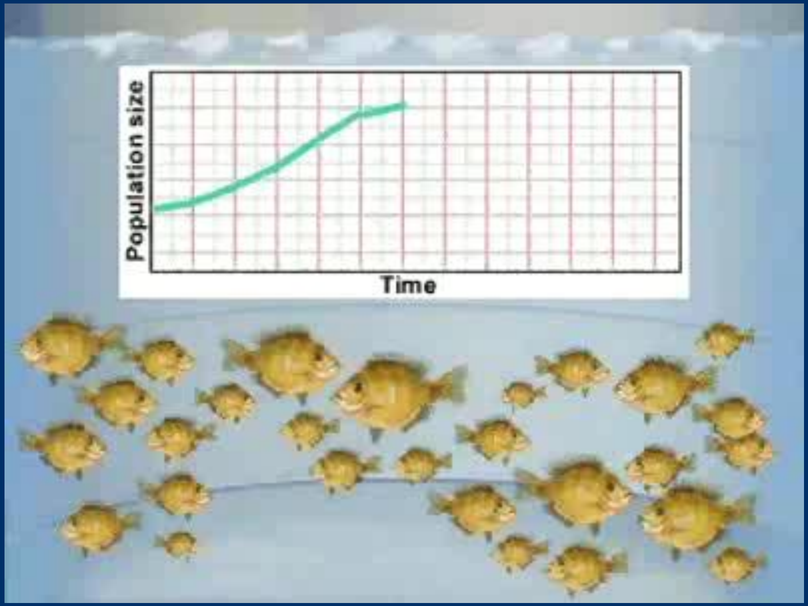
Limiting Factors and Carrying Capacity



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Modeling Population Growth, *continued*

Resources and Population Size

- The population model can be adjusted to account for the effect of limited resources, such as food and water. These resources are called **density-dependent factors** because the rate at which they become depleted depends upon the population density of the population that uses them.
- The **logistic model** is a population model in which exponential growth is limited by a density-dependent factor.

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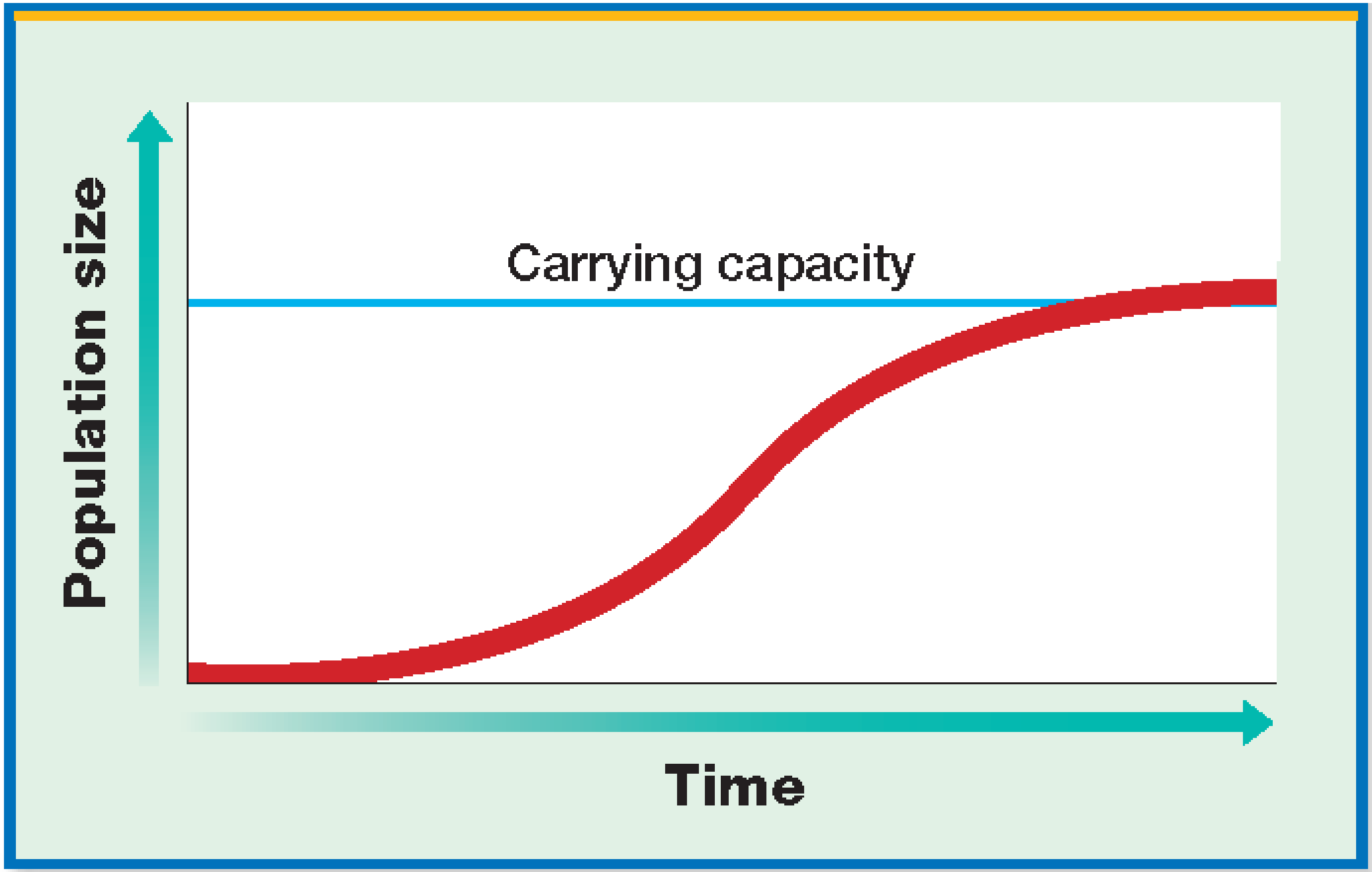
Logistic Growth



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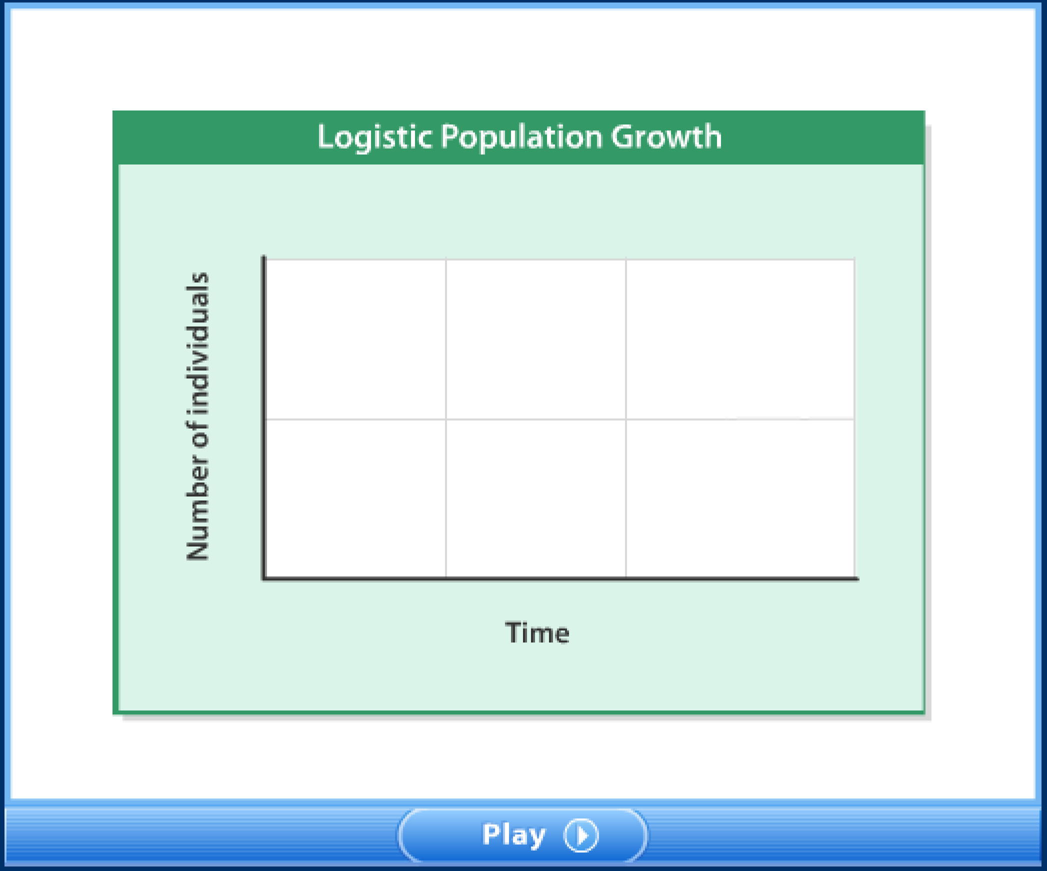
Logistic Model



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Growth Patterns in Real Populations

- Many species of plants and insects reproduce rapidly. Their growth is usually limited not by density-dependent factors but by environmental conditions, also known as **density-independent factors.**
- Weather and climate are the most important density-independent factors.
- The growth of many plants and insects is often described by an exponential growth model. The population growth of slower growing organisms, such as humans, is better described by the logistic growth model.

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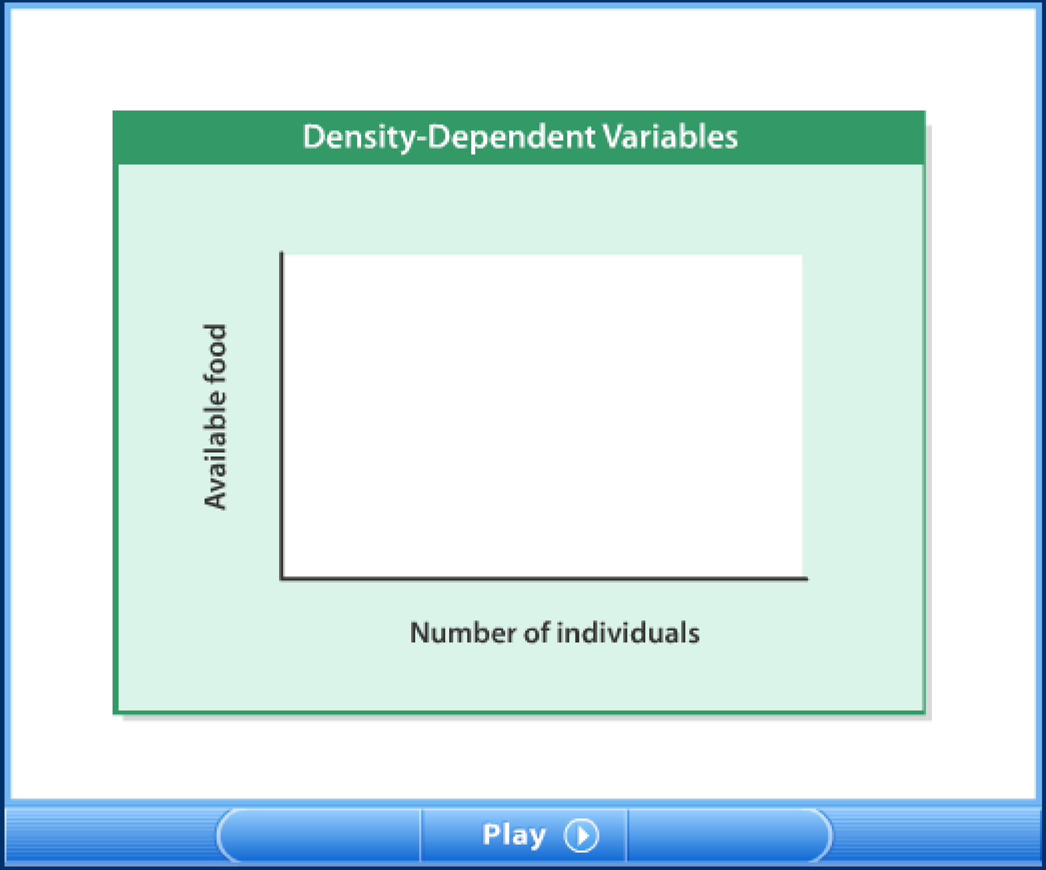
Comparing Density-Dependent and Density-Independent Factors



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Growth Patterns in Real Populations, *continued*

Rapidly Growing Populations

- Many species, including bacteria, some plants, and many insects like cockroaches and mosquitos, are found in rapidly changing environments.
- Such species, called ***r*-strategists,** grow exponentially when environmental conditions allow them to reproduce.
- This strategy results in temporarily large populations. When environmental conditions worsen, the population size drops quickly.

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Growth Patterns in Real Populations, *continued*

Slowly Growing Populations

- Organisms that grow slowly, such as whales, often have small population sizes.
- These species are called ***K*-strategists** because their population density is usually near the carrying capacity (*K*) of their environment.
- K-strategists are characterized by a long life span, few young, a slow maturing process, and reproduction late in life.

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Objectives

- **Summarize** the Hardy-Weinberg principle.
- **Describe** the five forces that cause genetic change in a population.
- **Identify** why selection against unfavorable recessive alleles is slow.
- **Compare** directional and stabilizing selection.

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The Change of Population Allele Frequencies

Allele Frequencies

- When Mendel's work was rediscovered in 1900, biologists began to study how frequencies of alleles change in a population.
- In 1908, the English mathematician G. H. Hardy and the German physician Wilhelm Weinberg independently demonstrated that dominant alleles do not automatically replace recessive alleles.
- Their discovery, called the **Hardy-Weinberg principle,** states that the frequencies of alleles in a population do not change unless evolutionary forces act on the population.

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The Change of Population Allele Frequencies, *continued*

The Hardy-Weinberg Principle

- The Hardy-Weinberg principle holds true for any population as long as the population is large enough that its members are not likely to mate with relatives and as long as evolutionary forces are not acting.

- There are five principle evolutionary forces: *mutation, gene flow, nonrandom mating, genetic drift,* and *natural selection.*

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Hardy-Weinberg Genetic Equilibrium

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

Play

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Hardy-Weinberg Genetic Equilibrium Example

CC	Cc	cc	
p^2 +	$2pq$ +	q^2	$= 1$

$$p^2 + 2pq + q^2 = 1$$
$$p + q = 1$$
$$p + 0.022 = 1$$
$$p = 0.978$$
$$p^2 = 0.956$$

Homozygous for the dominant allele

Homozygous for cystic fibrosis allele

$$0.00048 = q^2$$
$$0.022 = q$$

Heterozygous for cystic fibrosis allele: $2pq = 0.043$

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The Change of Population Allele Frequencies, *continued*

Mutation

- Although mutation from one allele to another can eventually change allele frequencies, mutation rates in nature are very slow.
- Furthermore, not all mutations result in phenotypic changes.
- Mutation is, however, the source of variation and thus makes evolution possible.

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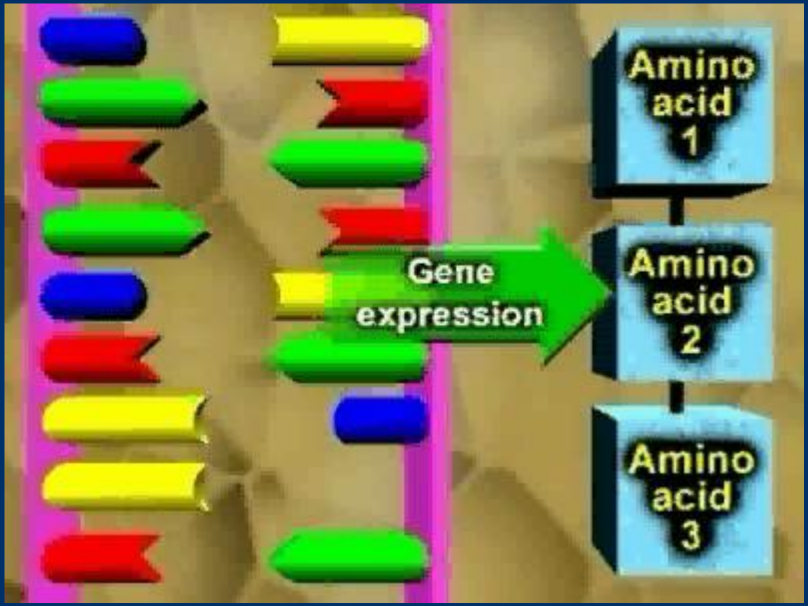
Mutation



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The Change of Population Allele Frequencies, *continued*

Gene Flow

- The movement of individuals from one population to another can cause genetic change.
- The movement of individuals to or from a population, called migration, creates **gene flow,** the movement of alleles into or out of a population.
- Gene flow occurs because new individuals (immigrants) add alleles to the population and departing individuals (emigrants) take alleles away.

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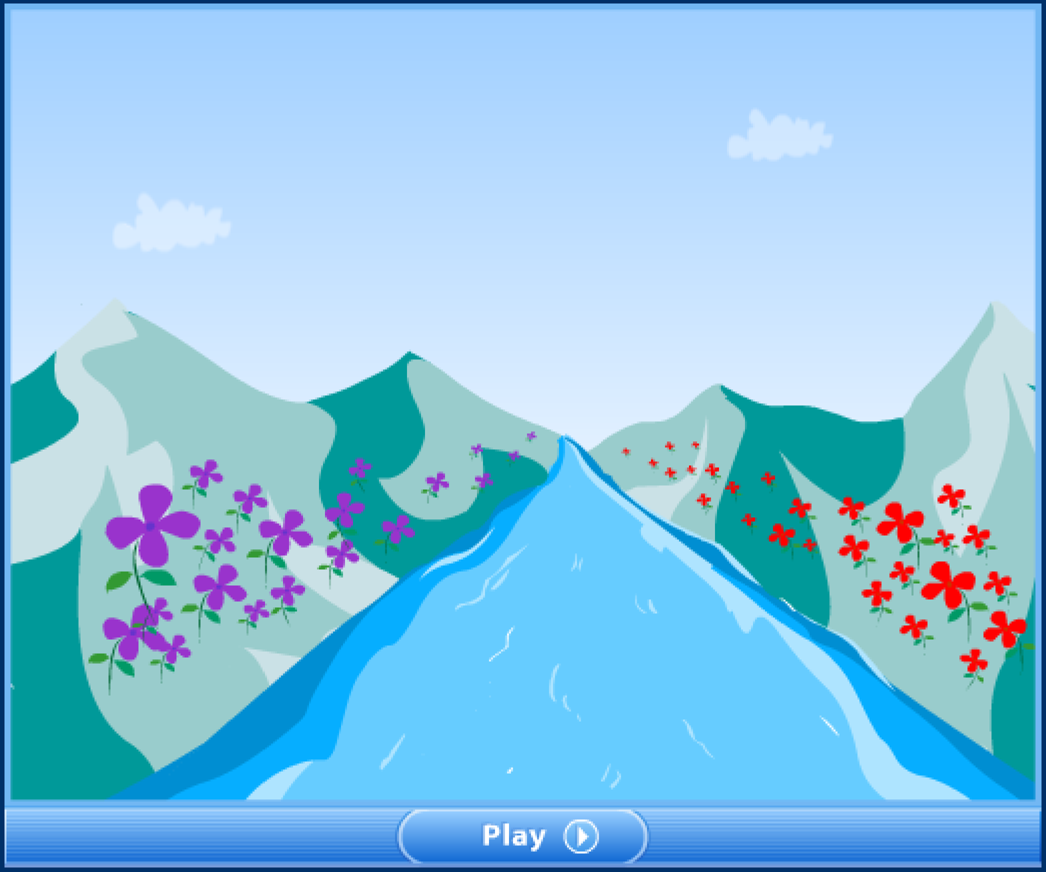
Population and Gene Movement



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The Change of Population Allele Frequencies, *continued*

Nonrandom Mating

- Sometimes individuals prefer to mate with others that live nearby or are of their own phenotype, a situation called **nonrandom mating.**
- Mating with relatives (inbreeding) is a type of nonrandom mating that causes a lower frequency of heterozygotes than would be predicted by the Hardy-Weinberg principle.
- Nonrandom mating also results when organisms choose their mates based on certain traits.

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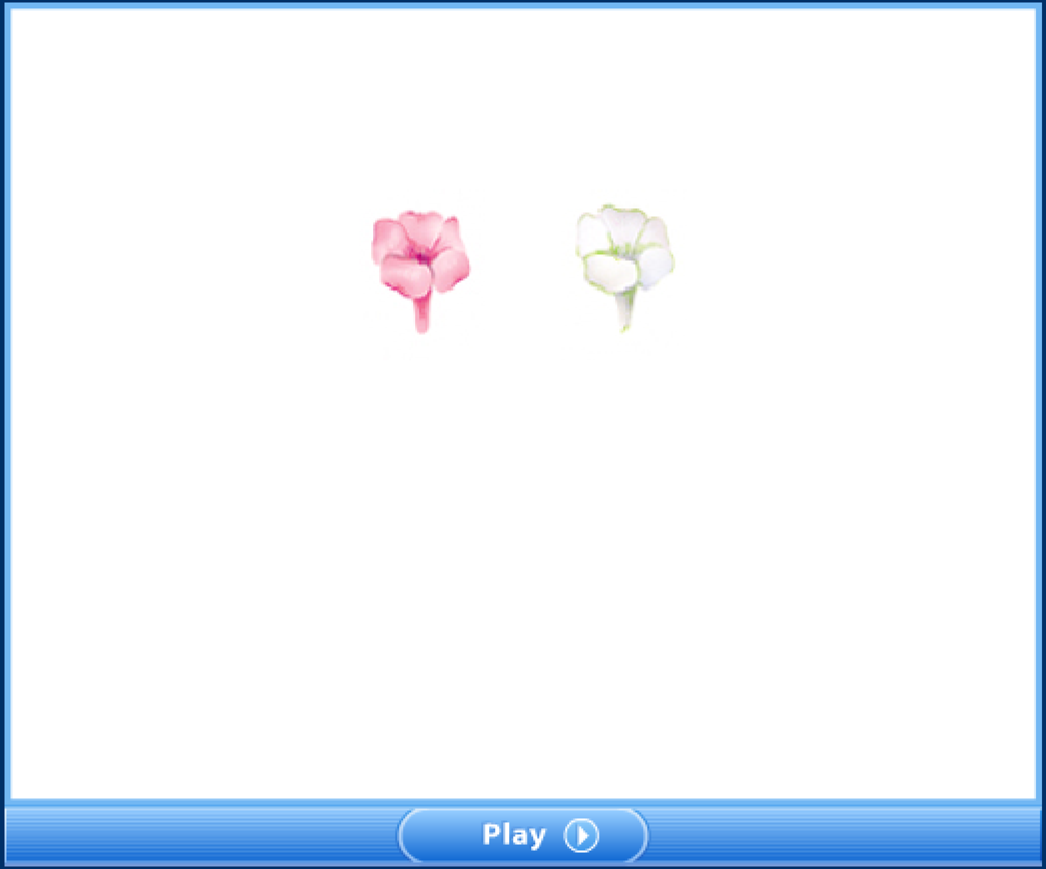
Comparing the Effects of Random and Nonrandom Mating



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The Change of Population Allele Frequencies, *continued*

Genetic Drift

- In small populations the frequency of an allele can be greatly changed by a chance event.
- Because this sort of change in allele frequency appears to occur randomly, as if the frequency were drifting, it is called **genetic drift.**
- Small populations that are isolated from one another can differ greatly as a result of genetic drift.

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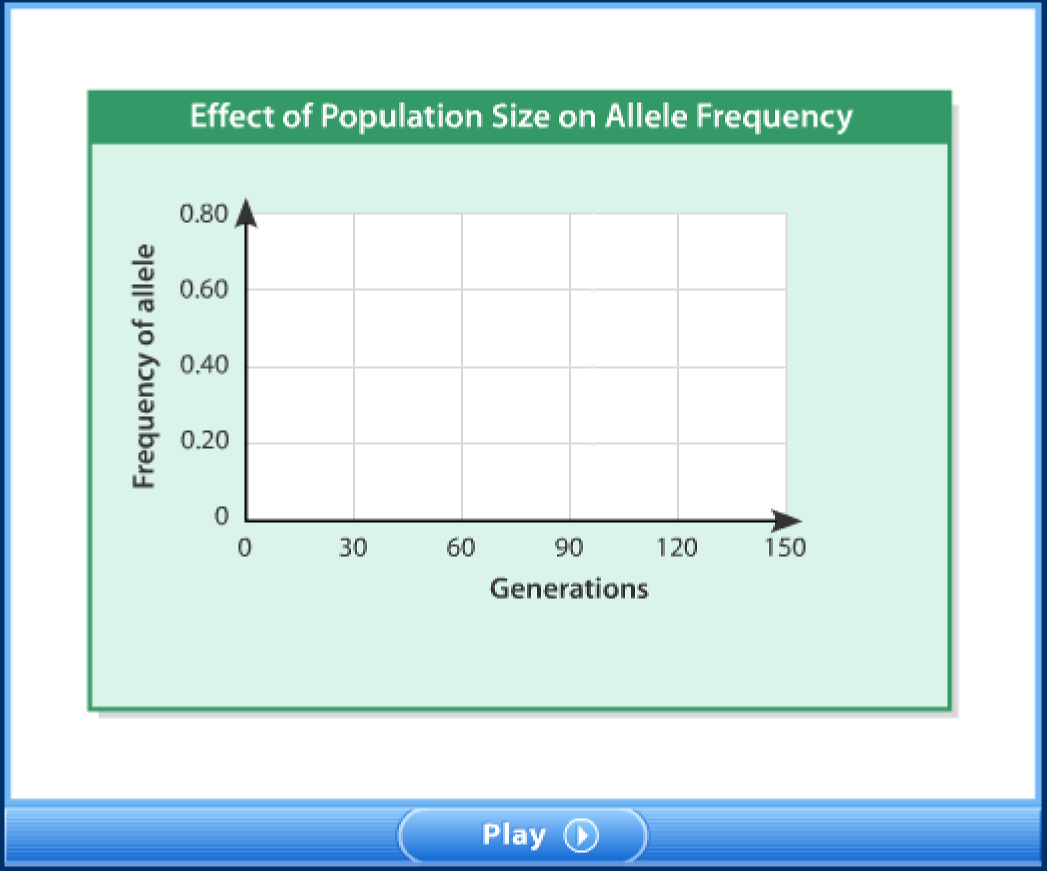
Genetic Drift



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The Change of Population Allele Frequencies, *continued*

Natural Selection

- Natural selection causes deviations from the Hardy-Weinberg proportions by directly changing the frequencies of alleles.
- The frequency of an allele will increase or decrease, depending on the allele's effects on survival and reproduction.

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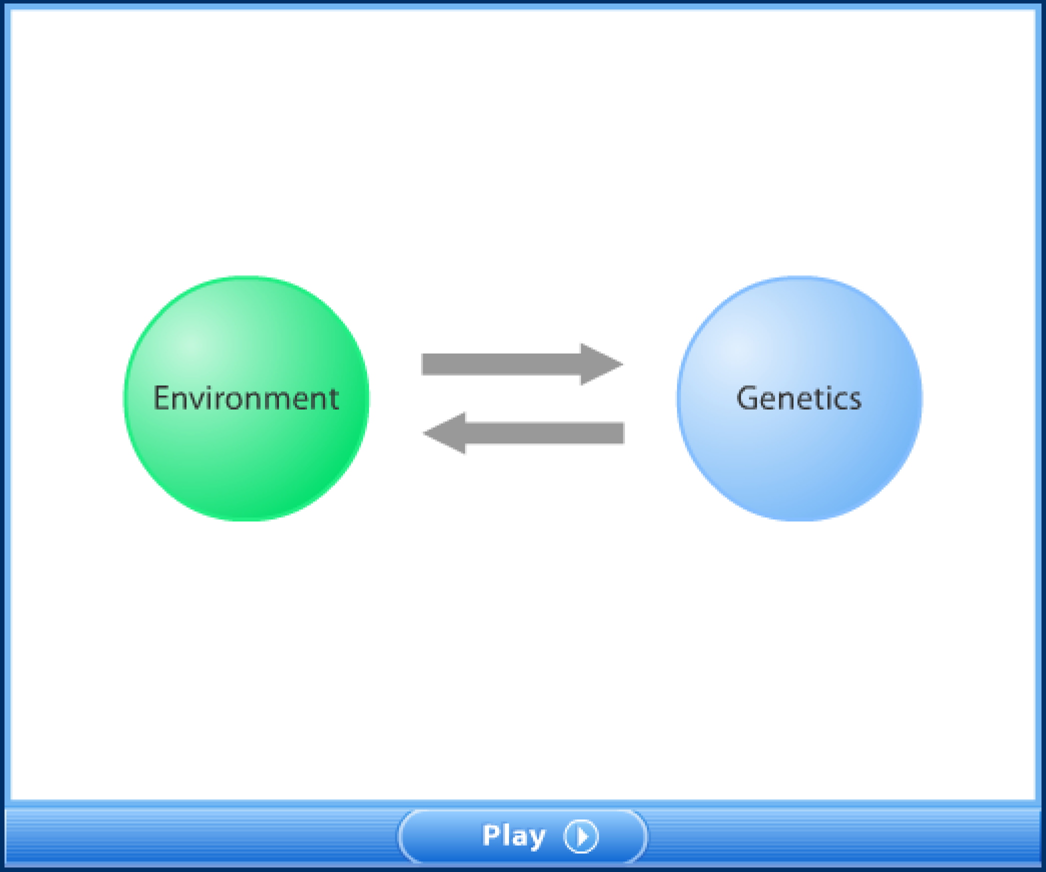
Natural Selection



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Action of Natural Selection on Phenotypes

How Selection Acts

- Only characteristics that are expressed can be targets of natural selection. Therefore, selection cannot operate against rare recessive alleles, even if they are unfavorable.

- Only when the allele becomes common enough that heterozygous individuals come together and produce homozygous offspring does natural selection have an opportunity to act.

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Action of Natural Selection on Phenotypes

Why Genes Persist

- Many human diseases caused by recessive alleles have low frequencies.
- Genetic conditions are not eliminated by natural selection because very few of the individuals bearing the alleles express the recessive phenotype.

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Natural Selection and the Distribution of Traits

- Natural selection shapes populations affected by phenotypes that are controlled by one or by a large number of genes.

- A trait that is influenced by several genes is called a **polygenic trait.**

- Polygenic traits tend to exhibit a range of phenotypes clustered around an average value. If you were to plot the height of everyone in your class on a graph, the values would probably form a hill-shaped curve called a **normal distribution.**

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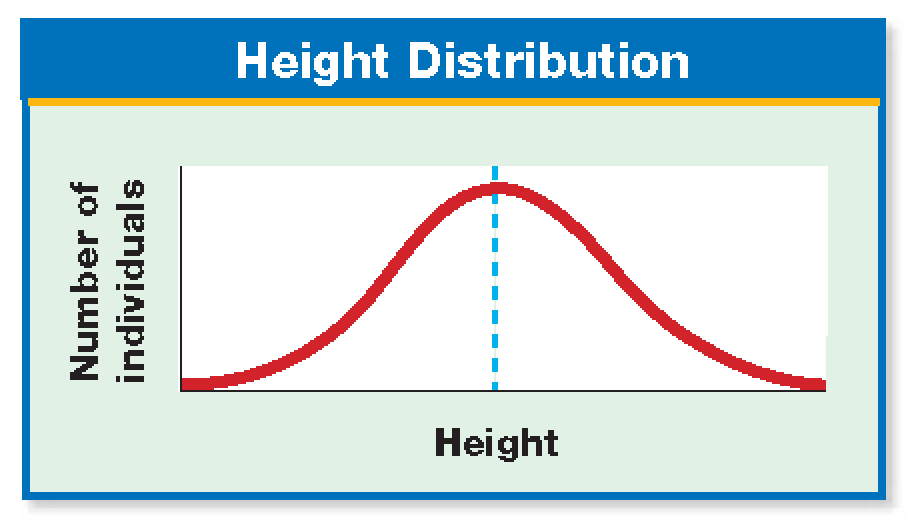
Natural Selection and the Distribution of Traits, *continued*



- This hill-shaped curve represents a normal distribution. The blue, dashed line represents the average height for this population.

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Natural Selection and the Distribution of Traits, *continued*

Directional Selection

- When selection eliminates one extreme from a range of phenotypes, the alleles promoting this extreme become less common in the population.
- In **directional selection,** the frequency of a particular trait moves in one direction in a range.
- Directional selection has a role in the evolution of single-gene traits, such as pesticide resistance in insects.

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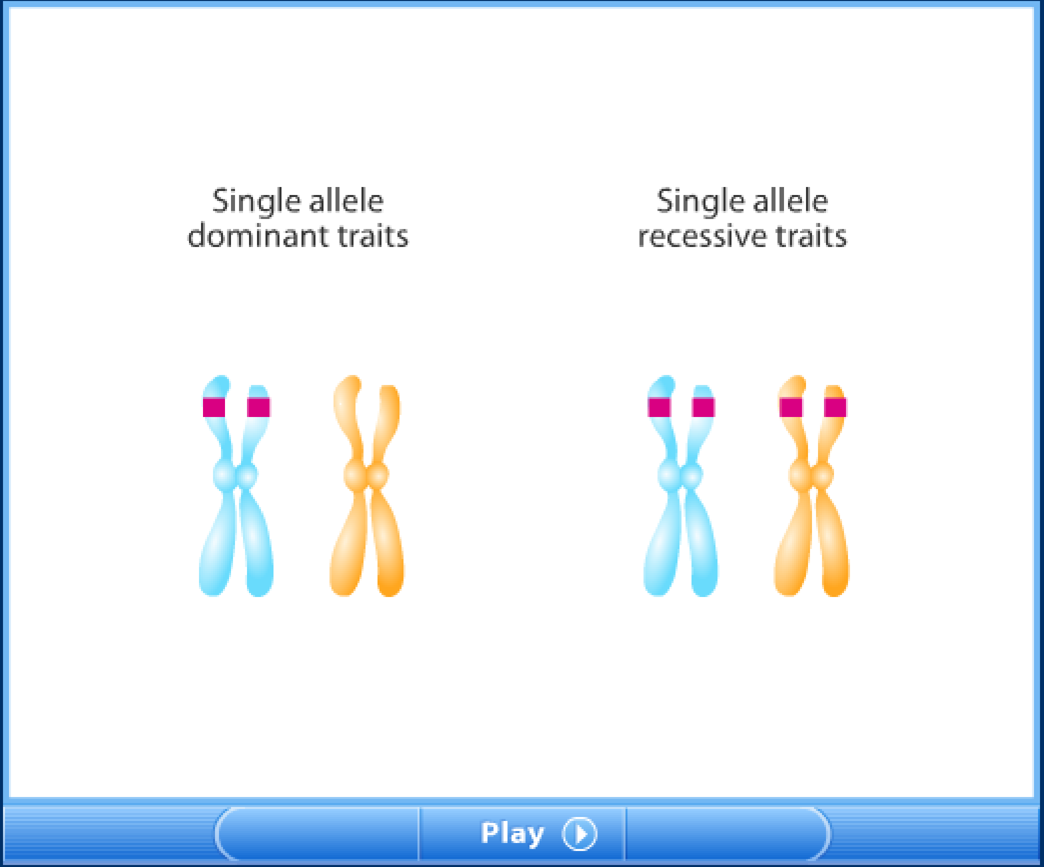
Comparing Single Allele, Multiple Allele, and Polygenic Traits



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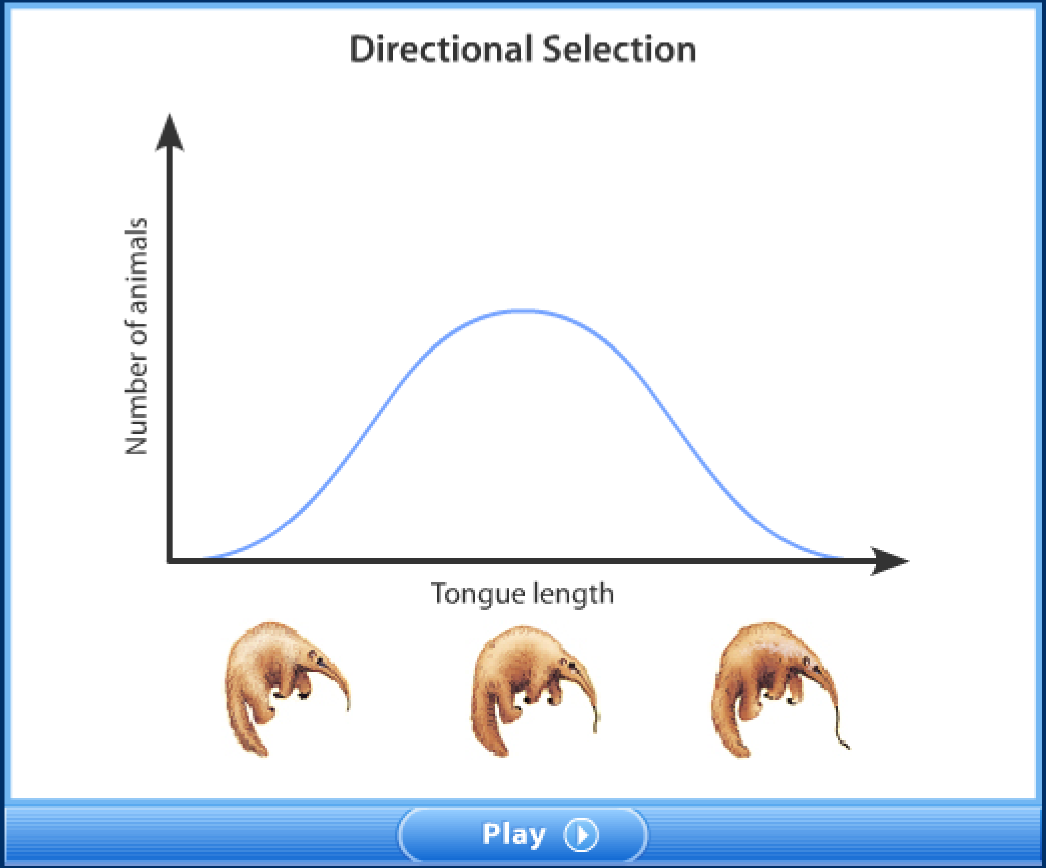
Directional Selection



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Natural Selection and the Distribution of Traits, *continued*

Stabilizing Selection

- When selection reduces extremes in a range of phenotypes, the frequencies of the intermediate phenotypes increase.
- As a result, the population contains fewer individuals that have alleles promoting extreme types.
- In **stabilizing selection,** the distribution becomes narrower, tending to "stabilize" the average by increasing the proportion of similar individuals.

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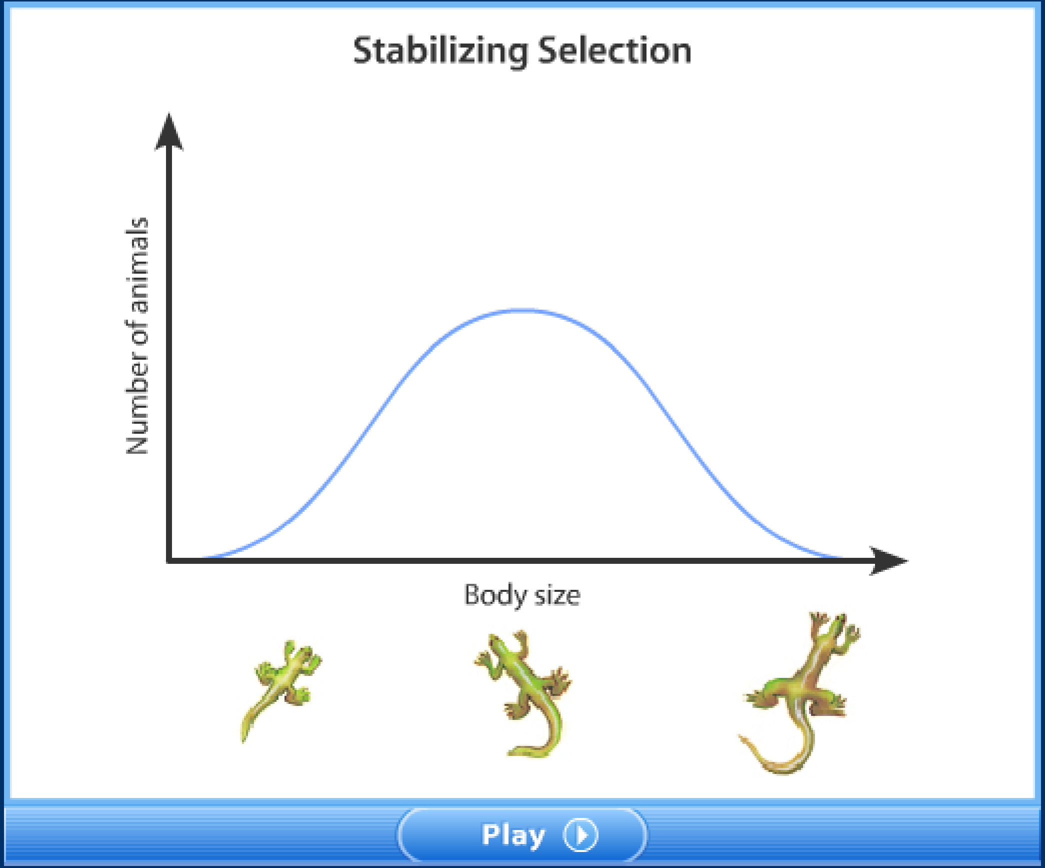
Stabilizing Selection



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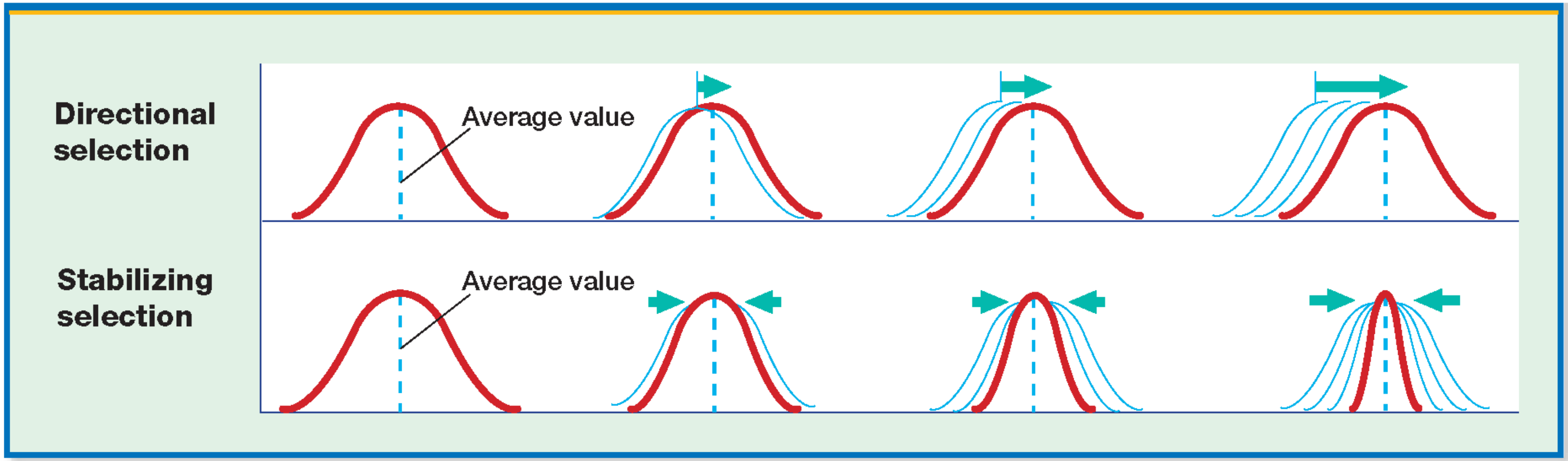
Two Kinds of Selection



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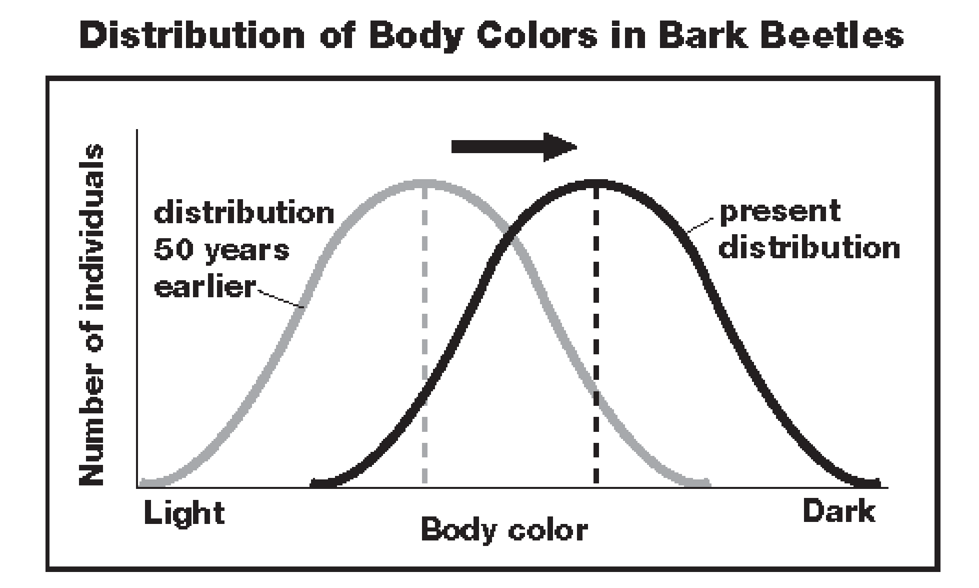
Multiple Choice

The chart below shows the distribution of body colors in a population of bark beetles at two times. The red curve is the present distribution, and the blue curve is the distribution 50 years earlier. Use the chart to answer questions 1–3.



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Multiple Choice, *continued*

1. Which evolutionary force is represented by the chart?

   A. gene flow
   B. mutation
   C. stabilizing selection
   D. directional selection

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Multiple Choice, *continued*

1. Which evolutionary force is represented by the chart?

   A. gene flow
   B. mutation
   C. stabilizing selection
   D. directional selection

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Multiple Choice, *continued*

2. What happened to the average color of the population over the 50-year period?

F. It became darker.
G. It became lighter.
H. It became darker and then lighter again.
J. It stayed the same.

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Multiple Choice, *continued*

2. What happened to the average color of the population over the 50-year period?

   F. It became darker.
   G. It became lighter.
   H. It became darker and then lighter again.
   J. It stayed the same.

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Multiple Choice, *continued*

3. Which environmental change was most likely responsible for the trend shown in the chart?

   A. Winters became colder.
   B. Summers became hotter.
   C. Predators of bark beetles became less numerous.
   D. The air became polluted with soot.

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Multiple Choice, *continued*

3. Which environmental change was most likely responsible for the trend shown in the chart?

   A. Winters became colder.
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