11.3 Other Mechanisms of Evolution

VOCABULARY

gene flow
genetic drift
bottleneck effect
founder effect
sexual selection

KEY CONCEPT **Natural selection is not the only mechanism through which populations evolve.**

MAIN IDEAS

- Gene flow is the movement of alleles between populations.
- Genetic drift is a change in allele frequencies due to chance.
- Sexual selection occurs when certain traits increase mating success.

Connect to Your World

Have you ever wondered why many male birds, such as cardinals, are brightly colored while females of the same species are dull brown? Such bright coloring may not make sense in terms of natural selection, since the male birds are more likely to be seen by predators. However, natural selection is not the whole story. There are other factors that can lead to the evolution of populations.

MAIN IDEA

Gene flow is the movement of alleles between populations.

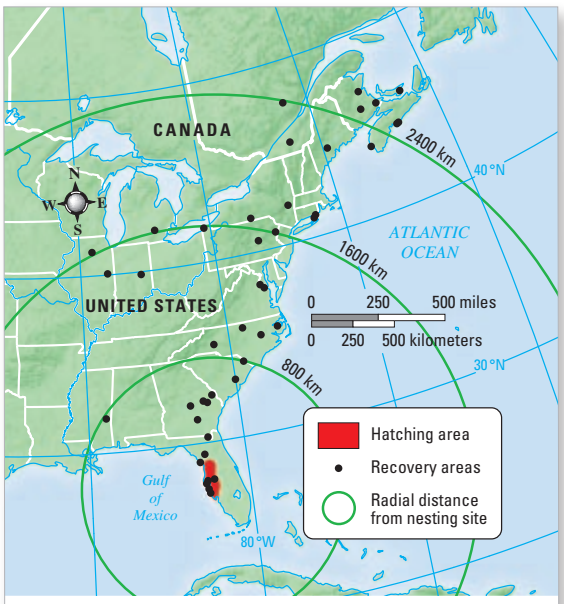


FIGURE 3.1 This map shows the locations where banded bald eagles were found during the first summer after hatching.

Bird-banding studies have shown that certain birds leave their nesting areas once they are able to fly. As shown in **FIGURE 3.1,** bald eagles that were banded as nestlings have been tracked during the same summer more than 2500 kilometers away. These eagles have possibly joined a new population.

When an organism joins a new population and reproduces, its alleles become part of that population's gene pool. At the same time, these alleles are removed from the gene pool of its former population. The movement of alleles from one population to another is called **gene flow.** For many animals, gene flow occurs when individuals move between populations. Gene flow can occur in fungi and plant populations when spores or seeds are spread to new areas.

Gene flow increases the genetic variation of the receiving population. Gene flow between neighboring populations keeps their gene pools similar. However, the less gene flow that occurs between two populations, the more genetically different the two populations can become. A lack of gene flow also increases the chance that the two populations will evolve into different species.

Predict **How does gene flow affect neighboring populations?**

MAIN IDEA

Genetic drift is a change in allele frequencies due to chance.

Imagine a patch of 100 flowers growing in a field. Fifty are white and fifty are purple. If you randomly pick flowers from this patch to create a bouquet, you would expect about half white and half purple flowers. The more flowers you randomly pick, the more likely you are to get these proportions. However, the fewer flowers you pick, the more likely you are to have a bouquet that is not representative of the patch. It might even be all one color.

A similar situation can occur in small populations. Small populations, like small sample sizes, are more likely to be affected by chance. Due to chance alone, some alleles are likely to decrease in frequency and become eliminated. Other alleles are likely to increase in frequency and become fixed. These changes in allele frequencies that are due to chance are called **genetic drift.** Genetic drift causes a loss of genetic diversity in a population.

Two processes commonly cause populations to become small enough for genetic drift to occur. Each of these processes results in a population with different allele frequencies than existed in the original population.

READING TOOLBOX

VOCABULARY

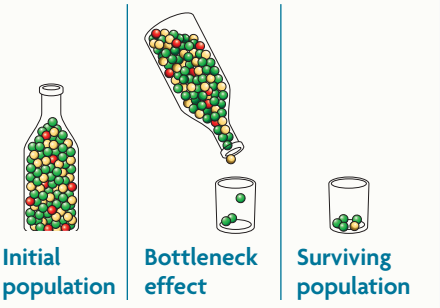
Fixed means "not subject to change." If an allele increases to a frequency of 1.0 (100%), it is said to be fixed in the population.

Bottleneck Effect

The **bottleneck effect** is genetic drift that occurs after an event greatly reduces the size of a population. One example of the bottleneck effect is the overhunting of northern elephant seals during the 1800s. By the 1890s, the population was reduced to about 20 individuals. These 20 seals did not represent the genetic diversity of the original population. Since hunting has ended, the population has grown to over 100,000 individuals. However, it has very little genetic variation. Through genetic drift, certain alleles have become fixed while others have been lost completely from the gene pool.

VISUAL VOCAB

The **bottleneck effect** describes the effect of a destructive event that leaves only a few survivors in a population.



Founder Effect

As shown in **FIGURE 3.2,** the **founder effect** is genetic drift that occurs after a small number of individuals colonize a new area. The gene pools of these populations are often very different from those of the larger populations. The founder effect can be studied in human populations, such as Old Order Amish communities. These communities were founded in North America by small numbers of migrants from Europe. For example, the Amish of Lancaster County, Pennsylvania, have a high rate of Ellis–van Creveld syndrome. Although this form of dwarfism is rare in other human populations, it has become common in this Amish population through genetic drift. Geneticists have traced this syndrome back to one of the community's founding couples.

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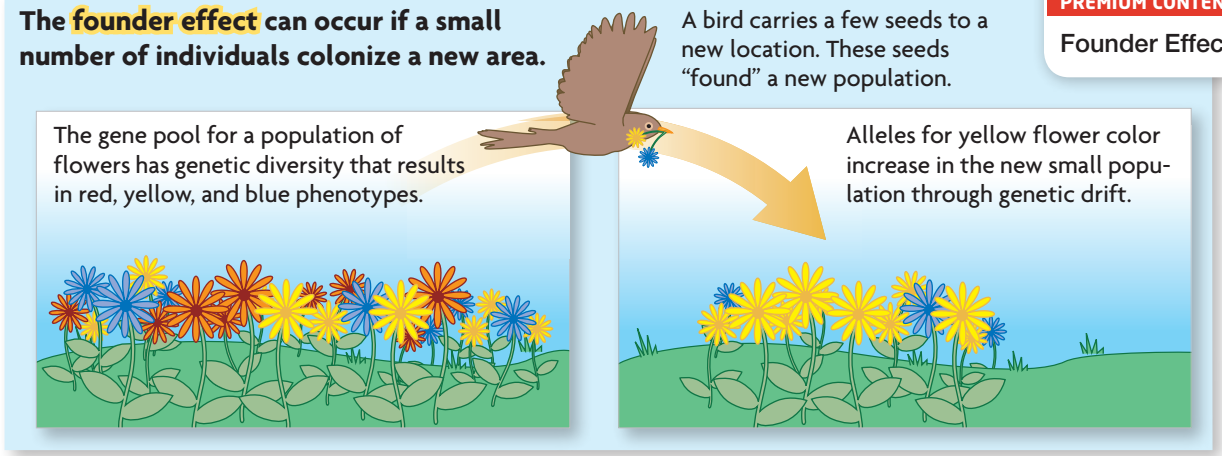
PREMIUM CONTENT
Founder Effect

FIGURE 3.2 The Founder Effect

The founder effect can occur if a small number of individuals colonize a new area.



Effects of Genetic Drift

Genetic drift can cause several problems for populations. One problem is that the population loses genetic variation. With little genetic variation, a population is less likely to have some individuals that will be able to adapt to a changing environment. Another problem is that alleles that are lethal in homozygous individuals may be carried by heterozygous individuals and, hence, become more common in the gene pool due to chance alone.

Apply **Why is genetic drift more likely to occur in smaller populations?**

QUICK LAB MODELING

Genetic Drift

Use a deck of cards to represent a population of island birds. The four suits represent different alleles for tail shape. The allele frequencies in the original population are 25% spade, 25% heart, 25% club, and 25% diamond tail shapes.

PROBLEM How does genetic drift occur?

MATERIALS
- deck of cards

PROCEDURE

1. Shuffle the cards and hold the deck face down. Turn over 40 cards to represent the alleles of 20 offspring produced by random matings in the initial population.
2. Separate the 40 cards by suit. Find the allele frequencies for the offspring by calculating the percentage of each suit.
3. Suppose a storm blows a few birds to another island. They are isolated on this island and start a new population. Reshuffle the deck and draw 10 cards to represent the alleles of five offspring produced in the smaller population.
4. Repeat step 2 to calculate the resulting allele frequencies.

ANALYZE AND CONCLUDE

1. **Analyze** Compare the original allele frequencies to those calculated in steps 2 and 4. How did they change?
2. **Analyze** Did step 1 or 3 demonstrate genetic drift?
3. **Evaluate** Does this activity demonstrate evolution? Why or why not? Does it demonstrate natural selection? Explain.

FIGURE 3.3 Male frigate birds inflate an air sac in their chest to attract females. This trait has evolved through sexual selection.

MAIN IDEA

Sexual selection occurs when certain traits increase mating success.

Mating can have an important effect on the evolution of populations. Both sexes benefit from having offspring that survive. However, the cost of reproduction often differs for males and females.

- Males produce many sperm continuously, making the value of each sperm relatively small. They can make many investments at little cost.
- Females are much more limited in the number of offspring they can produce in each reproductive cycle. Each investment they make is more valuable, and they want a good return.

In many species, this difference in reproductive cost makes females choosy about mates. **Sexual selection** occurs when certain traits increase mating success. There are two types of sexual selection:

- Intrasexual selection involves competition among males, such as the head-butting of bighorn sheep. The winner of the competition mates with the female.
- Intersexual selection occurs when males display certain traits that attract the female, such as peacocks fanning out their tails.

Traits that increase mating success are not always adaptive for the survival of the individual. As shown in **FIGURE 3.3,** bright red air sacs likely make male frigate birds very easy to spot by predators. How could such an exaggerated trait evolve?

Research has shown that some showy traits may be linked with genes for good health and fertility. Other traits are present in males that can offer better care for offspring or defense from predators. Therefore, females may use showy traits as signs of quality and health in males. These traits, such as the red air sacs of male frigate birds, can become very exaggerated over time through sexual selection.

Apply **Male Irish elks, which are now extinct, had 12-foot-wide antlers. Describe how sexual selection could have caused such an exaggerated trait to evolve.**

READING TOOLBOX

VOCABULARY

Intra- is Latin for "within." Intrasexual selection occurs within one sex.
Inter- is Latin for "between." Intersexual selection occurs between both sexes.

11.3 Formative Assessment

SELF-CHECK Online
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PREMIUM CONTENT

REVIEWING MAIN IDEAS

1. How does **gene flow** affect neighboring populations?
2. Name two processes through which **genetic drift** can occur.
3. How does **sexual selection** occur?

CRITICAL THINKING

4. **Analyze** Would a population of 10 individuals or 100 individuals be more vulnerable to genetic drift? Why?
5. **Infer** What impact can the **bottleneck effect** have on populations that have rebounded after near extinction?

CONNECT TO GENETICS

6. Ellis–van Creveld syndrome is a recessive trait. Explain why it has become common in the Amish of Lancaster County while remaining very rare in other human populations.