Effects of Gene Flow

Predict Explain how the difference in gene flow between populations could cause them to evolve in different or similar ways.

Roses can grow in the wild or be cultivated. A bee may transport pollen from a farm that cultivates roses of different colors to a nearby area where wild red roses grow. The pollen can fertilize a wild rose flower, introducing new genetic material into the wild population. This is an example of gene flow, which is the movement of alleles from one population to another. Gene flow can cause a population to evolve.

Genetic Drift

Small populations are more likely to be affected by chance than large populations. Let's look at how a chance event can affect the alleles that code for a lizard's tail shape.

Hands-On Activity

Modeling Population Changes

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

Predict How can random chance affect the allele frequencies in a population?

MATERIALS

- deck of cards

PROCEDURE

1. Shuffle the cards. Holding the deck face down, turn over 40 cards. These cards represent the alleles of 20 offspring produced by random mating of the individuals in the initial population.
2. Separate the 40 cards by suit and then find the allele frequencies for the offspring by calculating the percentage of each suit. Record these values in your Evidence Notebook.
3. Suppose a storm isolates a few lizards on another island where they start a new population. Reshuffle the deck and draw 10 cards to represent the alleles of five offspring produced in this smaller isolated population.
4. Repeat Step 2 to calculate the resulting allele frequencies. Record the results in your Evidence Notebook.

ANALYZE

Answer the following questions in your Evidence Notebook:

1. Compare the original allele frequencies to those calculated in Steps 2 and 4. How did they change?
2. Does this activity demonstrate evolution? Why or why not? Does it demonstrate natural selection? Why or why not?

What you observed in the activity is called genetic drift, which is a change in allele frequencies due to chance. For example, chance events such as natural disasters or birds dropping seeds on an island can change allele frequencies in a population. This phenomenon of genetic drift is typically observed in small populations because small populations are more likely to be affected by chance alone than large populations. The chance event causes some alleles to decrease in frequency, which may cause them to eventually disappear from the population all together. It causes other alleles to increase in frequency and possibly become fixed in the population.

Scientists have identified two processes that can cause population sizes to decrease enough for genetic drift to occur. Each of these processes results in a population with different allele frequencies than those that existed in the original population.

Bottleneck Effect

In the late 1800s, northern elephant seals were severely overhunted for their blubber, which was used in lamp oil. It is estimated that by 1890, there were fewer than 100 individuals left. After hunting ended, the population rebounded, and now there are more than 100,000 individuals.

FIGURE 13: The hunting of northern elephant seals greatly depleted the species' numbers and genetic diversity.

Analyze Use the model in Figure 13 to explain the change in genetic variation between the initial elephant seal population and the population after it rebounded.

The northern elephant seal suffered from the bottleneck effect. This is genetic drift resulting from an event that drastically reduces the size of a population. Through genetic drift, some alleles can be completely lost from the gene pool and others can be fixed in the population, resulting in lower genetic diversity.

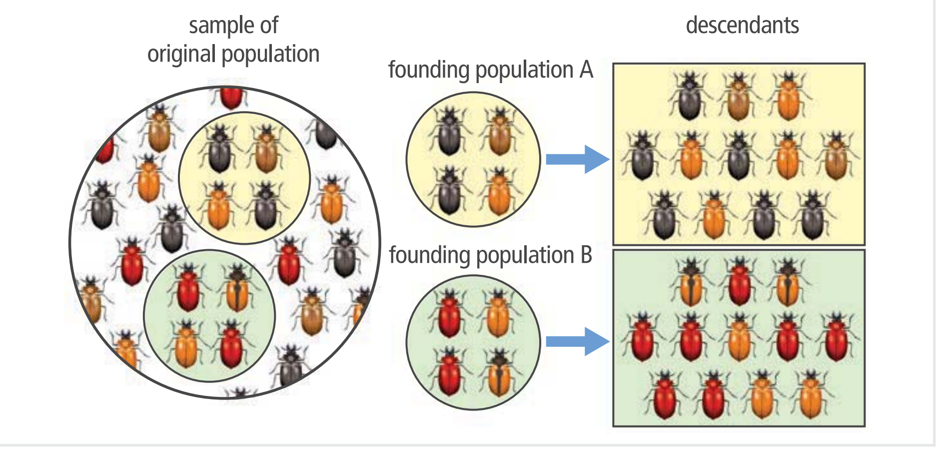
Founder Effect

The Old Order Amish communities were founded in North America by small numbers of migrants from Europe. The gene pools of these smaller populations are very different from those of the larger populations. 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.

Consider what would happen to a population of beetles that were nearly wiped out due to a natural disaster, such as the population shown in Figure 14. The original population had high levels of genetic diversity. After the disaster, two smaller populations of beetles survived, but there was no gene flow between the populations. The descendants of founding population A would have a different gene pool from the descendants of population B. For example, founding population A had beetles with genes coding for black exoskeletons. The descendants of these individuals also had black exoskeletons. Founding population B, however, had no individuals with genes for a black exoskeleton, so this gene was lost in population B.

Gather Evidence How does the genetic variation of the new population compare to that of the old population? Use evidence to support your answer.

FIGURE 14: Genetic variation decreases when a small number of individuals colonize new areas.



The founder effect is genetic drift that occurs when a small number of individuals become isolated from the original population and colonize a new area. Figure 14 demonstrates genetic drift due to the founder effect in a beetle population. The founding populations each represent a distinct gene pool observed in the founding population. As a result, allele frequencies within the founding populations change from the original population reducing genetic variation.

Sexual Selection

Male peacocks have elaborate tails made of long, colorful feathers. These tail feathers not only make male peacocks easy targets for predators, they also make flying away from predators harder. Female peacocks, though, are a muted, brown color and do not possess long tail feathers like the males. These flashy colors and ornamental traits seem to be in contrast with what should have evolved from natural selection, so how did they evolve?

FIGURE 15: The winner of a fight increases his chances of mating with a female.

In general, mating is less costly to a male than a female. Males produce many sperm, so they can invest in mating without much cost. Females, on the other hand, produce a limited number of offspring. They tend to select males that will give their offspring the best chance of survival. This difference in reproductive costs can make females choosier than males about mates. Sexual selection occurs when certain traits increase reproductive success.

Prior to the mating season, male animals like deer, elk, and moose fight other males. The winner in this competition establishes his dominance over other males and his fitness to mate with the females in the population. This type of competition among male members for the right to mate is known as intrasexual selection.

The superb bird of paradise, like other species of birds of paradise, engages in courtship behavior that increases mating success by attracting females. Superb males have feathers on their backs that are not used for flying. During courtship, the male birds use the back and chest feathers to form a funnel-like structure around their heads. This posture highlights their bright-colored breast feathers. They also flick their feathers and dance. Other birds of paradise have bright colors, large plumes, and long tail feathers and perform dances to attract the attention of females.

FIGURE 16: The male superb bird of paradise has bright feathers and large plumes to attract females.

Intersexual selection is a form of sexual selection in which males display certain traits that attract females. Males involved in intersexual selection are often more brightly colored, have larger features, or have other characteristics to attract females.

In birds of paradise, long feathers, bright plumes, and courtship behavior are due to intersexual selection. These traits are costly to develop, so males who possess them are usually healthy and strong. Scientific data show that, in some species, bright colors indicate parasite resistance. Sick males may have muted coloring and likely do not possess characteristics attractive to females. Females are able to pick the males in the best condition or that have better genes for mating.

Collaborate With a partner, discuss what a female might learn about a male through his color, size, and ornamental features, like bright tail feathers.

Stability and Change

A population is stable and in genetic equilibrium when its genetic makeup does not change over time. Because the conditions that lead to this genetic stability are rare in the natural world, evolution occurs.

There are five mechanisms that can lead to evolution:

- Mutation can lead to the formation of new alleles. Mutations produce genetic variation.
- Natural selection affects populations, acting on traits that increase an individual's ability to survive and reproduce.
- Sexual selection selects for traits that give members of a population a competitive advantage in mating and reproducing.
- Genetic drift affects small populations and is caused by random events that affect the population.
- Gene flow occurs when individuals move in and out of populations. This movement introduces and removes alleles from the gene pool.

Explain Why is genetic drift more likely in small populations than in large populations? Consider the male ruffs from the beginning of this lesson. How could genetic drift or sexual selection explain the different types of males in the population? Use evidence from the lesson to support your claims.