

11.2 Natural Selection in Populations

VOCABULARY

normal distribution
microevolution
directional selection
stabilizing selection
disruptive selection

KEY CONCEPT Populations, not individuals, evolve.

MAIN IDEAS

- ▶ Natural selection acts on distributions of traits.
- ▶ Natural selection can change the distribution of a trait in one of three ways.

Connect to Your World

How do you describe a person's appearance? Perhaps you use height, hair color, and eye color. These traits are often used in descriptions because these traits vary widely among humans. In this section you will learn about the way natural selection can act on such variation.

▶ MAIN IDEA

Natural selection acts on distributions of traits.

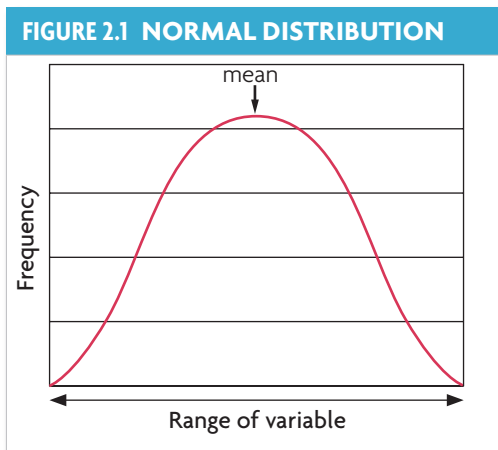
CONNECT TO

GENETICS

As you learned in **Extending Mendelian Genetics**, single-gene traits are expressed in either one distinct form or another. However, the range of phenotypes common for most traits is the result of polygenic traits, which are controlled by multiple genes.

Any time you stand in a large crowd of people, you are likely to observe a wide range of heights. Imagine organizing this crowd across a football field according to each individual's height, with very short people at one end, people of average height in the middle, and very tall people at the other end. You would soon notice a pattern in distribution of the human height trait. Relatively few people would be at each extreme height, very short or very tall. A majority of people of medium height would be in the middle.

This type of distribution, in which the frequency is highest near the mean value and decreases toward each extreme end of the range, is called a **normal distribution**. When these frequency values are graphed, the result is a bell-shaped curve like the one you see in **FIGURE 2.1**.



For some traits, all phenotypes provide an equal chance of survival. The distribution for these traits generally shows a normal distribution. Phenotypes near the middle of the range tend to be most common, while the extremes are less common. However, environmental conditions can change and a certain phenotype may become an advantage. Nature favors individuals with this phenotype. These individuals are able to survive and reproduce at higher rates than individuals with less favorable phenotypes. Therefore, alleles associated with favorable phenotypes increase in frequency.

Synthesize What other types of data might follow a normal distribution?

▶ MAIN IDEA

Natural selection can change the distribution of a trait in one of three ways.

Microevolution is the observable change in the allele frequencies of a population over time. Microevolution occurs on a small scale—within a single population. One process that can lead to microevolution is natural selection. Natural selection can change the distribution of a trait along one of three paths: directional, stabilizing, or disruptive selection. Such changes can have major effects on how a population looks and behaves.

Directional Selection

A type of selection that favors phenotypes at one extreme of a trait's range is called **directional selection**. Directional selection causes a shift in a population's phenotypic distribution. An extreme phenotype that was once rare in a population becomes more common. As shown in **FIGURE 2.2**, during directional selection, the mean value of a trait shifts in the direction of the more advantageous phenotype.

The rise of drug-resistant bacteria provides a classic example of this type of selection. Before antibiotics were developed in the 1940s, a trait for varying levels of drug resistance existed among bacteria. At the time, there was no advantage to having drug resistance. But once antibiotics came into use, the resistant bacteria had a great advantage.

The early success of antibiotics in controlling infectious diseases led to overuse of these drugs. This overuse favored even more resistant phenotypes. New drugs were then developed to fight the resistant bacteria. This resulted in the evolution of “superbugs” that are highly resistant to many drugs. Today, over 200 types of bacteria show some degree of antibiotic resistance.

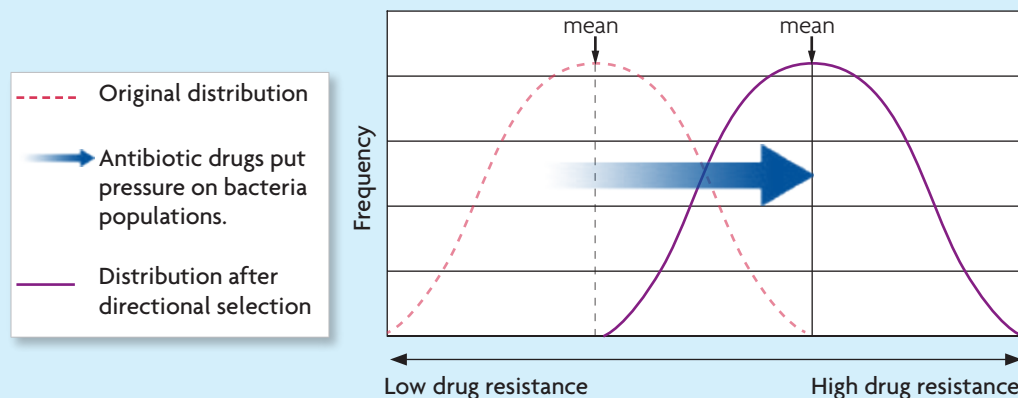
CONNECT TO

BACTERIA

Although many bacteria are helpful to other organisms, some do cause disease. You will learn more about how bacteria can evolve and become resistant to antibiotics in **Viruses and Prokaryotes**.

FIGURE 2.2 Directional Selection

Directional selection occurs when one extreme phenotype is favored by natural selection.



Today, scientists continue to research new drugs developed to treat infection-causing bacteria such as *Enterococcus faecalis*, which is resistant to many antibiotics.



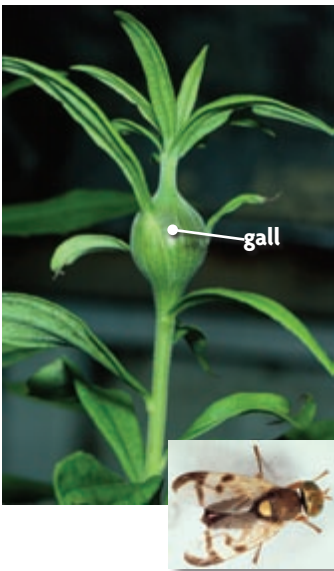


FIGURE 2.3 The gall fly and the goldenrod plant have a parasitic relationship. The fly benefits by receiving shelter and food during its larval stage, while the goldenrod is harmed, growing more slowly than a gall-free goldenrod.

Stabilizing Selection

The gall fly and its predators provide an excellent example of stabilizing selection. During **stabilizing selection**, the intermediate phenotype is favored and becomes more common in the population. That is, the distribution becomes stable at the intermediate phenotype rather than shifting toward one of the extremes. In the case of gall flies, something in nature selects against phenotypes at both extremes of the trait's range.

Gall flies lay their eggs in developing shoots of the tall goldenrod plant. The fly larvae produce a chemical that causes the plant tissue to swell around them. **FIGURE 2.3** shows the resulting mass of plant tissue, called a gall. The gall serves as a home where the larvae can develop. There is a range of phenotypes for body size in gall-fly larvae. Each body size causes a certain size gall to form, and each of the two main predators of gall flies specializes on a specific gall size.

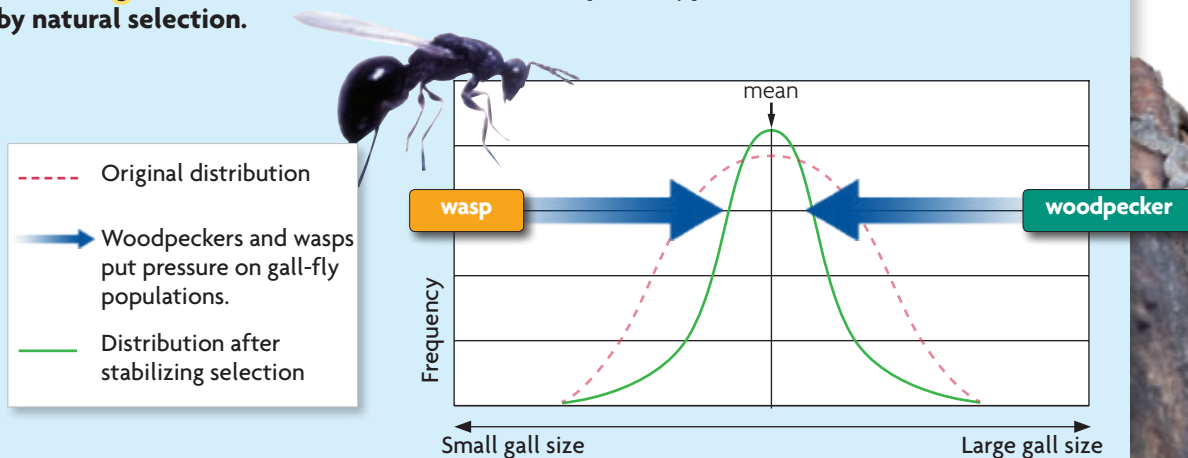
- Downy woodpeckers attack larger galls and feed on the larvae inside.
- The parasitic wasp lays its own eggs inside small galls. After the wasp larvae emerge from the eggs, they eat the gall-fly larvae.

In this situation, selective pressure from predators works against fly phenotypes that produce galls at both extremes, large and small. As a result, flies that produce middle-sized galls become more common. As you can see in **FIGURE 2.4**, over time, stabilizing selection results in a higher frequency of flies that produce middle-sized galls.

Stabilizing selection increases the number of individuals with intermediate phenotypes. Notice, however, that selection against both extremes decreases the genetic diversity of the gall fly population. Flies that produce small and large galls become less common. In some populations, these extreme phenotypes may be lost altogether.

FIGURE 2.4 Stabilizing Selection

Stabilizing selection occurs when intermediate phenotypes are favored by natural selection.



Disruptive Selection

Disruptive selection occurs when both extreme phenotypes are favored, while individuals with intermediate phenotypes are selected against by something in nature. As you can see in **FIGURE 2.5**, the middle of the distribution is disrupted. One example of this type of selection involves feather color in male lazuli buntings, a bird species native to North America.

Young male lazuli buntings vary widely in the brightness of their feathers, ranging from dull brown to bright blue. Dominant adult males are those with the brightest blue feathers on their heads and backs. These birds have their pick of the best territories. They also are most successful at attracting females. However, for young buntings, the brightest blue and dullest brown males are more likely to win mates than males with bluish brown feathers are.

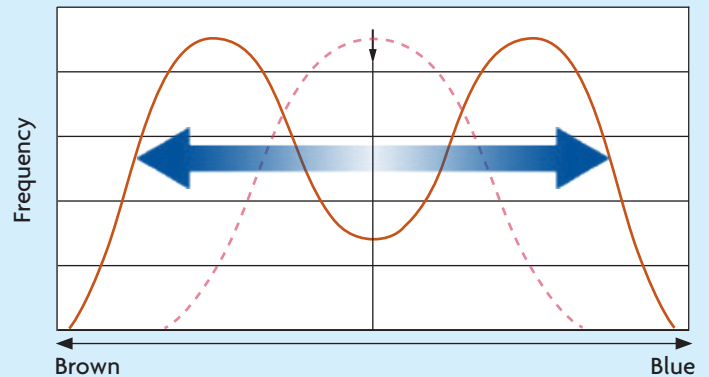
Research suggests that dominant adult males are aggressive toward young buntings that they see as a threat, including bright blue and bluish brown males. The dullest brown birds can therefore win a mate because the adult males leave them alone. Meanwhile, the bright blue birds attract mates simply because of their color.

Both extreme phenotypes are favored in this situation, while intermediate forms are selected against. The bluish brown males are not as well adapted to compete for mates because they are too blue to be left alone by adult males, but not blue enough to win a mate based on color alone. By favoring both extreme phenotypes, disruptive selection can lead to the formation of new species.

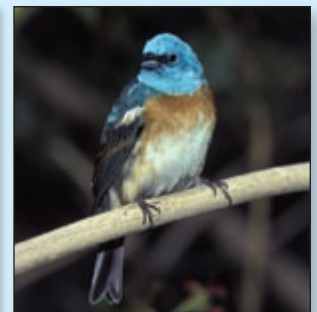
Apply If bluish brown coloring became advantageous for young males, what type of selection would likely occur in a lazuli bunting population?

FIGURE 2.5 Disruptive Selection

Disruptive selection occurs when both extreme phenotypes are favored by selection.



- Original distribution
- Dominant adult males put pressure on young males in the bunting population.
- Distribution after disruptive selection



Adult male lazuli bunting

11.2 Formative Assessment

REVIEWING ► MAIN IDEAS

1. In terms of phenotypes, describe what is meant by the phrase “distribution of traits.”
2. What are the three ways in which natural selection can change a distribution of traits?

CRITICAL THINKING

3. **Predict** How might the extinction of downy woodpeckers affect the phenotypic distribution of gall flies?
4. **Predict** How might overfishing of large pink salmon select for smaller body size in subsequent generations?



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PREMIUM CONTENT

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5. For polygenic traits, a smooth curve results when the range of phenotypes is plotted against frequency. If you were to plot the frequencies of two phenotypes of a single-gene trait, you would end up with a double bar graph. Explain why.