

Topic 7.1

Introduction to Natural Selection

Learning Objectives

- Learn about Darwin's theory of natural selection
- Know how reproductive success is used as a measure of evolutionary fitness
- Understand the effects of changing environments on the rate and direction of evolution

Topic Questions

- How does natural selection cause populations to evolve?
- How does competition among organisms for limited resources result in natural selection?
- How does natural selection relate to evolutionary fitness?
- What environmental changes can change the rate or direction of evolution by natural selection?

7.1.01 Darwin's Theory of Natural Selection

[EVO-1.C.1 EVO-1.C.2]

A biological **population** is made up of all members of a given **species** that live within the same geographical area. For example, all largemouth bass fish (*Micropterus salmoides*) living in a single lake represent a population. The members of a population have the potential to successfully interbreed (ie, mate with each other to produce fertile offspring); therefore, the population has a common set of genetic information, which is referred to as the population's **gene pool**. The **gene pool** is made up of all **alleles** of all genes present in the individuals that make up the population.

The genetic makeup of a population of organisms can change over time, with the result being **evolution** of the population. Evolution is defined as change in allele frequencies in the gene pool of a population over generations. This type of genetic change in a population can be caused by **multiple factors**, including **natural selection**, a main cause of evolution that was first described by **Charles Darwin**.

According to Darwin's theory of natural selection, organisms with traits (ie, phenotypes) that make the organisms well suited to their environment are more likely to survive and reproduce (ie, pass on their alleles) than organisms with less favorable traits (see Figure 7.1). Therefore, alleles that control the production of beneficial traits in a given environment **become more common** in a population over time, and alleles that cause the production of traits that are detrimental (ie, harmful) under given environmental conditions become less common. As a result, natural selection causes populations to **become better adapted** to their environments.

Population of frogs
shows genetic diversity
influencing skin color



Some frogs are
eaten by predators



Brown frogs are easily
seen and are therefore
eaten more frequently



Frogs reproduce

Green skin trait becomes
more common in the
population over time



Figure 7.1 An example of natural selection.

As discussed in Topic 8.4, organisms typically produce more offspring than a given environment can support, which leads to **competition** for limited resources among the individuals in a population. As a result, offspring that are able to get more resources from the environment are more likely to survive and reproduce than offspring that compete less successfully for resources.

Competition for limited resources is an example of how the conditions of a given environment can cause organisms within the environment to face challenges that make survival more difficult. These challenging conditions (eg, predators, disease, limited food), called **selective pressures**, are the factors that cause natural selection.

7.1.02 Reproductive Success as a Measure of Evolutionary Fitness

[EVO-1.D.1]

Darwin's theory of **natural selection** is often summarized by the phrase "the survival of the fittest," which can lead to the idea that evolutionary fitness is mainly shown by organisms with good physical strength or fighting ability. However, instead of being limited to characteristics such as organism size and strength, **evolutionary fitness** is measured by an organism's **reproductive success** (see Figure 7.2). Therefore, *any* trait that increases an organism's ability to survive and successfully produce fertile offspring (ie, offspring that are themselves able to reproduce) increases the organism's evolutionary fitness.

For example, adult tapeworms, which live within the digestive tract of some animals, do not have a digestive tract of their own. For a typical animal, which has to consume (ie, eat) and digest food to get nutrients, a missing digestive tract would prevent the animal from surviving. However, because tapeworms live within the digestive tract of *other* animals (ie, hosts), tapeworms can absorb nutrients across the surface of their bodies from food that the host has *already* digested. In this way, tapeworms can save energy by not having to maintain their own digestive systems, providing tapeworms with more energy to produce offspring (ie, increasing fitness).

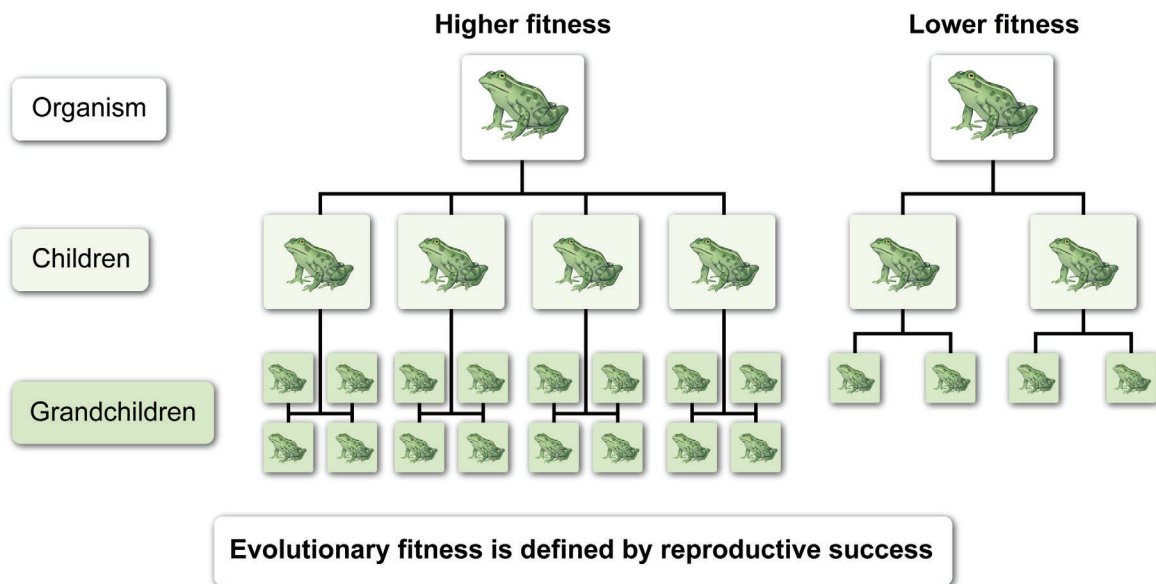


Figure 7.2 Evolutionary fitness.

Because of natural selection, **alleles** coding for traits that increase an organism's evolutionary fitness become more common in a population over time as the organisms reproduce. Reproduction causes genetic information (ie, alleles) to pass from parents to offspring; therefore, reproduction lets individual organisms contribute to (ie, help build) the **gene pool** of the next generation. Individuals that have more impact on the gene pool of the next generation by producing more offspring are said to have greater **relative fitness** than individuals in the population that produce fewer offspring (ie, those with less impact on the gene pool).

7.1.03 Effect of Fluctuating Biotic and Abiotic Environments on Evolution Rate and Direction

[EVO-1.D.2]

In an **ecosystem**, organisms interact with **biotic** (ie, **living**) and **abiotic** (ie, **nonliving**) environmental factors. Because both **biotic and abiotic** factors can affect organism survival and reproductive success, both of these types of factors function as **selective pressures**. Therefore, the specific environmental factors that organisms interact with in a given geographical area determine the effect that natural selection has on populations of these organisms.

In a changing environment, natural selection may **favor one phenotypic extreme** (ie, maximum or minimum) from a range of **phenotypes** (eg, range of organism colors from light to dark). In other words, natural selection can cause organism phenotypes to change (ie, evolve) in one direction (eg, toward darker coloration). In addition, the strength of selective pressures relative to one another can help determine how quickly evolution takes place in a given environment, with stronger selective pressures causing faster evolutionary change.

Both biotic and abiotic environmental factors can fluctuate (ie, change) or remain relatively stable over time. The presence or absence of these changes affects the strength and direction of selective pressures faced by organisms. If environmental conditions change (see Figure 7.3), phenotypes that were favored (ie, beneficial) in one generation of organisms may be selected against (ie, harmful) in the next generation. As a result, the frequency of particular **alleles** may decrease under one set of environmental conditions and increase when conditions change.

Having a fur color that blends in with the background color is beneficial for capturing prey

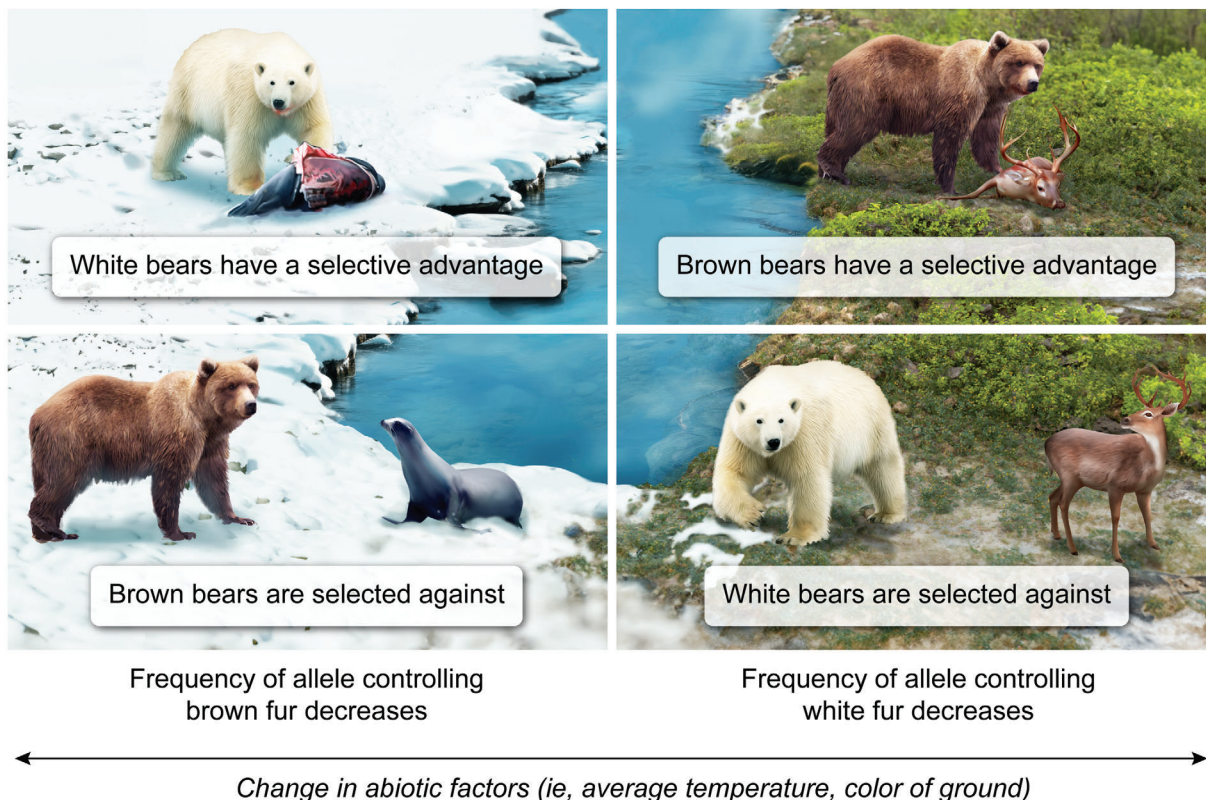


Figure 7.3 Change in evolutionary direction caused by abiotic environmental change.

Topic 7.1 Introduction to Natural Selection

Check for Understanding Quiz

1. In a population of bears, the allele coding for white fur decreases in frequency over time. Which of the following is a likely conclusion to draw from this information?
 - A. In the given environment for this population of bears, white fur is a beneficial trait.
 - B. In the given environment for this population of bears, white fur is a harmful trait.
 - C. In the given environment for this population of bears, white fur is neither beneficial nor harmful.
 - D. In the given environment for this population of bears, white fur changed from being a harmful trait to being a beneficial trait.

2. Which of the following statements concerning selective pressures is true?
 - A. Selective pressures are environmental conditions that make survival less difficult.
 - B. Selective pressures include both biotic and abiotic environmental factors.
 - C. Selective pressures that are stronger cause slower evolutionary change.
 - D. Selective pressures remain stable over time and do not change.

Note: Answers to this quiz are in the back of the book (appendix).