

Evolution occurs when natural selection acts on the genetic variability within populations. Genetic variation arises by chance through genetic mutations and recombination. The process of natural selection, however, does *not* occur by chance. The environment favours certain individuals over others. Just as human breeders have artificially selected for specific characteristics in domesticated plants and animals, the environment selects individuals that are better suited to their environment.

Sickle-cell anemia is a useful example of how mutation, genetic variation, and natural selection can lead to a change in a population. In humans, the sickle-cell allele resulted from a single base mutation in the DNA coding for hemoglobin. Individuals who are heterozygous for the allele are resistant to malaria and thus have a better chance of surviving than those who lack the allele. **Figure 1(a)** shows the distribution of malaria in Africa. People living in this region who are born with the sickle-cell allele are more likely to survive than those born without the allele. With survival comes reproduction and the passing on of the sickle-cell allele to the next generation. Over time, the result has been an increase in the frequency of the allele within those populations (**Figure 1(b)**). The sickle-cell mutation may never have occurred in the populations living in the malarial regions of northern Africa and the island of Madagascar.

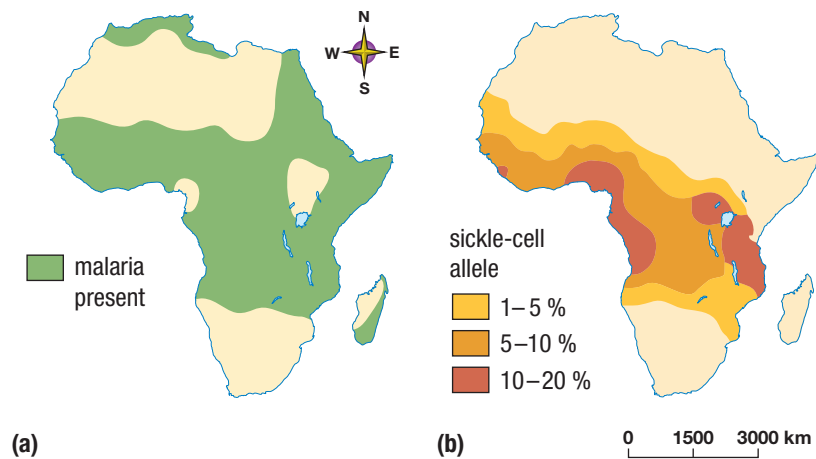


Figure 1 In the parts of Africa (a) where there is a high level of malaria, (b) the sickle-cell anemia allele is more prevalent.

Types of Selection

Selective pressures may result from any number of abiotic or biotic factors: diseases, climatic conditions, food availability, or predators—even your choice of mate! These selective pressures can result in different patterns of natural selection.

Directional Selection

Directional selection occurs when selection favours individuals with a more extreme variation of a trait. The result is a shift away from the average condition. Directional selection is very common in artificial breeding, where individuals with an enhanced trait are often selected. Strawberries have been selected for larger and sweeter fruits, chili peppers for hotter flavour, and thoroughbred horses for running speed.

Consider the following example of directional selection in nature. Hummingbirds use their bills to feed on nectar (**Figure 2**). Suppose a population of hummingbirds enters a new habitat with plants that have longer flowers. The hummingbird population includes individuals with a variety of bill lengths, though most have a bill best suited to medium-length flowers (**Figure 3(a)**, *before selection*, next page). In the new habitat, individuals with slightly longer bills are favoured by the environment and will be more successful than those with medium-length and shorter bills. Longer-billed birds will obtain more food and contribute more offspring to later generations (**Figure 3(a)**, *after selection*, next page). Eventually the bill length of the population will increase.

directional selection selection that favours an increase or decrease in the value of a trait from the current population average

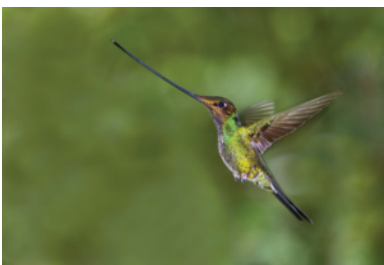


Figure 2 There are more than 300 species of hummingbirds. Their bill lengths can vary dramatically from species to species.

Stabilizing Selection

Stabilizing selection occurs when the average phenotype within a population is favoured by the environment. For example, imagine an initial population of hummingbirds that lives in an unchanging environment with medium-sized flowers (**Figure 3(b), before selection**). The most common medium-billed hummingbirds will be favoured. A longer bill requires more nutrients and energy to grow and carry around, while a shorter bill may reduce a bird's ability to reach food within the flowers. Selective pressures will reduce the reproductive success of individuals that exhibit extremely long or short bills (**Figure 3(b), after selection**).

stabilizing selection selection against individuals exhibiting traits that deviate from the current population average

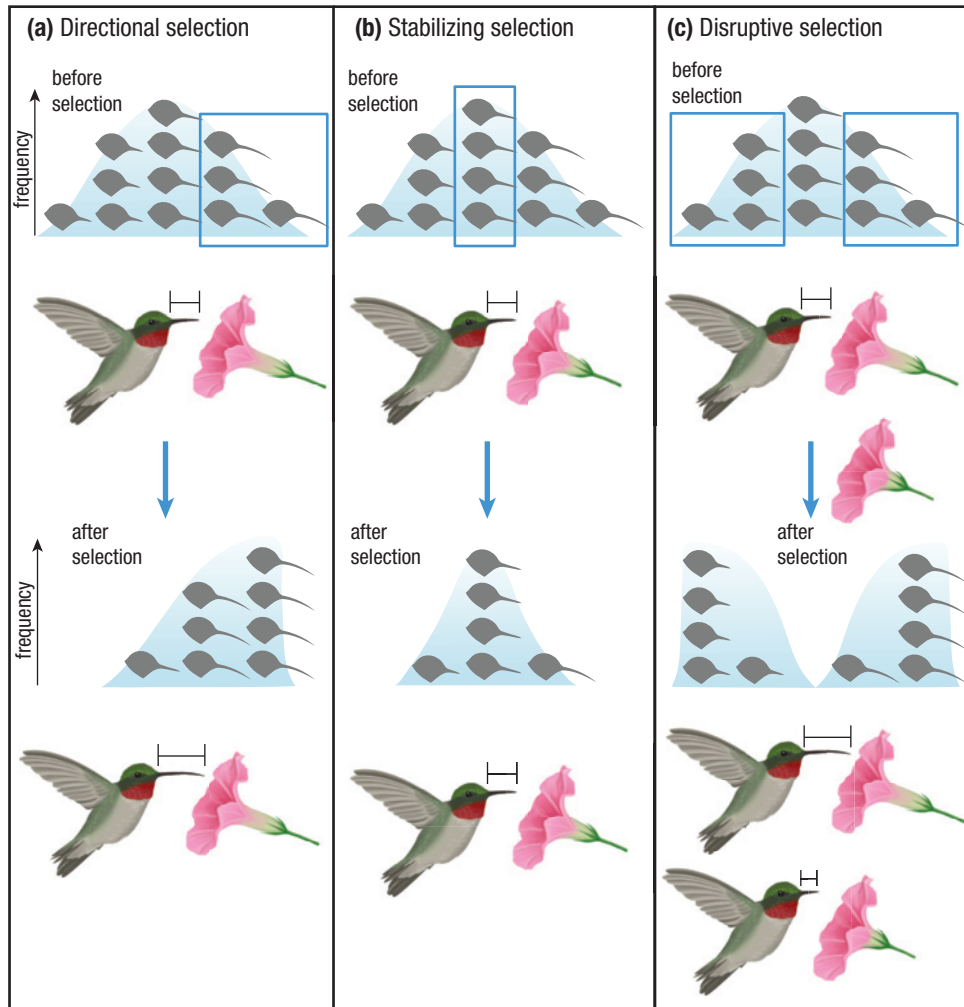


Figure 3 Examples of selection in a population of hummingbirds. (a) In a new environment with longer flowers, directional selection will favour individuals with longer bills. (b) In stabilizing selection, individuals with an average bill length are favoured. (c) In disruptive selection, the environment favours individuals with long and short bills over individuals with average bill lengths.

Human birth weights are also subject to stabilizing selection. Birth weights are variable, and part of this variability is heritable. According to the theory of evolution by natural selection, babies born at weights offering the best chance of surviving birth should be more numerous. More human babies are born weighing just over 3 kg than with any other weight. Babies with significantly lower weights are often developmentally premature and less likely to survive, while heavier babies often experience birth-related complications that threaten the life of both baby and mother (**Figure 4**).

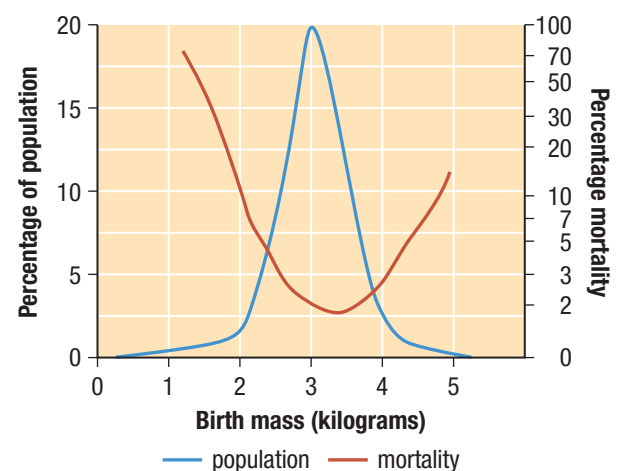


Figure 4 Human babies with average birth weights have a higher rate of survival than very large or very small babies.

disruptive selection selection that favours two or more variations of a trait that differ from the current population average

sexual selection differential reproductive success caused by variation in the ability to obtain mates; results in sexual dimorphism, and mating and courtship behaviours

Investigation 8.1.1

Bird Monogamy and Sexual Dimorphism (page 366)

In this observational study you will make a prediction based on the theory of evolution and gather data to test your prediction.

UNIT TASK BOOKMARK

Consider how you can use the different types of selection to predict outcomes related to your Unit Task.



Figure 6 Attracting more pollinators may ensure greater seed production.

Disruptive Selection

Disruptive selection favours individuals with variations at opposite extremes of a trait over individuals with intermediate variations. Sometimes, environmental conditions favour more than one phenotype. For example, two species of plants with different-sized flowers may be available as a food source for the hummingbird population (**Figure 3(c)**, *before selection*). Each species is a good source of nectar, but neither is well suited to a hummingbird with a medium-length bill. Birds with longer and shorter bills will be more successful and will contribute more offspring to later generations (**Figure 3(c)**, *after selection*).

Sexual Selection

Natural selection favours the reproductive success of individuals with certain traits over individuals with other traits. Good health enhances reproductive success, but finding a mate is even more important. **Sexual selection** is the favouring of any trait that specifically enhances the mating success of an individual. Sexual selection often leads to the males and females of a species evolving appearances and behaviours that are quite different from each other.

The most common forms of sexual selection are female mate choice and male-versus-male competition. In many species, females choose mates based on physical traits, such as bright coloration or behaviours (**Figure 5(a)**). In other species, males have evolved larger body size and other physical attributes such as antlers that are often used in direct competition (**Figure 5(b)**). The males often fight each other to establish control over a territory that is home to females with which they can mate. The difference between success and failure can be dramatic. For example, a very successful male elephant seal may mate with dozens of females each year and hundreds of females in his lifetime, while a weak male may live a longer life but produce no offspring. In this case the genes of the shorter-lived but dominant male are destined to become more common in succeeding generations.



Figure 5 (a) Male cardinals use brightly coloured plumage and song to attract females. (b) Male bighorn sheep compete head to head, using their horns for head-on clashes. Female bighorn sheep have much smaller horns.

While traits such as bright coloration and large antlers can be favoured by sexual selection, they are often a disadvantage when it comes to longevity. Avoiding predators is not made easier by brilliant plumage or a distinctive song. Fringe-lipped bats, for example, locate male tungara frogs by listening for their mating calls. Male frogs that call frequently are more likely to be eaten. Male frogs that never call remain safe but are unable to attract a mate.

Sexual selection is not limited to animal populations. Colourful flowers and scents are the most obvious sexual features of plants (**Figure 6**). Rather than attracting mates, these features attract pollinators. By maximizing their chances of being pollinated, plants have a greater likelihood of contributing more alleles to the next generation's gene pool.

Natural Selection in Action

Natural selection results in evolutionary changes within populations. Examples of such changes can be observed in nature and demonstrated under controlled experimental conditions.

Geneticists have recently revealed an example of directional selection in a human population. Tibetan people have inhabited the Himalayan mountains for thousands of years (**Figure 7**). At this elevation, the oxygen level is only 40 % of that at sea level. When people from lowlands move to this elevation, their bodies exhibit a physiological response. Over a period of days and weeks, their red blood cell count increases, helping them obtain adequate oxygen. This survival response, however, is not ideal because the increased red blood cell count makes blood more viscous. This places stress on the heart and results in reduced fertility and increased child mortality. Tibetans who live at high altitudes, however, do not exhibit elevated red blood cell counts yet have no difficulty coping with the low oxygen levels. Instead, directional selection has favoured a number of genetic mutations that increase the oxygen-carrying capacity of their blood while maintaining normal red blood cell counts. Geneticists have documented more than 30 genes that have been selected within the Tibetan population. One allele was almost 10 times more common in Tibetans in the study group than among people of lowland descent.

Under controlled experimental conditions, researchers at the University of Wisconsin tested the hypothesis that certain behaviours might have an inherited component and could be influenced by natural selection. The researchers modelled directional selection in populations of mice by choosing individuals for breeding that spent the most time on exercise wheels. After only 10 generations, the populations descended from the chosen mice exhibited much higher running distances and average speeds when compared to control populations (**Figure 8**).

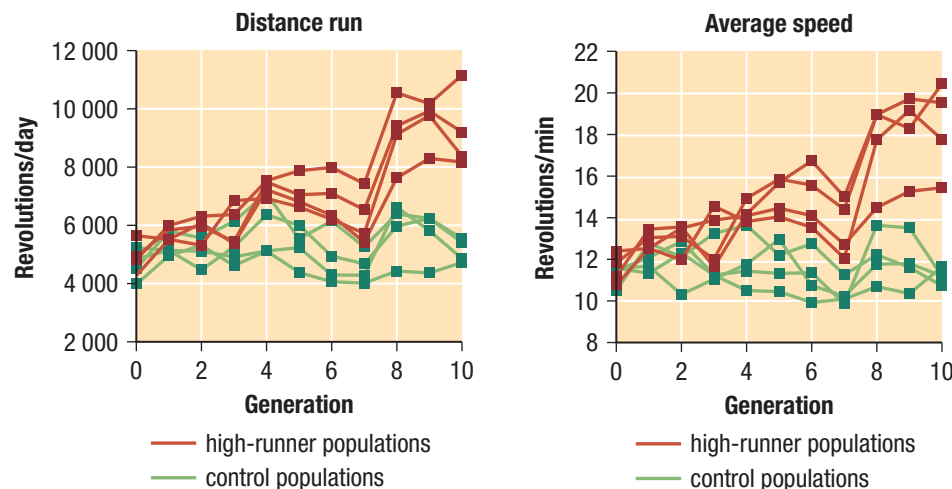


Figure 8 A controlled experiment in mice suggests that some behaviours have a genetic component and can be influenced by directional selection.

This heritable change in mouse behaviour is an example of rapid evolution. It happened quickly—in a matter of 10 generations. While there are many other examples of rapid and observable evolution, most major evolutionary changes are slow, occurring over hundreds of generations and thousands of years. In such cases we can observe the product of the lengthy and ongoing process of natural selection. It is often easy to speculate about the selective pressures that have been at work. **Table 1** provides some examples of well-known animal traits and the selective pressures that have contributed to their evolution.

What is less obvious is how natural selection produces complex structures. Imagining the various stages and selective pressures on species over millions of years is not easy, and unless there is fossil evidence, it may be impossible to know how a particular trait evolved. Nonetheless, it is possible and useful to hypothesize scenarios that led to the evolution of complex features. The following tutorial (next page) presents one such case and challenges you to generate a working hypothesis.

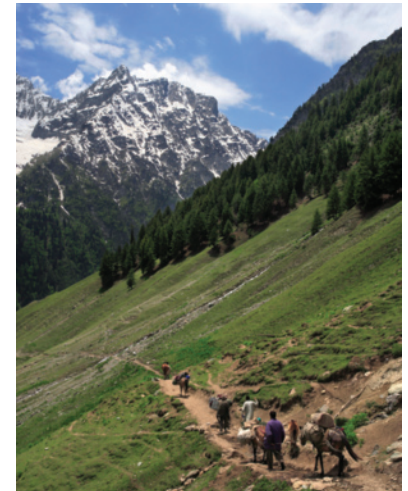


Figure 7 Tibetans living at high elevation have blood with a high capacity to carry oxygen.

Table 1 Possible Selective Pressures that Resulted in Specific Animal Traits

Animal trait	Selective pressure
hawk: acute vision	• ability to spot prey over long distances
polar bear: white fur	• ability to sneak up on seals on snow-covered ice
elephant: long trunk	• ability to reach for food and water while minimizing the movement of its massive body
lobster: large claws	• ability to crush large shells and other prey items
wolf: keen sense of smell	• ability to locate and track the movements of prey
human: large brain	• ability to reason and communicate • ability to construct and use tools

Tutorial 1 Cumulative Selection

Evolutionary biologists have an extraordinary challenge. They not only study the characteristics of living things, they attempt to unravel how such characteristics came into existence—how they evolved. As part of this process, evolutionary biologists often hypothesize a possible scenario that might have led to the evolution of a particular trait and then look for evidence to support or refute their hypothesis. In this tutorial we will outline a hypothesis for the evolution of insect pollination in plants. This represents one of the most significant adaptations in the history of life on Earth. Insect-pollinated plants are among the most diverse and successful of all living things.

To begin, we must base our hypothesis on a set of assumptions and we must choose an appropriate starting point. We are not attempting to outline the entire evolutionary history of plants themselves, only a particular trait—in this case insect pollination.

Our starting assumptions are as follows:

1. Insect-pollinated plants evolved from simple flowering plants that were wind pollinated. Wind-pollinated plants produce drab, greenish flowers and relatively large quantities of pollen that is not sticky. This is a reasonable assumption given that the simpler non-flowering seed plants—the gymnosperms—are wind pollinated, and modern flowering plants that are wind pollinated have simple flowers that produce large quantities of non-sticky pollen. They are typically small and green in colour.
2. Insects that fed on plants were very abundant during this evolutionary process. Some of these insects fed on flower pollen. This is a reasonable assumption because we know that many different insects visit various flowers and cones and feed on pollen.
3. All new genetic variations must arise from mutation events.
4. A complex adaptation involves a number of different mutations.
5. A mutation must be beneficial if it is to be favoured by natural selection.
6. The process of evolution may take millions of years.

Our evolutionary scenario describes a series of plausible beneficial mutations and the advantage they would have offered the evolving species. Our goal is to present a scenario that meets all of our assumptions.

Evolutionary Scenario

Original plant: wind-pollinated flowering plant producing millions of pollen grains; flowers drab and odourless

Original insect: seeks out flowers and feeds on the pollen

Mutation 1: Sticky pollen	Natural selection
• A slight modification of the outer surface of the pollen grains makes the pollen slightly sticky.	• Insects that visit this plant feed on its pollen and get a small amount of pollen stuck to their bodies. • Transported pollen is more likely to reach another flower. • Flowers with sticky pollen have more pollen transferred to other flowers and therefore produce more offspring.

Additional mutations that enhance the sticky quality of the pollen will be favoured for the same reason and over time will accumulate, resulting in sticky pollen.

Mutation 2: Less chlorophyll in flowers	Natural selection
• Flower tissues produce slightly less chlorophyll. • Plant does not rely on flowers for photosynthesis, so this change does not affect food production. • Plant cells contain many pigments; with less chlorophyll the other pigments are slightly more visible.	• Insects are more likely to locate these flowers. • Flowers are more likely to have their sticky pollen carried from one flower to another. • Flowers become more visible to insects and are more likely to receive pollen.

Additional mutations that enhance the colour of flower parts will make them more visible to insects and therefore more likely to be pollinated.

Mutation 3: Hairy insects	Natural selection
• An insect has slightly longer bristles on its body. • Longer bristles are more likely to get covered in sticky pollen.	• Insects are favoured because they are more efficient at pollinating the flowers. • The trait does not benefit the insect directly but increases the success of the flowers they feed on, resulting in a greater food supply.

Additional mutations that enhance the pollen-transferring ability of the insect will favour both the plant and insect.

Additional mutations	Natural selection
• Flower size, colour, or fragrance is enhanced.	• The flower is more likely to attract insects and be pollinated.
• The insect is better able to transfer pollen or find the flowers.	• Insects are more likely to find food.
• The plant has the ability to release small amounts of sap from its flowers. • The earliest rudimentary nectar is produced.	• The plant is more likely to attract insects and therefore increase pollination.

Scenario Challenge

With a partner, brainstorm a set of simple mutations and natural selection processes that might have led to the evolution of one or more of the following features:

Binocular vision in primates

Most mammals have eyes set out to the sides and have very poor depth perception but better peripheral vision. Consider what you know about the habitat and behaviour of most primates (**Figure 9**).



Figure 9 Orangutans and other primates have binocular vision.

Poison dart frogs

These colourful frogs are highly toxic and easy to spot (**Figure 10**). Note that both the males and females are coloured, so this is not an example of sexual selection. Consider which feature might have evolved first—coloration or toxicity.



Figure 10 Poison dart frogs are highly toxic.

Bromeliads

Bromeliads are flowering plants that live on other plants (**Figure 11**). They are usually attached to the branches of large trees in tropical rainforests. Their roots are adapted to holding on to branches while their leaves are arranged to form a water-tight basin for catching and holding rainwater.



Figure 11 Bromeliad plants capture rainwater in small pools at the base of their leaves.

Evolutionary Change without Selection

Not all evolutionary changes are the result of natural selection. Sometimes, there are changes in the genetic makeup of a population that are not influenced by the traits of individuals. As you will see, each of these changes tends to reduce genetic diversity within a population.

Genetic Drift

The genetic makeup of a population can change simply by chance. When individuals produce offspring, the chances of passing on any particular allele is subject to random chance. The smaller the number of individuals in a population, the greater the influence of **genetic drift**—the random shifting of the genetic makeup of the next generation. In small populations, genetic drift can result in a particular allele becoming either very common or disappearing entirely over a number of generations (**Figure 12**). Any lost alleles result in a net reduction in the genetic diversity of the population.

genetic drift changes to allele frequency as a result of chance; such changes are much more pronounced in small populations

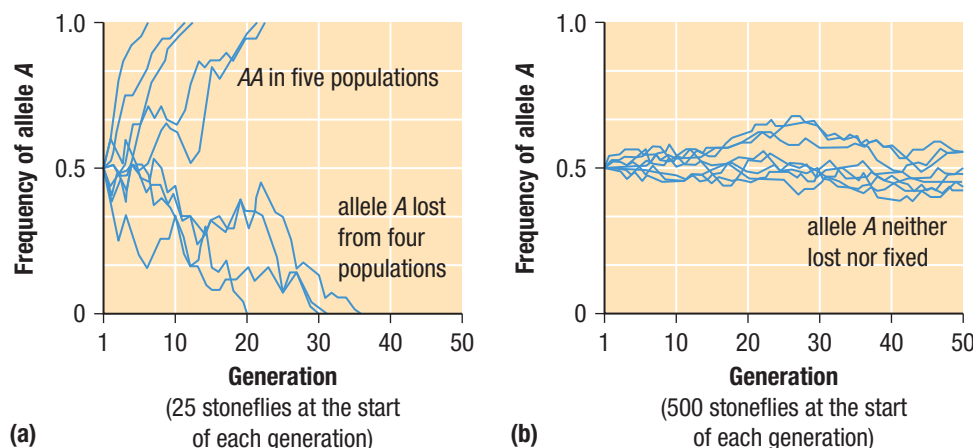


Figure 12 (a) In small populations, genetic drift can result in dramatic changes in allele frequency. (b) In larger populations, genetic drift is not usually significant.

genetic bottleneck a dramatic, often temporary, reduction in population size, usually resulting in significant genetic drift

Bottlenecks and the Founder Effect

Genetic bottlenecks result in a loss in genetic diversity following an extreme reduction in the size of a population (**Figure 13**). For example, if an initial population of 10 000 individuals is reduced to only 50 individuals, they are unlikely to contain all of the alleles found in the larger population. Many alleles, and in particular rarer alleles, are likely to be eliminated in this bottleneck event. If the population is allowed to recover, the genetic makeup of future generations will be limited to the alleles carried by those 50 surviving individuals and any new mutations.

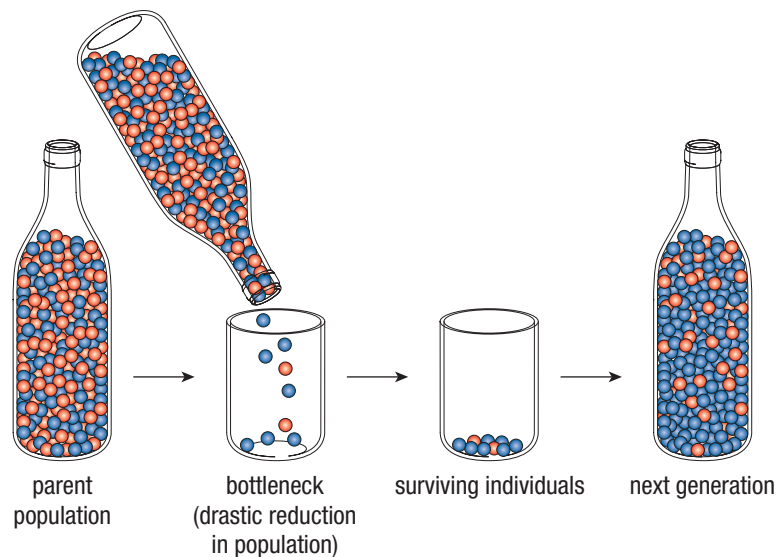


Figure 13 A dramatic reduction in the size of a population can result in a bottleneck. Here, the original population had equal numbers of blue and orange alleles. Following the bottleneck, the blue allele is much more prevalent.



Figure 14 Cheetahs have very little genetic variation because their population was subject to a genetic bottleneck.

founder effect genetic drift that results when a small number of individuals separate from their original population and establish a new population

Bottlenecks can have adverse consequences for populations. Cheetahs, for example, have very little genetic variability. As a result they are vulnerable to disease. Cheetahs also have low reproductive success and high juvenile mortality rates. All cheetahs are thought to be descendants of a population that experienced a severe bottleneck event—estimated to have left only seven individuals—about 10 000 years ago (**Figure 14**). Similarly, the northern elephant seal population was reduced by overhunting to 20 individuals in the 1890s. Although the population has rebounded to over 127 000 individuals, they are genetically very similar.

The **founder effect** occurs when a small number of individuals establish a new population. For example, a small number of finches from the coast of South America established a founding population on the Galapagos Islands. The initial population would—by chance alone—have a different mix of alleles than the large mainland population. By chance, an allele that was common in the large population might be uncommon in the founding population, or a rare allele might be much more common in the new population. For example, suppose an allele is found in only 1 in 1000 (0.1 %) finches in the mainland population. Now suppose that by chance, 1 of only 20 finches that reach the Galapagos Islands carries the same allele. This represents 5 % of the founding population—an increase of 50 times. While such a change does not increase the diversity of the population, it does mean that the new population will begin with a different gene pool than the original mainland population's gene pool.

Small populations that result from a bottleneck or founder effect are also subject to the effects of genetic drift. This will further increase the chances that their gene pool will differ from that of the original population. Although genetic drift and bottlenecks can be important in some cases, natural selection is usually the major driver behind changes that result in the evolution of a significant adaptation. Natural selection is the only mechanism known that is able to shape a species to its environment.

The Hardy–Weinberg Principle

To modern biologists, evolution is the change in the genetic makeup (or gene pool) of a population over time. Mathematically, a gene pool can be described by the frequency of each of the alleles within the population. Two mathematicians, Godfrey Hardy and Wilhelm Weinberg, used mathematical reasoning to explain the relationships between allele frequencies within a population and the chances of those frequencies remaining constant. This relationship, often represented by a mathematical equation, is referred to as the **Hardy–Weinberg principle**.

Any factor that causes allele frequencies to change leads to evolutionary change. Based on the Hardy–Weinberg principle, biologists recognize that the following conditions result in evolution:

- natural selection: favours the passing on of some alleles over others
- small population size: increases the likelihood of genetic drift
- mutation: introduces new alleles to a population
- immigration or emigration: introduces or removes alleles in a population
- horizontal gene transfer: the gaining of new alleles from a different species

These five conditions are known to occur in many populations and inevitably result in evolutionary changes over time. Knowing the influence that each of these factors can have on a population allows biologists to predict which populations are likely to exhibit the most evolutionary change. Biologists must also take into account the particular biology of each species. For example, a species that has high genetic diversity and reproduces very quickly will respond to natural selection more rapidly than a species with little genetic diversity that reproduces very slowly. Such factors account for how insects and bacteria have rapidly evolved resistance to pesticides and antibiotics.

Hardy–Weinberg principle in large populations in which only random chance is at work, allele frequencies are expected to remain constant from generation to generation

Mini Investigation

Modelling Genetic Drift

Skills: Predicting, Performing, Observing, Analyzing

SKILLS
HANDBOOK  A2.1

Genetic drift is more likely to occur in small populations. In nature, this may happen when there is a genetic bottleneck and a population is reduced to a small number of individuals. In this investigation you will model how such events can influence the allele frequencies of a population.

Equipment and Materials: containers of “Population A” and “Population B” (pop-it bead organisms); calculator

1. Remove all the individuals from the Population A container. Each individual is represented by two pop-it beads joined together. Each pop-it bead represents a single allele; different colours represent different alleles. Together the two pop-it beads represent the genotype of the individual. For example, heterozygous individuals will contain two different-coloured beads.
 2. Without separating the beads, count the total number of each type of allele (bead colour). Record this number as a percentage of the total number of alleles in the population gene pool. These values represent the initial allele frequencies. For example, if there are 50 individuals with a combined total of 20 red and 80 blue beads, then the gene pool contains 100 alleles and the allele frequencies are 20 % red and 80 % blue.
 3. Return all the individuals to the container and mix them thoroughly.
 4. Without looking, randomly remove 10 individuals from the container. Before doing so, make a prediction about the allele frequencies of these 10 individuals. These 10 individuals represent the survivors of a bottleneck event (or a small founder population).
 5. Count and record the allele frequencies of this population, and then return the 10 individuals to the container.
 6. Repeat Steps 3 through 5 twice.
 7. Repeat Steps 1 through 6 with Population B.
- A. Was there evidence of genetic drift? Did the allele frequencies change when the populations were reduced from 50 to 10 individuals? Were your predictions accurate? [K/U](#)
- B. Were any changes in allele frequencies consistent? For example, did the allele frequencies of the most common allele always increase? [K/U](#)
- C. Were any alleles lost in any of the new populations? [K/U](#)
- D. According to the Hardy–Weinberg principle, there are five conditions that can result in changes in allele frequencies. Which of these conditions were modelled in this investigation? Which were not? [K/U](#) [T/I](#) [A](#)
- E. Based on your results, do you think genetic drift is likely to cause an increase or a decrease in the genetic diversity of a population? [T/I](#) [A](#)

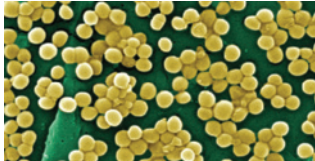
Consequences of Human Influence

UNIT TASK BOOKMARK

Consider how you can apply your understanding of how human activities change the selection pressures of species to your Unit Task.

Humans interact with all other species, either directly or indirectly. We commercially harvest many species from the wild; we alter habitats by clearing land for agriculture, urban expansion, and mining; and we pollute the air, soil, and water. The greenhouse gases we emit are changing Earth's climate and the chemistry of the oceans. We also set aside large areas as parks and intervene to protect endangered species. These interactions act as agents of natural selection and have the potential to influence the evolution of species. **Table 2** describes some consequences of human activities on the evolution of species.

Table 2 Consequences of Human Activities on Evolution

Human selective pressure	Evolutionary change and consequences	Example
- Commercial fishing targets large fish and often allows smaller fish to escape. Some fishing regulations even require the release of small fish. - Fish that reach maturity at a smaller size are more likely to escape and reproduce than individuals that reach sexual maturity at a larger size.	- The average adult size of many valuable commercial fish species, including cod, has declined dramatically. - The alleles that code for large adult size are being lost from the gene pool of the population.	 cod
- Habitat loss, the introduction of invasive species, and overharvesting have reduced the population sizes of many species to extremely low levels. - This has created genetic bottlenecks, reducing the genetic diversity of the species.	- Populations with little genetic variability are less able to survive environmental changes and diseases. - Even if their numbers rebound, populations will not recover their genetic diversity. - The population of northern elephant seals was reduced by hunting to about 20 individuals by the 1890s. The population is now over 127 000, but the seals have very little genetic diversity.	 elephant seal
- Climate change is altering selection pressures on species in many ways. - In some situations changes may happen too rapidly for species to adapt.	- Many migratory bird species are expected to begin migrating shorter distances and eventually stop migrating entirely. - Species such as caribou and polar bears living in alpine and arctic environments may not be able to adapt quickly enough to survive.	 caribou
Selective hunting of prize animals favours individuals with less desirable traits. For example, elephants that grow smaller tusks are less likely to be shot for their ivory. Bighorn sheep that grow smaller horns are less likely to be shot as trophy animals.	- Individuals that exhibit prized traits become less common in the population. - The average tusk size of mature African elephants is decreasing. - Close to 50 % of all male Asian elephants are tuskless. This may have resulted from selective hunting practices in the past.	 Asian elephant
- The use of insecticides and herbicides is widespread. - Resistant insects and weed plants are more likely to survive and reproduce.	- Many insects and plants, such as bedbugs and pigweed, are becoming resistant to pesticides. - The cost of controlling these pests and the health concerns and economic losses they cause are increasing.	 bedbug
The use of antibiotics and antimicrobial cleaners is widespread.	- Many infectious bacteria, such as methicillin-resistant <i>Staphylococcus aurea</i> (MRSA), are becoming resistant to multiple varieties of antibiotics, making it more difficult and expensive to treat patients. - Antimicrobial soaps and cleaners rapidly kill off weak bacteria that may be replaced by more resistant forms.	 <i>Staphylococcus aurea</i>

8.1 Summary

- Directional and disruptive selection produces evolutionary changes by favouring individuals that differ from the population norm.
- Stabilizing selection acts to limit evolutionary change by favouring the current population norms.
- Sexual selection is a form of natural selection in which traits that specifically enhance mating success are favoured.
- Evolutionary changes produced by natural selection can accumulate over time and result in major adaptations and the formation of new descendent species.
- Genetic drift produces evolutionary changes independently of natural selection.
- Bottlenecks and the founder effect enhance the influence of genetic drift.
- The Hardy–Weinberg principle can be used to identify factors that will result in evolutionary change.
- Human activities have a very strong selective influence on many species and therefore influence their evolution.

8.1 Questions

1. Biologists often describe evolution as a change in the frequency of alleles in a population. How does this definition relate to the process of natural selection? **K/U**
2. Describe the way in which natural selection has influenced the genetic makeup of Tibetan human populations. **K/U**
3. Use the sickle-cell allele to illustrate how natural selection can cause a mutation to be beneficial in one environment and harmful in another. **K/U A**
4. How does evolution favour behavioural traits in males of some species that cause them to risk their life in fights with other males over mates? **K/U A**
5. Which type of selection led to the following characteristics: **K/U T/I**
 - (a) hollow and very lightweight bones in birds
 - (b) hundreds of different but genetically very similar species of fruit flies living in the Hawaiian Islands
 - (c) turtles species that have changed little over millions of years
 - (d) males of many frog species that call every spring, while females are silent
6. Account for the fact that in stable environments species often show little or no evolutionary change. **K/U T/I**
7. If species are not changing, is it true to say that natural selection is not happening? Explain your reasoning. **T/I**
8. Both male and female blue jays are brightly and similarly coloured. Is this an example of sexual selection? Explain. **T/I**
9. Genetic drift leads to evolutionary change in the absence of natural selection. Explain how this is possible. Provide an example to support your answer. **K/U T/I**
10. The human population of Iceland was founded by a relatively small initial population more than 1000 years ago. Would you expect the genetic diversity of Icelanders to be more or less than the genetic diversity of Canadians? Explain your reasoning. **T/I A**
11. Antibiotic-resistant bacteria may expend extra energy and resources to produce special compounds and carry extra genetic material to protect themselves against antibiotics. Predict what might happen to these bacteria if they are not exposed to antibiotics for many generations. **T/I A**
12. Do online research and complete the following: **T/I A**
 - (a) Describe the key steps that are thought to have occurred in the evolution of eyes. Include labelled diagrams to illustrate the steps.
 - (b) Have eyes evolved once or more than once in the evolutionary history of life on Earth?
 - (c) Explain how having simple or even poor eyesight might be advantageous for a species compared to having no eyesight at all.
13. In each of the following situations, based on the Hardy–Weinberg principle, determine whether or not evolution would be expected to take place. Explain your choice. **K/U A**
 - (a) A very large population of mosquitoes lives in a stable environment.
 - (b) A small population of lizards inhabits a remote island.
 - (c) Climate change influences the flowering time of a species of wildflower.
14. Provide three examples of how human activity is directly influencing the evolution of wild (non-domesticated) species. **T/I A**

