11.2 Mechanisms of Evolution

Learning objectives

By the end of this section, you will be able to:

- *Explain the four most important evolutionary forces: natural selection, mutation, genetic drift, and migration*
- *Discuss nonrandom mating and explain how it contributes to evolutionary change*
- *Be prepared to define and explain all bolded terms*

The four most important evolutionary forces that will disrupt equilibrium are: natural selection, mutation, genetic drift, and migration into or out of a population. A fifth factor, nonrandom mating, will also disrupt the Hardy-Weinberg equilibrium but only by shifting genotype frequencies, not allele frequencies. In nonrandom mating, individuals are more likely to mate based on preference rather than at random.

Natural Selection

Natural selection acts on the population's heritable traits. **Natural selection** selects for beneficial alleles that allow for environmental adaptation, which leads to the frequency of the beneficial alleles increasing in the population. Deleterious alleles are selected against and thereby decrease in frequency in the population. Natural selection selects for organisms as a whole, not on an individual allele within the organism. An individual may carry a very beneficial genotype with a resulting phenotype that, for example, increases the ability to reproduce (fecundity). However, if that same individual also carries an allele that results in a fatal childhood disease, that fecundity phenotype will not pass to the next generation because the individual will not live long enough to reproduce. Natural selection selects for individuals with alleles that allow them to survive better and reproduce more. Scientists call this an organism's evolutionary (Darwinian) fitness.

Sexual Selection

Darwin identified a special case of natural selection that he called sexual selection. In **sexual selection** the fitness of certain traits is determined by different levels of reproductive success. Sexual selection leads to the evolution of dramatic traits that often appear maladaptive in terms of survival but persist because they allow greater reproductive success. Sexual selection occurs in two ways: through male–male competition for mates and through female selection of mates. Male–male competition occurs when males fight or compete for the opportunity to mate with a female(s). These competitions are often ritualized but may also pose significant threats to a male's survival. Sometimes the competition is for territory, with females more likely to mate with males with higher quality territories. Female choice occurs when females choose a male based on a particular trait, such as feather colors, the performance of a mating dance, or the building of an elaborate structure. In some cases, male–male competition and female choice combine in the mating process. In each of these cases, the traits selected for, such as fighting ability or feather color and length, become enhanced over generations in the males.

It is thought that sexual selection can only proceed to a certain point. This is because natural selection eventually prevents further enhancement of a characteristic due to negative impacts on the male's ability to survive. For example, colorful feathers or an elaborate display make the male more obvious to predators. If a male peacock's tail feathers, for example, become too long and he cannot escape predation, then it doesn't matter that he is more attractive to a female. Because of his long feathers, he is more likely to be predated and therefore not able to reproduce and pass on his traits. There is a delicate balance between having enough enhancements to attract a mate but not so much that it results in being predated.

Mutation

Mutation creates a new allele from an existing allele by changing the DNA sequence. A mutation may produce an allele that is beneficial, harmful, or neutral in the current environment. Harmful mutations may be removed from the population by natural selection and will generally only be found in very low frequencies equal to the mutation rate. Beneficial mutations will spread through the population due to natural selection. Whether or not a mutation is beneficial or harmful is determined by whether it helps an organism survive to sexual maturity and reproduce. It should be noted that mutation is the ultimate source of genetic variation. New alleles, and therefore new genetic variations, arise through mutation.

CONCEPTS IN ACTION – Learn more about mutations in [this video].

Check your knowledge

True or false: All mutations result in evolution.

Dandelions produce over a hundred seeds from one flower. Those seeds than blow through the environment and out compete the grass found in our yards. Is this an example of natural selection, sexual selection, or mutation?

Answers: False. While mutations can cause evolution, some mutations will result in no effect on a population at all. Many affect an individual in somatic cell mutations and not whole populations.
This is natural selection. Dandelions are very adapted to survive in many environments and their tiny seeds can root almost anywhere there is a bit of soil.

Genetic Drift

Another way a population's allele frequencies can change is **genetic drift**, which is simply due to random chance. Genetic drift is most important in small populations. Drift would be completely absent in a population with an infinite number of individuals; however, no population is that large. Genetic drift occurs because the alleles in the F_1 generation are a random sample of the alleles in the parental generation. Alleles may or may not make it into the next generation due to chance events including mortality of an individual, events affecting finding a mate, and even the events affecting which gametes end up participating in fertilizations (Figure 11.8).

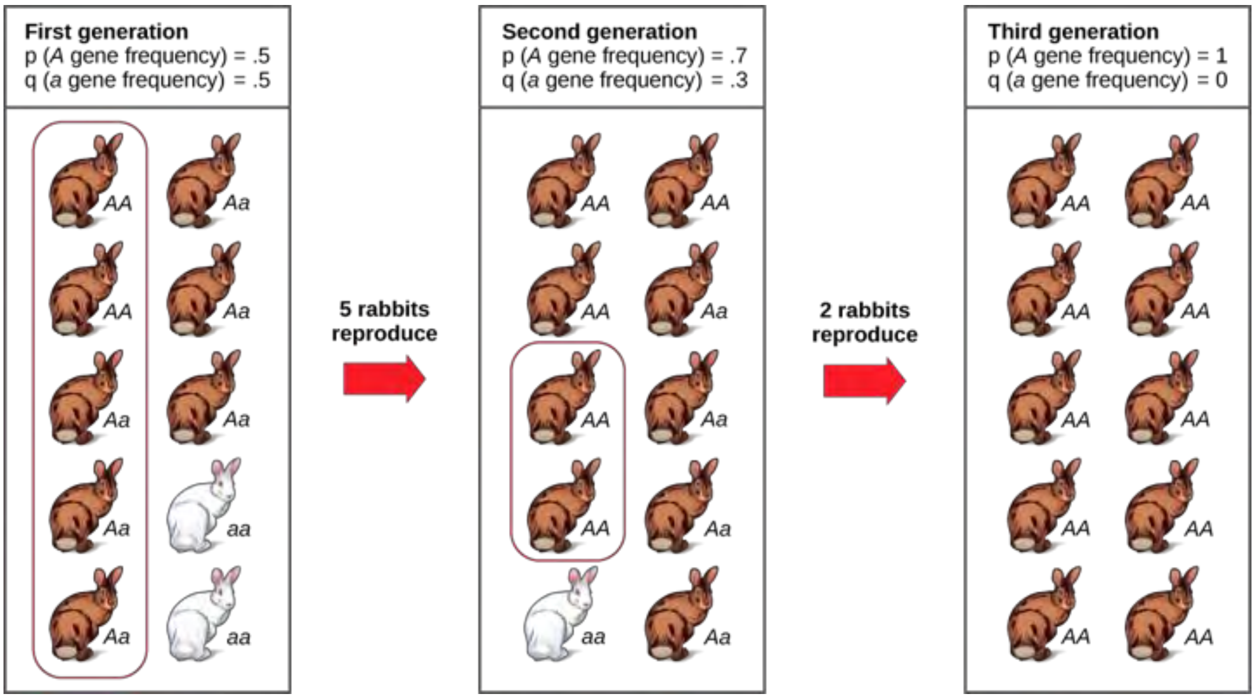

Figure 11.8 Genetic drift in a population can lead to the elimination of an allele from a population by chance. In each generation, a random set of individuals reproduces to produce the next generation. The frequency of alleles in the next generation is equal to the frequency of alleles among the individuals reproducing. (credit: Fowler et al. / Concepts of Biology OpenStax)

If one individual in a population of ten individuals happens to die before it leaves any offspring, all of its genes, a tenth of the population's gene pool, will be suddenly lost (Figure 11.9). In a population of 100, that 1 individual represents only 1 percent of the overall gene pool; therefore, it has much smaller impact on the population's genetic makeup and is unlikely to remove all copies of an allele (Figure 11.9).