

Chapter 16 Evolution of Populations**Summary****16–1 Genes and Variation**

Darwin's original ideas can now be understood in genetic terms. Beginning with variation, we now know that traits are controlled by genes and that many genes have at least two forms, or alleles. We also know that individuals of all species are heterozygous for many genes.

To understand evolution, genetic variation is studied in populations. A population is defined as a group of individuals of the same species that interbreed. Members of a population share a common group of genes, called a gene pool. A gene pool consists of all the genes, including all the different alleles, that are present in the population. In genetic terms, evolution is any change in the relative frequency of alleles in a population. The relative frequency of an allele is the number of times the allele occurs in a gene pool, compared with the number of times other alleles for the same gene occur.

The two main sources of genetic variation are mutations and gene shuffling. A mutation is any change in a sequence of DNA. Gene shuffling occurs during the production of gametes in sexual reproduction. It can result in millions of different combinations of genes. Mutation and gene shuffling do not change relative allele frequencies. However, they increase genetic variation by increasing the number of different genotypes.

The number of different phenotypes for a given trait depends on how many genes control the trait. A single-gene trait is controlled by one gene. If there are two alleles for the gene, two or three different genotypes are possible. An example in humans is the presence or absence of widow's peak. A polygenic trait is controlled by two or more genes, and each gene may have more than one allele. An example of a human polygenic trait is height.

Polygenic traits such as height produce many different phenotypes. Variation in a polygenic trait in a population often produces a bell-shaped curve, with most people falling near the middle of the curve.

16–2 Evolution as Genetic Change

Natural selection acts on individuals. Evolution acts on populations. Natural selection acting on individuals leads to the evolution of populations.

Natural selection on a trait controlled by a single gene with two alleles can cause one allele to increase and the other allele to decrease. Natural selection on polygenic traits is more complicated. Natural selection on polygenic traits can occur as directional selection, stabilizing selection, or disruptive selection. Directional selection takes place when individuals at one end of the bell-shaped curve have higher fitness than individuals near the middle or at the other end of the curve. The result of directional selection is a shift in the curve toward the higher fitness end. Stabilizing selection takes place when individuals near the middle of the curve have higher fitness than individuals at either end. The result of stabilizing selection is a narrowing of the curve around the middle. Disruptive selection takes place when individuals at the upper and lower ends of the curve have higher fitness than individuals near the middle. As a result of disruptive selection, the curve develops a peak at each end and a low point in the middle.

Natural selection is not the only source of evolutionary change. In small populations, alleles can become more or less common simply by chance. This kind of change in allele frequency is called genetic drift. It occurs when individuals with a particular allele leave more descendants than other individuals, just by chance. Over time, this can cause an allele to become more or less common in a population.

Genetic drift also may occur when a small group of individuals colonizes a new habitat. By chance, the small group may have different relative allele frequencies than the original population. When this happens, it is called the founder effect.

To understand how evolution occurs, scientists first had to answer the question: Under what conditions does evolution not occur? The answer to this question is called the Hardy-Weinberg principle. The principle states that allele frequencies in a population will remain constant unless one or more factors cause those frequencies to change. The situation in which allele frequencies remain constant is called genetic equilibrium. For a population to be in genetic equilibrium, five conditions are required: random mating, very large population size, no migrations, no mutations, and no natural selection. Random mating assures that each individual has an equal chance of reproducing. Very large population size prevents genetic drift from occurring. If all five conditions are met, relative allele frequencies will not change and evolution will not occur.

16–3 The Process of Speciation

Speciation means the formation of new species. For one species to evolve into two new species, the gene pools of two populations must become separated, or reproductively isolated. Reproductive isolation has occurred when the members of two populations cannot interbreed and produce fertile offspring. Reproductive isolation can involve behavioral, geographic, or temporal isolation.

Behavioral isolation occurs when populations have different courtship rituals or other behaviors involved in reproduction. Geographic isolation occurs when populations are separated by geographic barriers, such as mountains or rivers. Temporal isolation occurs when populations reproduce at different times.

Recently, Peter and Rosemary Grant proved that natural selection is still causing evolution of finches on the Galápagos Islands. The Grants showed that there was enough heritable variation in finch beaks to provide raw material for natural selection. They also showed that differences in beaks produced differences in fitness. These differences in fitness caused directional selection to occur.

Darwin thought that different finch species evolved on the Galápagos Islands from a single species of founding birds. We now know how this could have happened. A few finches may have traveled from mainland South America to one of the islands to found a new population. There, they survived and reproduced. Some birds crossed to a second island, and the two populations became geographically isolated. They no longer shared a gene pool. Seed sizes on the second island favored birds with larger beaks. The population on the second island evolved into a population with larger beaks. Eventually, the large-beaked birds on the second island became reproductively isolated and evolved into a new species.

Evolution continues today. For example, bacteria are evolving to have resistance to drugs. Evolutionary theory can help us understand these changes.