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## Evolution



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### Evolution and Common Descent

Biological evolution refers to genetically based changes in populations of organisms across generations. The term "evolution" is not used to refer to changes during the development, or ontogeny, of a single individual. Charles Darwin collected a large amount of data to demonstrate that all groups of organisms are descended from a common ancestor. This fact is as true of species and other more inclusive groups (e.g., genus, family) as it is for individuals. All organisms on Earth, both those alive today and those long extinct are connected through deep and complex webs of relationships. These ancestor-descendant relationships can be traced back billions of years. The data establishing this fact have become stronger in recent decades as scientists have discovered new types of evidence such as patterns of molecular similarity.

### Natural Selection

It has now been well established for more than 150 years that the organisms in lineages change through time (i.e., evolution occurs) and that all these organisms share common ancestry. However, understanding the details of how evolution occurs, by understanding the mechanisms of evolution, continues to be an

exciting field of research in biology. The discovery of natural selection by Charles Darwin and Alfred Russel Wallace in the mid-19th century was among the greatest intellectual leaps forward in human history. Natural selection is a powerful evolutionary force and is the mechanism driving adaptation. Adaptation is the process by which populations of organisms change across generations to become more effective at surviving and reproducing in their environment. If offspring with certain heritable traits are more likely to survive and reproduce (e.g., if gazelles with longer legs can run faster and are therefore less likely to be eaten by lions), those traits will, as a consequence, be more common in future generations because the genes of successful parents will be passed on to their offspring. Other things being equal, the average traits in the population will shift over time to those that help individuals in the population survive and reproduce. For example, populations of gazelles may evolve longer legs over time to help them elude predators. Or, populations of insects may evolve body shapes or colors over time that allow them to blend into the background, making them less visible to potential predators or prey. Predator populations may evolve more effective hunting strategies; and populations of plants in hot and dry habitats may evolve biochemical pathways that better allow them to perform photosynthesis under these conditions. Adaptations can be shaped by humans as well. When humans produce lines of domesticated animals or plants with certain characteristics by selecting which individuals are allowed to reproduce, this is known as artificial selection. In artificial selection, the breeder chooses which traits to favor (e.g., tomatoes that do not bruise easily; wheat that yields more grain per planted acre; cows that produce more milk; dogs with shorter legs; or "fancy pigeons" with unusual plumage, body form, or behavior). This human breeding practice was a critically important source of inspiration for Darwin as he began to realize that a similar phenomenon was occurring all the time in nature. In the case of natural selection, however, there is no need for a breeder, or any thinking being, to guide the process. This is because the traits that lead to survival and reproductive success are automatically the ones that are represented more in future generations.

### **Genetic Drift**

At one time, many people believed that remarkable adaptations were evidence of "design" by a creator of some kind. Now we know that natural selection is the mechanism responsible even for the most remarkable adaptations, such as the complex human eye. However, natural selection is not the only factor shaping evolutionary paths. In addition to natural selection, random factors can affect much of what happens in the evolution of a lineage. Genetic mutations (spontaneous changes in DNA sequence or organization) occur randomly throughout an organism's life. These mutations will have no noticeable effect on the future of the population unless they increase or decrease the organism's chance of survival. Which mutations are passed on to future generations depends not only on natural selection but also on random events. The effects of these random events are known as genetic drift. For example, certain phenotypes and genotypes may be more common on an oceanic island because they are the ones that, by chance (not because of their particular characteristics) happened to colonize the island or to survive a highly destructive storm. Under many circumstances, the effects of genetic drift may overwhelm natural selection. This can happen more in very small populations or in cases where natural selection favors certain traits over others only slightly. A tremendous amount has been learned about evolutionary processes since the era of Darwin and Wallace, but many exciting questions remain to be investigated.