**Natural Selection and Mutations**

The term **natural selection** was first used by Charles Darwin in his groundbreaking work *The Origin of Species*, which presented his unique views on evolution. Though the concept of evolution as such did not originate with Darwin, he was the first and most consistent defender of the mechanism of natural selection, which derives from the concepts of **survival of the fittest** and **differential reproduction.** It is the elegantly simple concept of natural selection that underlies much of contemporary evolutionary study and research.

**Natural Selection: The Driving Force Behind Evolution**

In a very real sense, natural selection is the driving force behind the evolutionary process as we currently understand it. The concept has its roots in the idea of the survival of the fittest, which states that those organisms that are best adapted to their environment are those that are most likely to survive. In other words, the organisms most capable of existing in a given environment will tend to outlive those that are less capable of surviving in the same environment. To use an obvious example, an animal with white fur will have a definite survival advantage over an animal with dark fur if they both live in Alaska. The white-furred animal is much less likely to be seen and eaten by predators (or noticed and escaped by prey). The differential survival of white-furred animals in this situation is called survival of the fittest.

Another concept, called differential reproduction, is a corollary to survival of the fittest. Differential reproduction is the idea that those organisms best adapted to a given environment will be most likely to survive to reproductive age and have offspring of their own. Organisms that are successful in their environments will be more likely to be successful in reproduction, and therefore the better-adapted organisms will reproduce at a greater rate than the less well-adapted organisms. In the example above, white-furred animals are less likely to be seen by predators and are therefore more likely to survive. Thus, more white-furred animals will make it to reproductive age and have offspring, who will most likely share their genes for white fur. Therefore white fur will come to dominate the population. Differential reproduction, or difference in the rates of reproduction of differently-adapted organisms, will favor the better-adapted organisms at the expense of the worse-adapted ones.

Natural selection is the process by which the organisms with the best or most favorable genetic adaptations out-compete other organisms in a population, tending to displace the less-adapted organisms. This process derives logically from the concepts of survival of the fittest and differential reproduction. Natural selection taking place over the course of many generations can change the basic attributes of the original population of organisms. In the example above, suppose that the original population of animals had dark fur and lived in the forests. In that environment, black-furred individuals would out-compete white-furred ones, which would be easier for predators to spot against the dark forest background. However, if the organisms began a migration into nearby less-forested snowy areas, the white-furred animals would gain a selective advantage over the dark-furred ones. The white fur would render the animals less visible against the light, snowy background. "Survival of the fittest" would mean survival of the white-furred animals, which would then be more likely to reproduce successfully. Over many generations, white-furred animals would come to dominate the population. When this situation occurs, there is said to be a **selection pressure** toward white fur, or white fur is said to be **selected for.**

Darwin used this concept of natural selection to explain the variation he observed within and between species. It became clear that those adaptations which conferred survival advantages in a given environment would come to dominate a population, all else being equal. This idea explained the difference in the shape and structure of the beaks of different types of finches - each type used its beak for a different purpose (i.e., picking up different types of seeds) and therefore the best shape for the beak's purpose was selected for by the process of natural selection.

**Mutation: The Basis of Natural Selection**

Natural selection is dependent on there being different variations of the same trait available. Additionally, these variations must confer different survival advantages or disadvantages. Natural selection could not operate on a uniform population that did not vary in any characteristic, because no organism would have a survival advantage. Similarly, if different characteristics existed but made absolutely no difference in survival and reproduction, natural selection could not operate because the possession of one characteristic or another would not confer a survival advantage.

Therefore, natural selection is dependent on the existence of **mutations** in the genes coding for different characteristics of an organism. Most mutations in DNA are spontaneous and random, sometimes caused by passing cosmic rays or other exposure to radiation. Mutations may also be caused by errors in the formation of the genes in the parents' gametes in sexual organisms. Additionally, "proofreading" enzymes built into many higher organisms sometimes fail, leaving an incorrect version of an organism's DNA. (Some lower organisms do not have a proofreading step. Many viruses do not proofread copies of their genomes, resulting in their extremely rapid mutation rate.)

A vast majority of mutations in an organism's DNA have deleterious effects on the organism and thus will be immediately selected against, or they will be irrelevant or have only very marginal effects. Only a tiny percentage of all mutations will confer a survival advantage on the organism that inherits it. Even these mutations generally change very little about the organism's structure or function. A small change is much more likely to be beneficial (or at least not harmful) to an organism than a large random change in a system that already works even somewhat well. For a good comparison, think of a car or other complex machine. The vast majority of alterations you could make would be harmful (for example, removing the engine, smashing the windshield, etc.). Another percentage will be irrelevant (for example, scratching the paint, denting the door, etc.) Only a tiny fraction of the possible alterations would result in an improvement of the car's function (for example, adding antilock brakes).

There is another important distinction to be made between different types of mutations. The type of mutation most people think of when presented with the word "mutant" is called a **macromutation**, or a mutation that involves a very large change. A frog born with eyes in its throat or with extra legs would be an example of a macromutant. Macromutations are equivalent to taking a blind leap over a precipice and hoping to land on a ledge. They are virtually never beneficial (no well-documented case exists) and are not the forces of change in natural selection. The (erroneous) belief that macromutations drive evolutionary change is called **saltationism**, and is generally discredited today. The second type of mutation is called a **micromutation**, or a mutation that involves a very small change. An incredibly vast majority of all mutations fall into this category. These mutations can be (and generally are) harmful in effect, but are not drastic changes, but rather fine gradations. Micromutations are what evolutionists discuss when studying natural selection.

Natural selection is quick to seize upon the very rare beneficial mutations that arise. Even a small survival advantage will be selected for over generations, eventually saturating the overall gene pool with the altered gene. Natural selection may depend on random mutations, and its operation may be slow and fitful, but it is extremely efficient in "weeding out" successful adaptations to be passed on to future generations.

Discussion Questions:

1. Why does a white furred animal have an advantage over a dark furred animal in an environment that is covered with snow?
2. What is differential reproduction?
3. Why won’t natural selection occur if organisms in a population have no variation in their traits?
4. What causes variation in a population?
5. Mutations are typically mistakes in which macromolecule?
6. Do most mutations provide an advantage to the organism? Explain your answer.

7. Are micromutations or macromutations usually beneficial to an organism? Explain your answer.