16.3

Welcome to Lesson 16.3, "Darwin Presents His Case." In this lesson, we'll describe the conditions under which natural selection occurs, and we'll explain the principle of common descent and what it suggests about the unity and diversity of life. Charles Darwin worked out the main elements of his theory about natural selection soon after reading Thomas Malthus and thinking about artificial selection. His scientific friends urged him to publish his brilliant arguments. Darwin did write up a complete draft of his ideas, but he put the work aside and didn't publish it for another 20 years because he knew that many scientists, including some of his own teachers, ridiculed Jean-Baptiste Lamarck's ideas. Darwin's theory was just as radical, so he wanted to gather as much evidence as he could to support his ideas before he made them public. In 1858, Darwin reviewed an essay by Alfred Russel Wallace, a British naturalist working in Malaysia.

Wallace's thoughts about evolution were almost identical to Darwin's. Not wanting to get "scooped," Darwin moved forward with his own work. Wallace's essay was presented together with some of Darwin's observations at a scientific meeting in 1858. The next year, Darwin published his work, *On the Origin of Species*, which described his ideas in detail. Wallace had the right idea, but Darwin had data and observations to support his hypotheses. Darwin's contribution was to describe a natural process--a scientific mechanism--that could operate like artificial selection. In *On the Origin of Species*, he supported his ideas with arguments from Malthus and Lamarck. Thomas Malthus's work had convinced Charles Darwin that if all populations have the potential to produce more offspring than can survive, members of that population will compete for a finite supply of environmental resources.

Darwin described this competition as the struggle for existence. But, which individuals would succeed in surviving and reproducing? Here is where natural inheritable variation took center stage in Darwin's thinking. He hypothesized that individuals with certain types of inherited variation are better suited, or *adapted*, to life in their environment than others. Members of a predatory species that are faster or have longer claws or sharper teeth can catch more prey. And members of a prey species that are faster or better camouflaged can avoid being caught. Any heritable characteristic that increases an organism's ability to survive and reproduce in its environment is called an **adaptation**. Adaptations can involve body parts or structures, like a tiger's claws; colors, like those that make camouflage or mimicry possible; or physiological functions, like the way a plant carries out photosynthesis.

Many adaptations also involve behaviors, such as the complex avoidance strategies prey species use. Take a look at these two species. Are these two snakes the same species or different species? They are two different species. The scarlet king snake is exhibiting mimicry--an adaptation in which an organism copies, or mimics, a more dangerous organism. Although the scarlet king snake is harmless, it looks like the poisonous eastern coral snake, so predators avoid it, just like they would avoid the eastern coral snake. Charles Darwin, like Lamarck, recognized that there must be a connection between the way an organism "makes a living" and the environment in which it lives.

According to Darwin, differences in adaptations affect an individual's *fitness*. **Fitness** describes how well an organism can survive and reproduce in its environment. Individuals with adaptations that are well suited to their environment can survive and reproduce and are said to have high fitness. Individuals with characteristics that are not well suited to their environment either die without reproducing or leave few offspring and are said to have low fitness. This results in differential reproduction success or, as some have termed it, survival of the fittest. Note that survival here means more than just staying alive.

In evolutionary terms, survival means reproducing and passing adaptations to the next generation. Charles Darwin named his mechanism for evolution *natural selection* because of its similarities to artificial selection.

Natural selection is the process by which organisms in nature with variations most suited to their local environment survive and leave more offspring. In both artificial and natural selection, only certain individuals produce offspring. But in natural selection, the environment--not a farmer or animal breeder--influences fitness. Natural selection occurs in any situation in which more individuals are born than can survive. Natural heritable variation affects the ability to survive and reproduce, and fitness varies among individuals. Well-adapted individuals survive and reproduce. From generation to generation, populations continue to change, either as they become better adapted or as their environment changes. Natural selection acts only on inherited traits because those are the only characteristics that parents can pass on to their offspring.

In this image, a grasshopper is laying eggs. Grasshoppers can lay more than 200 eggs at a time. Only a small fraction of these offspring survive to reproduce. Here is an example of variation in nature, and certain heritable variations--called adaptations--increase an individual's chance of surviving and reproducing. In this population of grasshoppers, heritable variation includes yellow and green body color. Green coloration is an adaptation: green grasshoppers blend into their environment and are less visible to predators. Because the green color serves to camouflage them from predators, green grasshoppers have a higher fitness than yellow grasshoppers. This means that green grasshoppers survive and reproduce more often than do yellow grasshoppers in this environment. Green grasshoppers become more common than yellow grasshoppers in this population over time because more grasshoppers are born than can survive; individuals vary in color, and color is a heritable trait.

The green individuals have a higher fitness in the current environment. Natural selection does not make organisms "better." Adaptations don't have to be perfect--just good enough to enable an organism to pass its genes to the next generation. Natural selection also doesn't move in a fixed direction. There is no one perfect way of doing something, as demonstrated by the diverse styles of pollination. If local environmental conditions change, some traits that were once adaptive may no longer be useful, and different traits may become adaptive. This can lead to a great diversity of adaptations in species living in different environments. And if environmental conditions change faster than a species can adapt to those changes, the species may become extinct.

We now know that natural selection is not the only mechanism driving evolution. Many different styles of pollination have evolved amongst flowering plants. Oak tree flowers are pollinated by wind. Apple tree flowers are pollinated by insects. Neither method is "better" than the other. Both kinds of pollination work well enough for these plants to survive and reproduce in their environments. Natural selection depends on individuals' ability to reproduce and leave descendants. Just as well-adapted individuals in a species survive and reproduce, well-adapted species survive over time. Charles Darwin also proposed that living species are descended, with changes over time, from common ancestors--an idea called descent with modification. Over many generations, diverse adaptations to changing resources that are limited could cause a single species to split into two or more new species.

For evidence of descent with modification over long periods of time, Darwin pointed to the fossil record. This process requires enough time for all this descent with modification to occur. James Hutton and Charles Lyell's work supported Darwin's theory: deep time gave enough time for natural selection to act.

Darwin's idea that natural selection and adaptation can produce new species offered an explanation for the diversity of life shown by the very first evolutionary tree. This "tree-thinking" implies that all organisms are related. Look back in time and you will find common ancestors shared by tigers, lions, and cheetahs. Look further back and you will find ancestors that these felines shared with dogs, then horses, then bats.

Further back still is the common ancestor that all mammals shared with birds, reptiles, and fish. Far enough back are the common ancestors of all living things. According to the principle of common descent, all species--living and extinct--are united by descent from ancient common ancestors and exhibit diversity due to natural selection and adaptation. A single "tree of life" links all living things. This page from one of Darwin's notebooks shows the first evolutionary tree ever drawn. This sketch shows Darwin's explanation for how descent with modification could produce the diversity of life.