

## **Charles Darwin and Natural Selection**

**Slide 2** Now that we have explored many of the processes involved in producing and sustaining living organisms, it's time to think about the big picture again. When we begin to look at populations, growth rates, genetic variability within populations, and so on, we are going to be struck by some of the same things that struck Charles Darwin before, during, and after his famous voyage aboard the *Beagle*. During that voyage Darwin had the opportunity to observe how organisms might be related to recent fossils of their predecessors. He also saw how organisms had changed as they had moved into different environments. His ideas took shape during a time when scientists were beginning to understand that the earth was old and that geologic processes took time to produce the landforms that we see today. He began to think about changes in species through time and made some important observations:

- Organisms do not reproduce exponentially even though they theoretically could.
- Individuals within a species are similar but not exactly identical.
- Those individuals with subtle differences that help them adapt to their environment have the best chance of surviving and reproducing.

**Slide 3** Based on his observations, Darwin came up with a theory that does a very good job of explaining how organisms are related to each other, their environments, and the fossil record. He proposed natural selection as the major agent of evolution. Natural selection acts to ensure that traits that give an organism an advantage in a particular environment are conserved while traits that put an organism at a disadvantage are removed from a population. Descent with modification, or the passing of advantageous traits to successive generations, follows logically from natural selection, allowing species to change over time, depending on environmental conditions and the genetic variability inherent in a species. In our discussion of evolutionary processes, remember that biological evolution is defined as the change in the genetic composition of a population over time. While natural selection is not the only process that can change the genetic composition of a population, it is an important one to consider.

**Slide 4** When he proposed the theory of natural selection, Darwin had no actual examples of the process to put forward. However, examples of natural selection in action abound, particularly in the areas of pesticide and antibiotic resistance. Antibiotics are used to kill bacteria and are very useful in stopping bacterial infections in humans and animals. When an antibiotic is given to a person with a bacterial infection, it usually kills all the bacteria, and the person gets better. If a few bacteria in the infecting population carry a gene that makes them resistant to the antibiotic that is being used, however, some of the bacteria survive the antibiotic treatment and are free to begin multiplying in the host again. Because bacteria reproduce by simple binary fission, the genes for antibiotic resistance are passed on to all of the offspring, and a resistant population is produced. Further treatment with the same antibiotic is ineffective because virtually all of the bacteria in the population are resistant. In these cases the gene for antibiotic resistance is

selected for by the environmental conditions (the presence of the antibiotic) in which the bacteria find themselves.

**Slide 5** The theory of natural selection states that certain individuals in a population will have traits that increase the likelihood that they will survive and reproduce in the current environment. Natural selection helps ensure that the alleles for those advantageous traits are passed on to the next generation. Environments, as we are becoming painfully aware, have a way of changing, and environmental changes can put selective pressure on populations. The result is that traits that once gave an individual an advantage become deleterious or neutral. We will look at three types of natural selection:

- Stabilizing selection
- Directional selection
- Disruptive selection

**Slide 6** Many phenotypic characteristics, such as human height or hair color, span a range and will show some sort of normal distribution. Stabilizing selection reinforces the “average” phenotype, selecting against the less common phenotypes at the extremes of the graph shown here.

Let’s look at frog leg length as an example. Since frogs are amphibians, they have to be able to move efficiently both on land and in water. There are all sorts of frogs adapted to all sorts of habitats, but let’s consider bullfrogs living in and around a pond. They need legs that work well for swimming and for jumping. What they have are long, muscular legs with webbed feet – a good compromise for the environment they live in. You could imagine that some bullfrogs would have more flipper-like legs that would be great for swimming but not so great for jumping. Other bullfrogs might have big burly jumping legs without webbed feet – good for jumping but not very effective for swimming. Individuals with these traits out on either edge of the distribution would be less likely to survive and reproduce, so the range of phenotypes becomes narrower. As long as bullfrogs, such as the one shown here, continue to live around ponds, it is likely that the optimum leg length will not change much.

**Slide 7** Let’s keep thinking about the frogs. When it’s time to eat, the frog sits quietly, waits for a tasty bug to come by, sends out its long, sticky tongue, and snags the bug. The longer the frog’s tongue is, the more bugs it can snag. Because frogs with longer tongues will have a better chance of surviving and reproducing (because they can capture more resources), longer tongue length will be selected for. In time the average tongue length will be shifted towards longer tongue length. This type of selection is known as directional selection.

Directional selection usually cannot continue indefinitely because some physical factors may limit how far a particular trait can go. In the case of frog tongue length the size of the frog’s mouth will ultimately limit how long its tongue can get. If the tongue gets too long, it won’t fit in the frog’s mouth anymore, or it may interfere with actually swallowing the bug it has helped to catch.

**Slide 8** Disruptive selection, where phenotypes at the extremes of the normal distribution are favored, appears to be somewhat rare. Beak shape in birds is the example most often cited for disruptive selection. Because of the major types of food sources available in an environment, having a specialized beak shape may be more advantageous than having an “average” beak shape. In the case of the black-bellied seed cracker, large beaks are good for cracking hard seeds from one food source, small beaks are useful for feeding on the small, soft seeds of the other major food source, and intermediate beaks aren’t very good for eating either type of seed. Birds with the intermediate beak size never quite get enough to eat and don’t survive or reproduce well.

**Slide 9** Natural selection is a dynamic process that occurs in a dynamic world. Although humans don’t like to admit it, the earth is constantly changing. The climate of the earth has fluctuated widely over time from extensive ice ages to periods of wide-spread subtropical conditions and everything in between. The positions of the land masses have changed, bringing formerly separated species into competition with each other or separating different populations of the same species. Pollution, like the filling of the atmosphere with oxygen as photosynthetic organisms began to flourish, and catastrophic events, such as asteroid impacts and wide-spread volcanism, have all presented organisms with environmental changes to which they must adapt ... or else. Natural selection constantly acts as an agent of evolution, selecting for the most successful individuals and allowing those species that have sufficient genetic variation to adapt to changing environments.