

STAAR Science Tutorial 51 **TEK 7.11C: Natural Selection**

TEK 7.11C: Identify some changes in genetic traits that have occurred over several generations through natural selection and selective breeding such as the Galapagos Medium Ground Finch (*Geospiza fortis*) or domestic animals.

Adaptations

- A **trait** is any characteristic in a living organism that is inherited from its parent or parents through the reproduction process.
- The physical and behavioral characteristics of an organism are a combination of its inherited traits and the effect of the environment on the organism. For example, a human inherits a certain skin color, but that color is modified by exposure to sunlight (you get a “tan”—darker skin). Some characteristics are totally the product of genetic inheritance (blood type, eye color), while others are totally the product of the environment. Almost all human knowledge is learned from the environment, but in other animals, some “instinctual” knowledge is inherited.
- Every species has a unique set of characteristics that helps it survive in its environment. These are known as **adaptations**. Adaptations can either be structural, physiological or behavioral.
- **Structural adaptations** are physical characteristics such as body size and shape, bone structure, eye placement, fur thickness or fur color. For example, a giraffe has a long neck which enables it to reach high into trees for food. A deer has eyes on the side of its head to better see predators behind it, while an owl has forward facing eyes to better judge the distance to its hunted prey. A bear living in the Mexican desert has very thin brown fur, while a polar bear has very thick white fur. Some species change fur or feather color with the seasons, to blend in (camouflage) with the environment and better avoid predators or sneak up on prey. Desert plants have long root systems to gather as much water after a rain as possible, thick stems to store that water, and spines to protect that water from animals.
- **Physiological adaptations** are internal processes that help the organism survive. Kangaroo rats, who live in very dry climates, need very little water, because their kidneys are extremely efficient in eliminating waste with a minimum of water. Some desert fish and amphibians can go into a dry, suspended animation state called estivation when all water in their habitat dries up. Many animals hibernate during the winter or dry season by slowing their metabolism down. Some animals are immune to poisons that would kill other animals. Some plants can tolerate a high level of salt in the soil.

- **Behavioral adaptations** are learned or inherited (instinct) behaviors such as migration, nesting, mating rituals, child-rearing hunting in packs or grazing in herds, all designed to increase the chance of survival. Birds know where and how to build a nest by instinct. The mating rituals of birds of paradise species are instinctual. Migration routes and timing are usually learned from parents or the group, but the ability to navigate is physiological. Hibernation is part behavioral and part physiological adaptation. An animal cannot just choose to hibernate, if it does not have the ability to slow down its metabolism.

Variation in Genetic Inheritance

- For **sexually reproducing** species that, combining the randomly-selected genes from two parents, offspring are not exact genetic copies of their parents. This means that there is a range of inherited traits in a population, some of which are better adapted to the environment than others. The major advantage of sexual reproduction is the automatic creation of genetic variation.
- In **asexually reproducing** species, offspring usually are exact genetic copies of the single parent. Most species that reproduce in this way are very small or microscopic, reproduce very quickly, and have very large populations.
- See *Tutorial 49: Sexual and Asexual Reproduction* for a detailed description of these processes.
- Each time that an organism reproduces sexually or asexually, there is a small chance that a mistake will be made in copying the genes. This is called a **mutation**. Most mutations result in the death of the organism, but some can turn out to be beneficial and help the organism to better survive. In this way, new adaptations are created.
- The **mutation rate** is very slow in sexually reproducing species, because they reproduce at a slow rate and their populations are usually small. In asexually reproducing species, genetic change can occur quickly, because of their high reproduction rate and large population.
- As the population of a species grows, the range of the population (the area it occupies) grows. Over time, the population may spread to areas with a different climate, different predators or different food sources. This spread-out population may become so separated into sub-populations that the genes no longer mix. When the sub-populations become different enough genetically that they cannot interbreed, a new species is created. This process of creating several different species from one ancestral species is called **adaptive radiation**.

Natural Selection and Evolution

- **Evolution** is the change of a species' genetic code over time. All living organisms evolve in response to their environment. For example, a species of bacteria can develop a resistance to a certain antibiotic drug over many generations of reproduction. But because they reproduce so quickly (a new generation each hour) and in such large numbers, it may only take a few years for the evolution of drug resistance to occur. In most species, evolution is a much slower process, because the reproduction rate is much slower and the total population lower.

- **Charles Darwin** and **Alfred Russel Wallace** independently developed the theory of evolution by natural selection. Their theory was first published in 1858.
- The premise of evolution by **natural selection** is that organisms better adapted to their environment are more likely to survive and reproduce at a greater rate than less well adapted organisms. Over time, the adaptations that best help the species survive become more common, and harmful adaptations become less common and eventually disappear from the gene pool of the species.
- Both Darwin and Wallace developed their natural selection theory during extensive expeditions around the World. In particular, Darwin studied 14 related species of **finches** (a small bird) he found on the **Galapagos Islands** off the coast of South America. Each finch species had a different food source, and most lived on different islands in the chain. A similar single species of finch lived on the main coast of South America close to the islands. The differences between the finches that was most obvious was their different beaks. Each finch species appeared to have a beak adapted for a specific food source, which varied with each islands' climate and soil:

- The Cactus Finch found on islands with little rainfall has a long beak designed to reach between cactus needles to eat the fruit of prickly pear cactus.



- The Medium Ground Finch eats medium sized seeds found on the ground, and has a heavy, rounded beak designed to crush open the seeds.



- The Large Ground Finch eats larger seeds than the Medium Ground Finch, and thus has a larger head and beak, though the shape of the beak is the same as the Medium Ground Finch, because the function of the beak is the same.



- The Warbler Finch has a long, narrow beak designed for insect eating. This is the smallest finch that Darwin studied.



- The Woodpecker Finch uses cactus spines or needles as a tool to pry insects out of small holes in a plants bark or stem.



- Darwin believed that an original finch species migrated from the main coast of South America to the Galapagos Islands, and the finches on each island became adapted to that island's unique food source—the adaptive radiation process discussed above. Over time, genetic variations in beak size and shape made some birds more successful at getting the available food than others, and those more successful birds passed their beak shape and size on to their offspring. The birds with poorly adapted beaks were less likely to survive and reproduce, and over time, their beak shape and size became less common. Because the islands are widely separated, each islands' finch population tended to breed only with others on the same island. Eventually, the finches on each island were different enough to become separate species.

- The natural selection process is easily seen today in bacteria and their evolution of drug resistance. Because certain bacteria causes disease in humans, antibiotic drugs have been developed to kill these specific bacteria. At first, all of the bacteria are killed by the drug. Eventually, a mutation appears in a single bacteria that gives it resistance to the drug. All other bacteria are killed, but the one mutated bacteria survives and reproduces. Now all of the bacteria in the human are of the drug-resistant type. If the drug-resistant bacteria spreads to other humans, its population replaces that of the bacteria killed off by the antibiotic. Many diseases that once were easily treated by common antibiotics are now becoming untreatable. This evolution by natural selection process may take many decades or just a few years, since the mutation and its spread to other hosts are chance events.
- Humans use a controlled process called **selective breeding** in domesticated plants and animals to get the same results as natural selection but in a faster, predictable process. By choosing parents with desired traits and breeding them selectively over many generations, the many different breeds of dogs, cats, cattle and seed crops available today were developed over a shorter span of time than would have occurred naturally.

Practice Questions

1. A _____ is any characteristic in a living organism that is inherited from its parent or parents through the reproduction process.
2. An _____ is a unique set of characteristics that helps a species survive in its environment.
3. Examples of structural adaptations include _____

4. Examples of physiological adaptations include _____

_____.
5. Examples of behavioral adaptations include _____

_____.
6. How are variations between individuals created by the sexual reproduction process? _____

7. A _____ is created when a mistake is made in copying the genes from one generation to the next.
8. The mutation rate of a species depends on its _____

_____.
9. The process of creating several different species from one ancestral species is called _____.
10. The change of a species' genetic code over time is called _____.
11. The theory of evolution by natural selection was independently developed by _____ and _____.
12. _____ states that organisms better adapted to their environment are more likely to survive and reproduce at a greater rate than less well adapted organisms.
13. To develop his theory of evolution by natural selection, Darwin studies _____ on the _____ Islands, and the different sizes and shapes of their _____.
14. _____ is the process used by humans to selectively breed parents of domestic plants and animals based on desired traits.