**Evolution: Natural selection and Artificial Selection**

Are you able to digest cow’s milk, or are you lactose intolerant? The ability to digest milk as an adult is thought to come from the lifestyle of our ancestors thousands of years ago. About 10,000 years ago, when dairy farming started, humans that could drink milk had an advantage over humans that couldn’t because they had an extra source of food that was high in nutrients, fats, and proteins. This was a really big deal because food wasn’t always easy to come by, especially in the winter months. So, if you are able to digest lactose, then one of your ancestors was likely a dairy farmer!

**What is evolution?**

Evolution is how species experience heritable (passed from one generation to the next) changes in their traits over time. In order for evolutionary changes to occur, many generations over thousands to millions of years are often required - meaning, these adaptations don’t happen overnight! The ability of humans to digest lactose as adults is a perfect example of this. As babies, a majority of humans have the ability to digest lactose. As we develop into adults, some people lose the ability to digest lactose, and others continue to have no problem digesting milks, cheeses, and other food products containing lactose. A hereditary mutation responsible for the trait allowing humans to digest lactose well into adulthood is kept “on”, resulting in lactose tolerance. This trait is a result of a mutation from thousands of years ago. The mutation causing the trait was beneficial and heritable, so it spread throughout the human population and many of us today have this trait!

There are 4 mechanisms of evolution (how evolution happens): natural selection, mutation, genetic drift, & gene flow. Of these 4 mechanisms we will talk about *natural selection*.

**Natural selection - one of the mechanisms of evolution**

Natural selection is a process that favors heritable traits that increase the survival chances of an organism, allowing the organism to reproduce more!

**An example of natural selection at work - antibiotic resistance**

You may have heard about antibiotic resistance. Bacterial infections in humans are commonly treated with antibiotics. However, because of their overuse and misuse, some pathogenic bacteria have become resistant to some of these treatments. This is dangerous for humans, because treatments that used to cure potentially fatal diseases are now less effective in some cases, or not effective at all. How have antibiotics become less effective?

When you have an infection, the multiplying pathogenic bacteria inside of you are not all identical. Most of them are the same, but every now and again one of them will be slightly different genetically. If they were all genetically identical, they would react to their environment the same way and all be harmed by the same things. One harmful thing could wipe out the entire species. But when there are slight genetic differences, harmful conditions, like the presence of an antibiotic, might kill most of the pathogenic bacteria but some may be better able to survive and then thrive. These characteristics are favored in this environment so these bacteria can continue to thrive, and make you ill. Different environments favor different traits and so natural selection has taken place!

**What is artificial selection or selective breeding?**

There are other types of selection, in addition to natural selection, that are out there in the world. Think about some decisions you make about the types of pets you want or what kind of foods you prefer to eat. *Artificial selection*, also called "*selective breeding*”, is where humans select for desirable traits in agricultural products or animals, rather than leaving the species to evolve and change gradually without human interference, like in natural selection.

**An example of artificial selection - Dog breeding**

Around 30,000 to 40,000 years ago, humans began domesticating wolves. Nowadays, these domesticated animals are what we call dogs! Domestication is the act of separating a small group of organisms (wolves, in this case) from the main population, and select for their desired traits through breeding. Over thousands of years, the domestication of wolves resulted in the loss of some of the more aggressive traits, like the instinctual, defensive behavior in the presence of humans (barking or howling, bearing their teeth, poising to attack, or running away), and the size and shape of their teeth. The exact reasoning why humans began domesticating wolves isn’t known although evolutionary biologists suspect that wolves helped humans to hunt during the ice age (Callaway, 2015). In fact, they’ve also hypothesized that if this is true, their domestication could have been what helped human ancestors through the ice age and why Neanderthals went extinct (Callaway, 2015)! Now humans select for a variety of traits in dogs based on personal preference and companionship, instead of as a way to increase human survival.

Dog breeding is a perfect example of how humans select for desirable or fashionable traits. There are three different types of breeds that exist:

1. *Purebred* is a type of dog that comes from a lineage of the same dog breed and that has never mated with another breed. For example, a purebred german shepherd is all german shepherd and nothing else.
2. A *cross-breed dog* is a dog that was the offspring of two different types of purebreds. Let’s say your purebred german shepherd mated with a purebred husky. The resulting offspring would be a cross-breed of half german shepherd, half husky.
3. Finally, *mixed-breeds* are a combination of multiple breeds, where their parents were not purebreds. There are too many possible combinations to count!

One advantage to choosing cross-breeds and mixed-breeds over purebred dogs is that harmful genetic mutations that tend to frequently occur in certain lineages can be covered up, or “bred out”, by the genetic background of the other dog breed(s) in the individual. In purebreds, since there is only one lineage, these mistakes are often more apparent and can make purebred dogs prone to certain diseases.

**An example of artificial selection - Genetically modified organisms**

Humans haven’t only selected traits in animals. We’ve also shaped an incredible amount of agricultural plant products that make plants easier to grow and tastier to eat. Recently we have started to artificially select traits at a molecular level where we mix DNA from different plant or animal species to make genetically modified organisms (GMOs). To genetically modify an organism, genetic information (or, the blueprint of the organism) is added or removed, or replaced by the information from another organism that has a trait we desire. For example, let’s say you have a species of corn that is highly susceptible to drought, but is the most delicious corn that exists. If you could identify the genetic information that coded for drought resistance from another plant, then you could insert that into the blueprints of your corn species to make it more resistant to drought!

GMOs are used in agriculture to help crops become more resistant to drought, cold, salinity, pests and diseases. This is advantageous for us because it allows us to feed our growing population by doing agriculture in places that are usually less than ideal or not possible. With more areas to do agriculture, we have larger agricultural production to feed ourselves.

**Common misconceptions about evolution**

Evolution is not the same as adaptation or natural selection. Remember: natural selection is a cause of evolution. Terms like “progress” or “improvement” are not a part of the definition of evolution because evolution is *context dependent*. Imagine a scenario where one trait might be highly advantageous in one environment, but highly detrimental in another. A good example of this is the fur color of mice. It’s advantageous if mice blend in with their habitat so that they can avoid predators. In the forest, it will be more likely that mice take on a darker color to match the earth. If you were to take a mouse with dark fur out of their original habitat and place it on a white sandy beach, it will get snatched up by a bird very quickly because it’s so easy to see.

**Consider the following:**

Can beneficial traits arise in more than one area by accident? Yes! Let’s go back to our lactose tolerance example at the beginning of the article. When multiple environments favor the existence of a trait, these beneficial traits can pop up through mutation and spread throughout their individual populations completely independently. Evolutionary biologists call this *convergent evolution*. In the lactose tolerance example, this is exactly what happened. A population in Europe evolved the ability to digest lactose as an adult independently from an African population. Both populations had begun farming dairy, and both traits arose around the same time. What’s cool is that, when the lactose tolerance trait arose, these populations were far enough away that they were not able to reproduce with each other making the development of the trait a neat coincidence.