Task 4: Stability and Change

LT: I can use text evidence to explain how one species can become two new species.

The opposite of stability is change, a word that you are already likely familiar with. Stability and change are important ideas that can help you to better understand evolution; thinking about stability and change today will also help you to better understand the articles you are going to read.

One way to think about stability in evolution is to think of structures that don't change, or that change very little over time. When you're thinking about the process of evolution, you can think of change as the differences that happen in the structures of species that share a common ancestor. As you read the articles today, you can think about when structures are stable and when they change. You can also think about what factors affect stability and change.

The Galápagos Islands are remote islands off the coast of South America. Organisms that made their way to the islands became separated from the populations on the mainland.

Where Do Species Come From?

Chapter 1: Speciation

Evolution is not just a thing of the past—it's happening all the time. That means new species are still evolving today. There are many ways in which species can evolve, but one type of evolution occurs when one species is divided into more than one population living in different environments. If these populations live in different environments for many, many generations, they may evolve so many differences that they are no longer the same species. What used to be populations of the same species become populations of different species.

The process of one species evolving into two or more different species is called speciation. Speciation often starts when populations are separated by a barrier, such as a body of water or a mountain range. After they are separated, the populations don't encounter one another regularly anymore. They become separate populations, and over time they may evolve into different species. To learn more about some populations that were divided into very different environments and became different species, choose one of the chapters that follow.

Tortoises that live on the Galápagos Islands are a different species from tortoises on mainland South America.

The Chaco tortoise from mainland South America is the closest living relative to the Galápagos tortoise.

Chapter 2: Galápagos Tortoises

Tortoises have lived in South America for many millions of years. About 3 million years ago, some tortoises living in South America floated about 1,000 kilometers (more than 600 miles) across the Pacific Ocean from the mainland of South America to the Galápagos Islands. Unlike turtles, tortoises can't swim—so once they arrived on the islands, the tortoises never left! The population of tortoises that floated to the islands became permanently separated from the population of tortoises on the mainland.

The islands had different environments than the mainland environment, so different traits were adaptive—helpful for survival—for the island tortoises than for the mainland tortoises. Some of the islands had desert environments, where food was scarce. Over many generations, the population of tortoises on the Galápagos Islands evolved specialized shells, as well as changes to some other body structures. Meanwhile, the environment on the South American mainland didn't change much over time, so the structures of the tortoise population there remained relatively stable. They stayed about the same as the structures of their common ancestors. Today, the structures of Galápagos tortoises are so different from the structures of mainland tortoises that they would not reproduce with each other even if they were brought back together. These two populations that once came from a shared common ancestor population are now different species.

Natural selection acted on the populations of tortoises in mainland South America and in the Galápagos. All tortoises have a random chance of being born with a mutation that can change the shape of their shells. Millions of years ago, some Galápagos tortoises were born with this mutation and had shells that curved upward at the neck. The curved shape made more space for the tortoises' necks and allowed them to reach up high. This mutation was an adaptive trait on the Galápagos Islands with desert environments where food was scarce: it helped tortoises with the curved shell structure survive by reaching leaves higher up and getting more food. As the mutation for the curved shell was passed down by tortoises that had been born with it, curved shells became more common in the Galápagos tortoise population over many generations.

Changes that result in one species becoming two do not happen with just one generation. The Galápagos tortoises did not become a new species as soon as they arrived at the islands; it took a long time. Speciation takes place slowly as mutations build on one another, adding up to big changes in structure.

This is a Galápagos tortoise with a "saddleback" shell. The saddleback shell is an adaptive trait that helps the tortoise survive on islands where food is scarce.

Chapter 3: Polar Bears

Where do polar bears come from? The story starts with brown bears. About 400,000 years ago, Earth experienced an unusually warm period that allowed forests to grow in far northern areas of the Arctic. Some brown bears moved north into the new forests in search of food. When colder climates returned and the land was covered in ice and snow again, the descendants of the brown bears that had moved north were stuck in the ice-covered Arctic. This population of brown bears became separated from the population of brown bears in southern regions.

The bears' new environment in the Arctic was different from the environment of forested land farther south. The Arctic is a cold ocean environment, with sheets of ice covering huge areas of water in winter. The entire landscape is often covered with ice and snow. In this environment, different traits were adaptive, or helpful for the bears' survival, than were adaptive farther south. Over many generations, the population of bears in the Arctic region changed. They evolved, for example, specialized teeth and fur that were adaptive in their new environment. Meanwhile, the forest environment farther south didn't change much at all, so the traits that were adaptive there didn't change either. The brown bear population that remained in the forest stayed similar to their ancestor population. Today, the body structures of the bears that live in the Arctic environment are different from those of the brown bears that live in the forest environment. The bears that live in the Arctic are a different species called polar bears.

How did all that happen? The populations of bears in the forest and in the Arctic both experienced natural selection over time. Bears have a random chance of being born with mutations that change their structures, such as teeth and fur. Some of these mutations resulted in changes that helped the bears in the Arctic to survive in their environment. For example, some of the bears were born with back teeth (molars) that were jagged instead of flat. These jagged

When a long period of warm weather allowed forests to grow in far northern areas of the Arctic, some brown bears migrated north into the new forests to look for food.

Over time, bears living in the Arctic became so different from their brown bear relatives that they became a different species. We call the new species polar bears.

teeth helped them chew and digest meat better than bears with flat molars that were adaptive for eating plants. In the cold ocean environment of the Arctic, bears could walk out onto the ice and catch seals resting on the ice. Seal meat was a key food source for bears in the Arctic, and jagged teeth that helped them chew and digest seal meat were an adaptive trait. Eventually, the jagged teeth mutation, which allowed the bears to thrive on a diet of seals, became a common structure in the Arctic bear population. Bears that could chew and digest seals were more likely to survive and reproduce than bears without jagged teeth.

Having jagged molars was not the only adaptive trait for the bear population in the Arctic. Random mutations also resulted in fur that appears white. (It is actually transparent!) Bears born with transparent fur had a hunting advantage because they were able to blend into their snowy background while sneaking up on prey. Scientists think transparent fur also helps bears stay warmer in cold temperatures, because transparent fur does a better job of trapping body heat than brown fur does. Staying warmer and being able to hunt more effectively both mean having a better chance of surviving and reproducing, and passing on genes for transparent fur to offspring.

Over time, polar bears became a separate species from brown bears. Changes that result in one species becoming two species do not happen in a single generation. This process of speciation takes place slowly as adaptive mutations build on one another over many generations, adding up to big changes in body structures. Polar bears did not become a new seal-eating species with fur that appears white as soon as their environment became icy—it took a long time for the bears to adapt to that environment. As they adapted, bears born with jagged molars and transparent fur became more and more common, until the population began to look like the polar bears we see today.

Chapter 4: Flightless Ducks

Millions of years ago, some small ducks from North America ended up on the recently formed Hawaiian Islands. It is likely that these ducks flew across the Pacific Ocean to Hawaii. The islands are thousands of kilometers from mainland North America—so once the ducks arrived in Hawaii, they never left! The population of ducks on the islands became separated from the population of ducks on the mainland.

An artist made this illustration of the moa-nalo, a species of flightless ducks that once lived on the Hawaiian Islands.

The island ducks' new environment was different from the mainland environment they had left behind. For one thing, there were no duck-eating predators on the islands. Over millions of years, natural selection acted on the populations of ducks in North America and in Hawaii. Since the island ducks no longer needed to escape from predators, different traits were adaptive, or helpful to their survival, than had been adaptive on the mainland. Over many generations, their bodies got bigger and their wings got smaller, so they lost the ability to fly—after all, they no longer needed to fly away from predators!

Losing the ability to fly wasn't the only way in which natural selection affected the island ducks. All ducks have a random chance of being born with mutations that change the shape and size of their bones. Some ducks were born with larger leg bones that allowed them to travel over land more easily. Larger leg bones are heavy and make it harder to fly, but these ducks didn't have to fly away from predators. Since the ducks no longer relied on flight for safety, larger and stronger legs were an adaptive trait—the ducks born with larger leg bones could search for food on land more easily than other ducks. These ducks got more food, lived longer, and had more chances to reproduce than ducks with smaller, weaker legs. Becoming flightless also turned out to be an adaptive trait. Having smaller wings and bones in the upper body allowed the birds to use less energy as they traveled over ground. The ducks no longer relied on flight, and those with smaller upper bodies did not need to eat as much to survive as ducks with full-sized wings did.

During that time, the North American ducks' environment changed very little, so those ducks' body structures stayed mostly the same. Over many generations, the body structures of Hawaii's flightless birds, called moa-nalos, became so different from the mainland ducks that they would not have reproduced with each other even if they had been brought back together. They were different species. Sadly, the moa-nalos have gone extinct. However, scientists have learned about them by studying fossils.

Moa-nalos are extinct, but scientists use fossils like this bone and beak to gather data about what they were like.

This process of becoming a new species didn't happen right away. It took a long time for the moa-nalo to become a new species. Over many generations, because individuals with strong legs and small wings lived longer and reproduced more, the mutations that caused those changes spread through the moa-nalo population. Eventually, the specialized bones that allowed them to search for food more easily became a common structure in the population. This is an example of speciation taking place over time as mutations accumulate over many generations. As these mutations build up, they cause big changes in body structures. That's why changes that result in one species becoming two do not happen in just one generation.

1. How did the original population that became two descendant species first become separated?

2. One of the populations had structures that changed over time. Describe the changes that happened and why they happened:

3. Why did the other population in the article stay mostly the same (stable)?

4. What caused the descendant species to have different body structures from the common ancestor population?