Reading 8.2 – Adaptive Radiation

In class today, you performed some experiments that showed you how new species tend tend to form. You saw how each new species was able to accumulate specialized adaptations for specific environmental conditions. The idea that new species can accumulate specialized adaptations, and that the process of speciation leads to new species filling the available niches in an ecosystem is called **adapative radiation**. In the reading below you will learn about how this idea of adaptive radiation was first developed by Charles Darwin and how it became part of his larger theory of evolution.

Question 1: What did you discover in your class investigations that best summarizes the relationship between the evolution of bug speed and different predators?

a) Bacteria always evolve to get faster for any environment, since faster is always better regardless of what type of predator is in the environment.

b) Bacteria evolve to get faster in certain environments and slower in other environments; it depends on what trait gives the bug a competitive advantage for the predators it encounters.

c) Bacteria always evolve to get slower for any environment, since slower is always better, regardless of what type of predator is in the environment.

Question 2: What did you discover in your class investigations that best summarizes the relationship between the evolution of adaptations that increase the chances for survival versus those that increase the chances for reproduction?

a) Organisms always evolve to become camouflaged for any environment, because camouflaging gives fish a better chance of surviving and hunting without being seen and a better chance of reproducing with a mate.

b) Organisms always evolve to become less camouflaged for any environment, because getting a mate is more important than surviving.

c) Organisms evolve to become more camouflaged in some environments, and in other environments, orgnaisms evolve to become less camouflaged. It depends on which selective pressure is greater: the pressure for survival from predators and from hunting or that for reproduction from mates.

In many of the situations you have studied in this unit you discovered that there are tradeoffs in the competitive advantage for certain variations of a trait. What works well in one environment may not work so well in another. Because of these tradeoffs, the direction of evolution is always dependent on the environmental conditions. In different environments, different traits give different competitive advantages, because different ecosystems exert different selective pressures.

A trait variation that gives a competitive advantage in a jungle ecosystem might give a competitive disadvantage in a desert ecosystem. A trait variation that gives a competitive advantage in one lake, might give a competitive disadvantage in a different lake. Even within a small ecosystem where the environment changes just a little, there can be a tradeoff in competitive advantage depending what part of the ecosystem you are in.

Question 3: Give an example of different locations in these ecosystems that have different environmental conditions that might lead to evolution of different traits. The first ecosystem has been started for you:

A forest with variation in the environmental conditions.
location 1: ___the forest floor where some trees have failed down_____
location 2: ___the forest floor where there are lots of trees overhead_____
location 3: _____

A canyon with variation in the environmental conditions.
location 1: _____
location 2: _____

The side of a mountain with variation in the environmental conditions.
location 1: _____
location 2: _____

A river with variation in the environmental conditions.
location 1: _____
location 2: _____
location 3: _____

The concepts of natural selection and evolution were first developed by Charles Darwin over a hundred years ago. Darwin developed his ideas through careful observation of animals interacting in ecosystems, and by studying the different traits he saw in those populations. For two years, he traveled on the ship the H.M.S BEAGLE while observing, measuring, and recording the living creatures in different ecosystems around the world. He also noted the forms of skeletons of extinct animals he found. He wondered why some species went extinct, where new species came from, and why there were different species in different ecosystems.

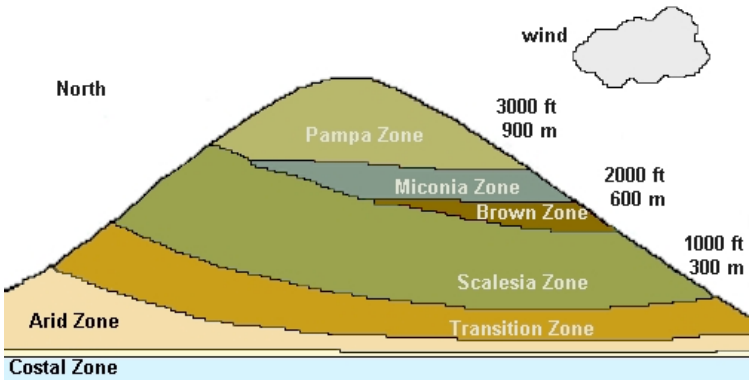
An important development of his understanding was his visit to the Galapagos Islands in the Eastern Pacific Ocean. It was there that he began to see new patterns in the populations of plants and animals on each different island that led him to understand how plants and animals evolve through natural selection.

Darwin found that the Galapagos Islands had species unique to them, found in no other part of the world. He also found that the species on the island had strong similarities to ones that existed on the nearby coast of South America (600 miles to the east).

Darwin identified 14 species of finches in the Galapagos Islands. He wondered why there were 14 species on these islands, when there was only one species of finch on the mainland of South America. He determined that the finches on the islands descended from finches that travelled to the islands at some point in the past. But even if this was the case, why were there now such striking differences in the descendants? Why were there so many species that came from that one ancestor species?

Question 4: Some ocean islands are geographically isolated from nearby continents by vast stretches of water. Because of this isolation, they often contain species unique to that isolated ecosystem, not found anywhere else in the world. What are some islands around the world that you know of that you now suspect might contain unique species?

While every island in the Galapagos Islands is a unique ecosystem, the number of different ecosystems on each island also varies. Darwin noticed that different species of plants and different species of animals lived in different ecosystems on the island. Here is a diagram of the different ecosystem zones he observed on one island:



Question 5 Why might plants with different sized seeds grow better in different types of ecosystems or in different zones within the same ecosystem?

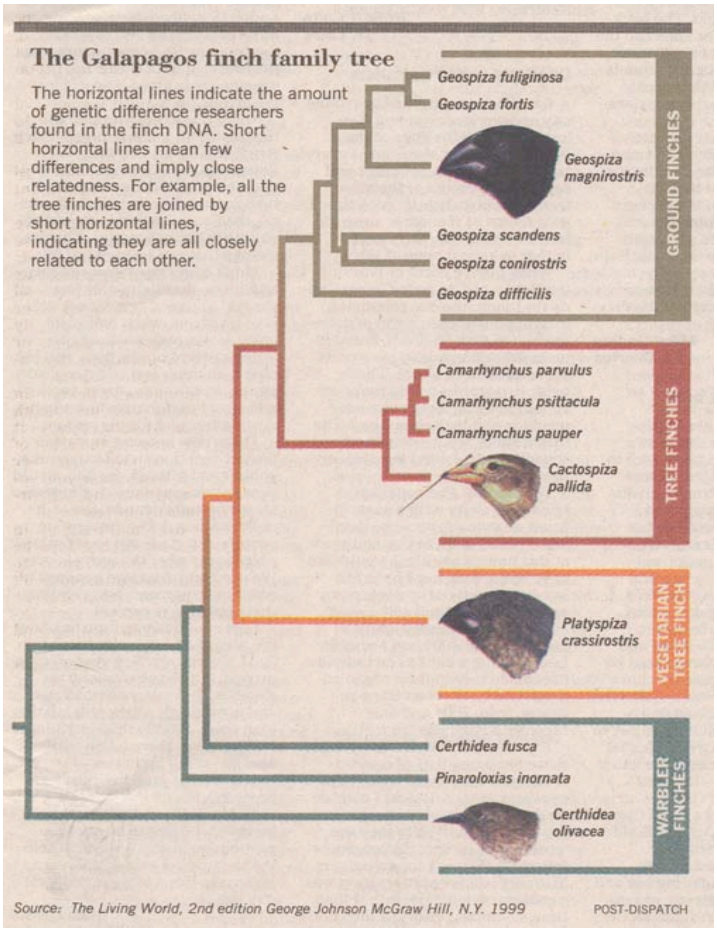
Question 6: In an earlier exploration with the Plant Speciation Model, you investigated how speciation occurred in an ecosystem with two distinct regions of normal and contaminated soil. In this diagram, you can see that are many more than two distinct zones where the environment is different. Why might evolution of a single species of bugs on this island lead to large number of new species of bugs?

Question 7 Compare the typical shape and beak of a ground finch to a tree finch in the diagram below. Which type of food might a ground finch be able to catch and break open more easily with

this type of beak: a large tree nut with a very hard to crack shell or a very small seed with a thin easy to break shell?

Darwin carefully measured the beak size and shape of birds in each species. He noticed that the beak differences were associated with differences in diet and the different sources of food they ate.

He concluded that the descendants of the finches that reached the islands in the past adapted to different ecosystems on these islands, as each population on each island encountered different selective pressures from the different food sources (seeds, insects, flowers, the blood of seabirds, and leaves). Over many generations, beaks changed in structure and function in ways that gave that population a competitive advantages for getting certain foods more easily so that they could survive and reproduce. This idea is called **adaptive radiation**. It refers to this type of branching evolution where different groups of individuals become isolated from each other.



In their relative isolation (each island was separated from one another by miles of sea), natural selection exerted a different set of pressure on each population. They were forced to adapt to take advantage of different food sources in different ecosystems, as well as in different environmental conditions in different areas of the same ecosystem. This leads to formation of many different species across many different ecosystems.

Darwin realized that **every** population has individuals that have traits that are slightly different from one another (**variation**). This variation gives some individuals a **competitive advantage for survival** in a certain environment. Those that have the competitive advantage stay alive longer and **reproduce more often** than other individuals, and they are the ones that **pass on their traits to the next generation more often** than other individuals. Over time, their traits become more common in the population. This process **repeats each generation** and from this repeating cycle of **natural selection** the population **becomes progressively better adapted to the environment** or "**evolves" over time**.

Because there are different ecosystems for populations to evolve in, a population that enters one ecosystem will evolve differently than a population that does not enter that ecosystem. As populations migrate, expand, or become isolated from each other, evolution causes those populations to change. Populations that don't go extinct tend to become better fit to survive and reproduce in their new ecosystem (or new zone within an ecosystem) the more generations they remain around.

Specialized traits in different populations form in ecosystems (such as specialized bird beaks for specific food sources found on different islands). Over time, these differences in variations between populations become more and more pronounced through mutation, genetic drift, and natural selection. And as each population continues to acquire more and more specialized traits for survival in that ecosystem, they also become more specialized at reproducing with other members of their population (since it would be a competitive disadvantage to mistakenly try to reproduce with members from other populations). Eventually, this specialization in mating leads to reproductive isolation of the population and a new species is formed.

The Galapagos finches provide an excellent example of this process. Among the birds that ended up in arid environments, the ones with beaks better suited for eating cactus got more food. As a result, they were in better condition to mate. Similarly, those with beak shapes that were better suited to getting nectar from flowers or eating hard seeds in other environments were at an advantage there. Darwin did not believe that the environment was producing the variation within the finch populations. He claimed that variation already existed in the population and that nature just selected for the most suitable beak shape and against less useful ones. Darwin described this process as the "survival of the fittest." Darwin was unaware of the mechanisms of inheritance, DNA, and protein synthesis, many of which would not be discovered until after his death.

Question 8 Critique Darwin's phrase "survival of the fittest". You have learned from earlier activities that the very fittest don't always outcompete all of their competitors all the time. Suggest a an alternate phrase of your own, that could be used to better convey his big idea.