Lab 18. Environmental Change and Evolution: Which Mechanism of Microevolution Caused the Beak of the Medium Ground Finch Population on Daphne Major to Increase in Size From 1976 to 1978?

Introduction

Bacteria have developed resistance to antibiotics over time. A pesticide that was once highly effective at killing mosquitoes no longer works. House sparrows that live in the northern United States and Canada are larger-bodied than the ones that live in the southern United States and Mexico. These cases are all examples of *microevolution*, or evolutionary change on a small scale. Microevolution occurs within a population. A population is a group of organisms that live in the same area and mate with each other. Biologists define microevolution as a change in the frequency of one or more genes within a population over time. As specific genes within a population become more or less common over time, the traits that are associated with those genes will also change. There are four basic mechanisms that drive microevolution.

The first mechanism of microevolution is a genetic *mutation*. A mutation in a gene can result in an individual having a new version of a trait. The individual with the new gene can then have offspring with the same gene. The new gene could then become more common in a population over time. However, since mutations are rare and only happen in individuals, this process alone cannot result in a big change in the frequency of a gene within a population in only one or two generations.

The second mechanism of microevolution is the process of *migration*. Individuals can either join a population (immigration) or leave a population (emigration). A specific version of a gene will become less common within a population when several individuals with that gene leave the population, and a specific version of a gene will become more common within a population when several individuals with that gene join the population. The migration of a large number of individuals into or out of a population can therefore result in a dramatic shift in the frequency of a gene within a population in a relatively short period of time.

The third mechanism of microevolution is *natural selection*, which occurs when (a) there is variation in a trait among the individuals that make up a population, (b) the trait is determined by one or more genes, (c) the trait affects survival and/or ability to reproduce, and (d) individuals who reproduce pass on their genes to the next generation. The frequency of a gene in any given generation, as a result, reflects the traits and genes of the individuals that were able to survive long enough to reproduce in the previous generation. Over time, genes that determine traits that are associated with an increased chance of survival and successful reproduction will become more common in a population, and genes that determine traits that decrease an individual's chance of survival or reproduction will become less common.

The fourth, and final, mechanism of microevolution is *genetic drift*. In any generation, some individuals may, just by chance, survive longer or leave behind more offspring than other individuals. The frequency of a gene in the next generation will therefore reflect the genes and traits of these lucky individuals rather than individuals with traits that are advantageous in terms of survival or reproduction.

It is often difficult to determine which of these four mechanisms is responsible for an evolutionary change within a population. To illustrate this point, you will be studying a population of birds called the medium ground finch (*Geospiza fortis*) that lives in the Galápagos Islands, an

FIGURE L18.1

The Galápagos archipelago

archipelago made up of a small group of islands located 600 miles off the coast of mainland Ecuador in South America (see Figure L18.1). There is a small island in the Galápagos called Daphne Major (see Figure L18.2).

Biologists Peter and Rosemary Grant have been studying the medium ground finch population on Daphne Major since 1974. They travel to Daphne Major every summer to study these birds. They capture, tag, and measure the physical characteristics of every bird on the island. They also keep track of the ones that die. Finally, and most importantly, they keep track of when a bird breeds, how many offspring it produces, and how many of those offspring survive long enough to breed.

In the summer of 1976, there were 751 finches on Daphne Major when the Grants left the island. The 1976 medium ground finch population had an average beak depth of 9.65 mm and an average beak length of 10.71 mm. In 1977 a severe drought began, and only 20 mm of rain fell on the island over the entire year. Much of the plant life on the island withered and died. The medium ground finches on Daphne Major, as a result, struggled to find food, and the population quickly decreased in size. By the end of 1978, there were only 90 finches left on the island. When the Grants returned to Daphne Major in 1978 to study the characteristics of the finch population, they made an unexpected discovery. They found that the average size of the beak for the medium ground finch on this island had increased. The 1978 population of the medium ground finch population on Daphne Major had an average beak depth of 10.55 mm and an average beak length of 11.61 mm, which was almost a full mm thicker and longer than the 1976 population. The beak of the medium ground finch population had clearly evolved in only two years.

The dramatic increase in the size of the medium ground finch beak was a clear example of microevolution. The Grants therefore wanted to determine which mechanism of microevolution caused the dramatic change in beak size. After they had analyzed the data that they had collected from 1976 to 1978, the Grants proposed that natural selection was the mechanism that caused the beak of the medium ground finch to increase in size. Some scientists, however, thought that this explanation was unacceptable because the change in the trait happened in only two years, and they viewed natural selection as a slow and gradual process. These scientists suggested that a better explanation for the increase in beak size was migration or genetic drift. In this investigation, you will use the data that the Grants collected on Daphne Major to determine which of these three explanations is the most valid or acceptable.

Your Task
Use the Grant's finch data set and what you know about migration, natural selection, and genetic drift to determine which of these three mechanisms of microevolution caused the average size of the medium ground finch beak to increase from 1976 to 1978.

The guiding question of this investigation is, **Which mechanism of microevolution caused the beak of the medium ground finch population on Daphne Major to increase in size from 1976 to 1978?**

Materials
You will use an Excel file called Finch Data during this investigation.

Safety Precautions
Follow all normal lab safety rules.

Investigation Proposal Required?   ☐ Yes   ☐ No

Getting Started
You will need to examine the characteristics of the medium ground finch on Daphne Major before and after the drought of 1977 in order to answer the guiding question for this investigation. Luckily, we know a lot about the physical characteristics of all the medium ground finches found on Daphne Major.

The medium ground finch is a small brown bird (see Figure L18.3). Their brown color helps them blend into their surroundings and avoid the owls that live on the island. (Owls eat small birds.) As with any species, no two medium ground finches are exactly alike. Medium ground finches weigh between 12 and 17 grams and have wings that range in size from 60 mm to 70 mm. These birds also have small beaks. The beak of a medium ground finch ranges in size from 8 mm to 13 mm. The medium ground finch eats seeds (which they must crack open before eating) and the occasional insect.

You may also need to examine the characteristics of the plant life found on Daphne Major before, during, and after the drought of 1977. There are two species of seed-producing plants on Daphne Major: *Tribulus terrestris* (puncturevine) and *Portulaca oleracea* (purslane). The *Tribulus* plants produce large, hard seeds (Figure L18.4) and the *Portulaca* plants produce small, soft seeds (Figure L18.5). Medium ground finches tend to eat seeds from the *Portulaca* plants because they are soft and easy to get.

You will be given the observations and measurements collected by the Grants. These data have been entered into an Excel spreadsheet. The spreadsheet will make it easier for you to analyze all the available data. To answer the guiding question for this investigation, however, you must determine what type of data you will need to examine and how you will analyze it. To determine *what data you will need to examine and how you will analyze these data*, think about the following questions:

- What would you expect to see if the change in beak size in the 1976 and 1978 populations of the medium ground finch was caused by migration? Natural selection? Genetic drift?
- What types of comparisons will you need to make between the two populations to test each of the three explanations?
- Are there trends or relationships that you will need to look for in the data?
- Are there other factors that may help you test each explanation?

Connections to Crosscutting Concepts, the Nature of Science, and the Nature of Scientific Inquiry

As you work through your investigation, be sure to think about
- the important role that conceptual models play in science,
- the relationship between structure and function in nature,
- the different types of methods that scientists use to answer questions, and
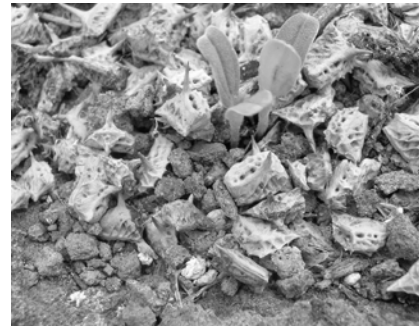- the difference between laws and theories in science.

A medium ground finch

Seeds produced by the Tribulus plant

Seeds produced by the Portulaca plant

Initial Argument

Once your group has finished collecting and analyzing your data, you will need to develop an initial argument. Your argument must include a claim, evidence to support your claim, and a justification of the evidence. The claim is your group's answer to the guiding question. The evidence is an analysis and interpretation of your data. Finally, the justification of the evidence is why your group thinks the evidence matters. The justification of the evidence is important because scientists can use different kinds of evidence to support their claims. Your group will create your initial argument on a whiteboard. Your whiteboard should include all the information shown in Figure L18.6.

FIGURE L18.6

Argument presentation on a whiteboard

The Guiding Question:	
Our Claim:	
Our Evidence:	Our Justification of the Evidence:

Argumentation Session

The argumentation session allows all of the groups to share their arguments. One member of each group will stay at the lab station to share that group's argument, while the other members of the group go to the other lab stations one at a time to listen to and critique the arguments developed by their classmates. This is similar to how scientists present their arguments to other scientists at conferences. If you are responsible for critiquing your classmates' arguments, your goal is to look for mistakes so these mistakes can be fixed and they can make their argument better. The argumentation session is also a good time to think about ways you can make your initial argument better. Scientists must share and critique arguments like this to develop new ideas.

To critique an argument, you might need more information than what is included on the whiteboard. You will therefore need to ask the presenter lots of questions. Here are some good questions to ask:

- What did your group do to analyze the data? Why did your group decide to analyze it that way?
- What other ways of analyzing and interpreting the data did your group talk about?
- Why did your group decide to present your evidence in that way?
- Why did your group abandon the other explanations?
- How sure are you that your group's claim is accurate? What could you do to be more certain?

Once the argumentation session is complete, you will have a chance to meet with your group and revise your original argument. Your group might need to gather more data or design a way to test one or more alternative claims as part of this process. Remember, your goal at this stage of the investigation is to develop the most valid or acceptable answer to the research question!

Report

Once you have completed your research, you will need to prepare an investigation report that consists of three sections that provide answers to the following questions:

1. What question were you trying to answer and why?
2. What did you do during your investigation and why did you conduct your investigation in this way?
3. What is your argument?

Your report should answer these questions in two pages or less. The report must be typed and any diagrams, figures, or tables should be embedded into the document. Be sure to write in a persuasive style; you are trying to convince others that your claim is acceptable or valid!