

## Lab 10: Natural Selection

Name \_\_\_\_\_

Date \_\_\_\_\_

### Learning Objectives:

1. Recognize Charles Darwin and his contribution to the theory of Evolution.
2. Define natural selection and evolution.
3. Define biological fitness and adaptation.
4. Understand the relationship between natural selection and evolution.
5. Be able to model natural selection in response to changes in the food resources available.

### Pre-Lab Activity:

Read the introduction and complete the following.

1. Define the following:
  - a. Evolution
  - b. Natural Selection
  - c. Adaptation
  - d. Biological Fitness
2. What was Darwin's hypothesis about the differences in bill shapes and body sizes of the finches on the Galápagos Islands?
3. What are the requirements outlined by Darwin as necessary for natural selection to occur?

Watch the Interactive video. The video requires you to answer questions before moving on. Make sure to record your responses below to the questions.

<http://media.hhmi.org/biointeractive/interactivevideo/finchquiz/index.html>

4. Different finch species have beaks of different shapes and sizes. What do these beak differences tell us?
5. Genetic evidence supports which of the following explanations for the presence of 13 different finch species on the Galápagos Islands?

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6. In 1977, Daphne Major experienced a severe drought. The figure shows the beak depths of the initial population of medium ground finches before the drought (red bars), and of the drought survivors (black bars). What do the data show? Select all that apply.
7. The top figure shows the beak depths of the 1976 finch population (red bars) before the drought, and the population after the drought (black bars). The lower figure shows the beak depths of the offspring of the drought survivors in 1978. What do these figures tell us?
8. The Grants witnessed strong selection during the droughts in 1977 and 1985. Compare the two droughts. Select all that apply.
9. How did the Grants test their hypothesis that differences in the finch songs can keep different species of finches from breeding with one another?
10. The film defines species as populations whose members don't interbreed. What keeps different Galápagos finch species from mating? Select all that apply.

### Introduction:

Evolution is a process and Biological **evolution** can be defined as a cumulative change in the allele frequencies in a population over time. Different mechanisms of evolution were presented by scientists, but the well-established mechanism for evolution is by **natural selection**. In the 1850s **Charles Darwin** outlined some conditions necessary for natural selection to occur which include: heritable variation within the population, the presence of more individuals than the environment can support, and an environment that favors certain traits in the population over others. The reproductive success of an individual relative to others in the population is referred as the organism's **biological fitness** and any heritable trait that increases the fitness of an individual is **adaptation**. Individuals with higher fitness will be better adapted and have more reproductive success in a population than others within that same population. Subsequent generations will therefore have a higher frequency of those successful traits ("descent with modification"). By this process, an entire population evolves and becomes better adapted to the environment. In this connection we have to mention Jean Lamarck, a Botanist who was considered as the pioneer of explaining how the process of evolution works. But Lamarck's theory of use and disuse of organs for better survival was not robust enough to explain the natural process of adaptation and survival of species.

Charles Darwin was an English naturalist, biologist and geologist. He was recruited as an accompanying naturalist on the HMS Beagle (a royal navy ship) for a voyage. From this voyage (1831-1836), he came up with a theory from extensive observation that all species share a common ancestor, and that adaptation and competition for resources leads to natural selection. Darwin's extensive study on the diversity of **finches** on the **Galápagos Islands** is one of the most notable works that lead towards establishing the theory of natural selection. In particular, Darwin noted the variations in bill shapes and body sizes of finches in these islands and hypothesized that these characteristics were selected upon by the availability and types of food resources on each of the islands. Darwin's theory of Natural Selection was influenced by a famous Geologist of that time, Sir Charles Lyell's work and interpretation of Earth's geological changes. Sir Lyell established from his observation that these geologic changes happen by accumulation of small changes over time. Charles Darwin published his book "**On the Origin of Species by means of Natural Selection**" in 1859 which revolutionized the idea of evolution as a scientific process. Though Charles Darwin's work is more widely known, at the same time another English Geologist and Biologist **Alfred Wallace** was also working independently on the same concept of natural selection as a possible explanation of evolution. Interestingly, both Charles Darwin and Alfred Wallace were influenced by Thomas Malthus who was an economist. Sir Malthus's work on population dynamics helped Darwin and Wallace to apply the concept of competition on survival of biological species.

Darwin's theory of evolution was better explained in the twentieth century, after the discovery of DNA structure and genes which confirms that hereditary genetic variations or mutations contribute to the process of evolution. If there is environmental pressure, evolution can also happen in short period of time.

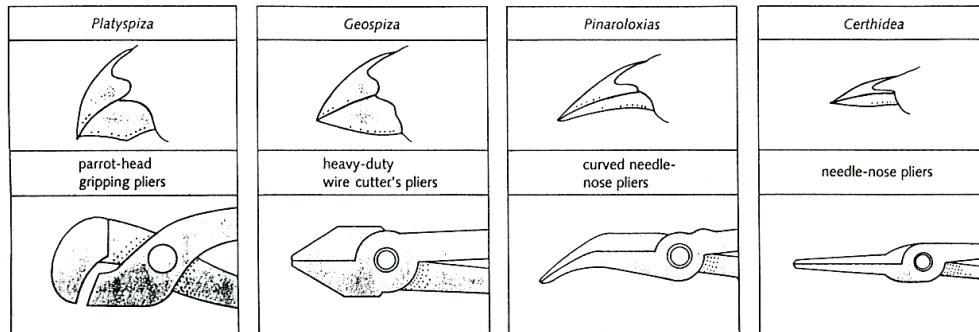
### Critical thinking:

In Science, "theory" is not an observation or a decision based on one individual's personal opinion. Scientific Theory is a conclusion made from a large body of evidence and observed fact. Following are some theories which are milestone in better understanding life including humans and the mechanism of body function.

- Cell Theory
- Theory of Evolution
- Germ theory
- Gene Theory

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In today's lab, you are going to simulate natural selection based on how well each bill shape competes for three different types of food sources. The objective is to demonstrate that some types of bills are better suited for a specific resource than others, and that some traits can become common or lost over a period of time. **Pliers** and **forceps** will be used to mimic various beak types (Figure 1). Food resources (**beads, radish seed, and sunflower seed**) available in the lab.



**Figure 1. A comparison of four finch bill types compared to different tools**  
(<http://faculty.ycp.edu/~kkleiner/fieldnaturalhistory/NatSelectionEvolPattenrs.htm>)

### Activity: Modeling Natural Selection with Tools

#### Materials Needed

For a team of four students, you need:

- Food source: beads, radish seeds, and sunflower seeds
- Resource location: large weigh boats
- 2 Food cache: small cups
- 2 Types of beaks: various pliers and forceps

Each group has two pliers at their table. Each plier represents a beak type of a finch. Record the two types of pliers that your group will be testing? \_\_\_\_\_

#### Exercise A - Scenario 1 Abundance

For scenario 1, there is an abundant amount of food with lots of variety for your birds. Fill your resource location (large container, weight boat) halfway full with radish seeds, sunflower seeds, and beads. This represents the resource location of food for your birds.

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### Procedure

#### **Competition 1: 2 Bills, All Food Types**

Each group has two forceps/pliers at their table. For 30 seconds, two individuals from the group, each with their own bill type (pliers or forceps), will compete in moving as many seeds as possible from the resource location (large container) to the food cache (smaller container) using their respective beaks. Record the number of each seed type in the space below for each plier/forceps. Repeat the competition two more times (**a total of three trials**). Record the number of seeds in the small container after each trial below. Calculate the average number of seeds and record in Table 1.

Trial 1:

Trial 2:

Trial 3:

If the bill type collected **more than 30 seeds** total on average during the competition, your bird survived. However only the “beak” with the greatest number of total seeds will move on to competition 2.

**Table 1: Average number of seeds cached in Competition 1, Scenario 1.**

Bill Type	Radish	Sunflower	Beads	Total	Survived?
1.					
2.					

#### **Competition 2: 2-3 Bills, All Food Types**

Survivors from Competition 1 (the individual from each group that had the most seeds) will compete with the survivor from two other groups (2-3 bills per group). For 30 seconds, each group will compete in moving as many seeds as possible from the resource location to their cache using their bill types that won the first competition. **Conduct 3 trials** for this competition. Record the data after each trial below. Calculate the averages and record them in Table 2.

Trial 1:

Trial 2:

Trial 3:

If the bill type collected **more than 30 seeds** total on average during the competition, your bird survived. However only the “beak” with the greatest number of total seeds will move on to competition 3.

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**Table 2: Average number of seeds cached in Competition 2, Scenario 1.**

Bill Type	Radish	Sunflower	Beads	Total	Survived?
1.					
2.					
3.					

### **Competition 3: 2 Bills, All Food Types**

Survivors from Competition 2 will compete to become the “greatest survivor”. For 30 seconds, the two final survivors (the individuals from competition 2 that had the most seeds) will compete in moving as many seeds as possible from the resource location to their cache. **Only 1 trial will be done for this competition.** Record the number of seeds in Table 3.

If the bill type collected **more than 30 seeds** total on average during the competition, your bird survived. However only the “beak” with the greatest number of total seeds is the “greatest survivor”.

**Table 3: Number of seeds cached in Competition 3, Scenario 1.**

Bill Type	Radish	Sunflower	Beads	Total	Survived?
1.					
2.					

Did both birds survive?

What type of bill was the greatest survivor?

### Exercise B - Scenario 2 Drought Limited

For scenario 2, there has been a drought which resulted in limited amounts of food resources for your birds. However, there is still a variety of food for birds to choose from. Remove most of the food from the large resources location so there is only a single layer of food on the bottom of the container (but at least 60 seeds).

#### Procedure

### **Competition 1: 2 Bills, All Food Types - Limited**

For 30 seconds, two individuals with different bills from your group will compete in moving as many seeds as possible from the resource location to the food cache. **Conduct 3 trials for this competition.** Record the number of seeds in the small container after each trial. Then calculate the average number of seeds and record in Table 4.

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Trial 1:

Trial 2:

Trial 3:

If the bill type collected **more than 30 seeds** total on average during the competition, your bird survived. However only the “beak” with the greatest number of total seeds will move on to competition 2.

**Table 4: Average number of seeds cached in Competition 1, Scenario 2.**

Bill Type	Radish	Sunflower	Beads	Total	Survived?
1.					
2.					

Did both of your birds survive?

### **Competition 2:** 2-3 Bills, All Food Types - Limited

Survivors from Competition 1 (individuals with the greatest number of seeds) will form two groups to compete. For 30 seconds, each group will compete in moving as many seeds as possible from the resource location to their cache. **Conduct 3 trials for this competition.** Record the data after each trial. Then calculate the averages and record them in Table 5.

Trial 1:

Trial 2:

Trial 3:

If the bill type collected **more than 30 seeds** total on average during the competition, your bird survived. However only the “beak” with the greatest number of total seeds will move on to competition 3.

**Table 5: Average number of seeds cached in Competition 2, Scenario 2.**

Bill Type	Radish	Sunflower	Beads	Total	Survived?
1.					
2.					
3.					

Did all of the birds survive?

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### Competition 3: 2 Bills, All Food Types - Limited

Survivors from Competition 2 (the individual with the greatest number of seeds) will compete to become the “greatest survivor”. For 30 seconds, the two final survivors will compete in moving as many seeds as possible from the resource location to their cache. **Only 1 trial will be done for this competition.** Record the number of seeds in Table 6.

The individual that collects at least 30 seeds and the most food is the greatest survivor.

**Table 6: Average number of seeds cached in Competition 3, Scenario 2.**

Bill Type	Radish	Sunflower	Beads	Total	Survived?
1.					
2.					

Did any of the birds survive the drought?

What bill type was the greatest survivor?

### Exercise C - Scenario 3 Drought Limited, Only 1 Source of Food

For scenario 3, there has been a drought which resulted in limited amounts and type of food resources for your birds. Remove all of the seeds from your resource location and replace it with a single layer of radish seeds on the bottom of the container (but at least 60 seeds).

#### Procedure

### Competition 1: 2 Bills, Only Radish Seeds

For 30 seconds, two individuals with different bills from your group will compete in moving as many radish seeds as possible from the resource location (large container) to the food cache (smaller container).

**Conduct 3 trials for this competition.** Record the number of seeds in the small container after each trial. Then calculate the average number of seeds and record in Table 7.

Trial 1:

Trial 2:

Trial 3:

If the bill type collected **more than 30 seeds** total on average during the competition, your bird survived. However only the “beak” with the greatest number of total seeds will move on to competition 2.

**Table 7: Average number of seeds cached in Competition 1, Scenario 3.**

Bill type	Radish	Survived?
1.		
2.		



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### Competition 2: 2 - 3 Bills, Only Radish Seeds

Survivors from Competition 1 will form two groups from to compete. For 30 seconds, each group will compete in moving as many seeds as possible from the resource location to their cache location for each seed type. **Conduct 3 trials for this competition.** Record the data after each trial. Then calculate the averages and record them in Table 8.

Trial 1:

Trial 2:

Trial 3:

If the bill type collected **more than 30 seeds** total on average during the competition, your bird survived. However only the “beak” with the greatest number of total seeds will move on to competition 3.

**Table 8: Average number of seeds cached in Competition 2, Scenario 3.**

Bill Type	Radish	Survived?
1.		
2.		
3.		

### Competition 3: 2 Bills, Only Radish Seeds

Survivors from Competition 2 will compete to become the “greatest survivor”. For 30 seconds, the two final survivors will compete in moving as many seeds as possible from the resource location to their cache. **Only 1 trial will be done for this competition.** Record the number of seeds in Table 9.

The individual that collects at least 30 seeds and the most food is the greatest survivor.

**Table 9: Average number of seeds cached in Competition 2, Scenario 3.**

Bill Type	Radish	Survived?
1.		
2.		

Did any of the birds survive the drought that resulted in only 1 food source?

What bill type was the greatest survivor?

Was the greatest survivor of scenario 3, the same as the greatest survivor of scenario 1 and 2?

## FUNDAMENTALS OF BIOLOGY (BIOL 1101)

### Questions

1. What did we use to simulate the finches' beaks?
2. What did we use to simulate food resources?
3. What three scenarios were simulated?
4. Which bill type was best adapted for each scenario, the "greatest survivor"?
5. Were any traits lost (plier types eliminated because they did not collect enough seeds to survive) from the competition in the different scenarios? What does this simulate?
6. Look at the individual seed counts for the different pliers/forceps during the various competitions. What type of seed was most often collected by the different tools? Did there appear to be a specific seed type easier to collect for each beak shape?

### **Reference:**

East Tennessee State University: [etsu.edu](http://etsu.edu)

Howard Hughes medical Institute: [HHMI.org](http://HHMI.org)