



Natural Selection: For the Birds

Adapted from a Discovery Institute CUNY lesson (<http://discovery.csi.cuny.edu/pdf/lessonplandraft.pdf>)

Overview

Students simulate natural selection in a bird population by “feeding” with different “beaks”, trying to obtain enough resources to live to reproduce and pass on their genetic information (and beak type) to the next generation.

Introduction:

In the mid nineteenth century, an Austrian monk, Gregor Mendel, was the first scientist to introduce the idea that the observed variations among individuals in a population are due to “factors,” now known as genes. From his work with thousands of pea plants, Mendel concluded that these “factors” are passed down from parent to offspring, thus accounting for the similarities among members of the same family.

Genetic variation (hereditary differences between individuals) provides for the diversity of appearances, capabilities, and behaviors from which the environment selects for the next generation. The more genetic diversity that exists in a species, the better the species will be able to adapt to the environment.

Around the time that Mendel made his investigations with pea plants, Charles Darwin was formulating his theory of evolution based on natural selection. Darwin noted that there is a struggle for existence among individuals of the same species and among different species living in the same area. Competition exists for available resources and the environment directs the preferential survival of certain traits in populations over others.

In this lab, students see the result of natural selection on a variety of species when only a single food source is left due to climate change. A real-life illustration of a similar event is exemplified in the finches of Galapagos Islands. The giant finch (*Geospiza magnirostris* var. *magnirostris*), which lived on the island of Floreana, primarily ate the seeds of the prickly pear cactus (*Opuntia megasperma* var. *megasperma*). The beak of this finch and this cactus’ seeds coevolved to become larger, in an evolutionary “arms-race”. When this species of *Opuntia* went extinct on Floreana due to predation by introduced species (such as goats), the giant finch lost the food source it was best adapted to, and it went extinct in 1957.

Motivation:

Pretend that you are a member of a population of seed eating birds. Just as all of you have very diverse traits and yet are members of the same species, so do these birds. These birds have differently shaped beaks. Sudden changes in the climate have caused a shortage of food and only one seed type has survived the environmental change. All of these birds are competing for the same food source. Those that obtain food will survive and reproduce. The genetic traits of those that do not survive will not be passed to future

generations. You will simulate a population of birds as they try to survive through several generations.

Objectives:

Upon completion of the lab, students should be able to

1. Define natural selection.
2. Demonstrate, through a simulation, evolution based on natural selection.
3. Discuss how natural selection affects the Hardy-Weinberg Equilibrium.
4. Identify which “beak” is the most effective in our simulation.
5. Effectively analyze results in tabulated and graph formats.

Materials:

- Seeds: sunflower seeds work well; you might also use beans.
- 15 of at least five of the following “beak” types: forceps, clothespin, plastic spoons, binder clips, hairclips, tongs, test tube holders.
- One test tube, or other collection cup, per student in class.
- Calculator for each team
- Class sets of each of the following: graph paper, data tables, and instructions

Associated California Biology Standards:

- 7a. Students know why natural selection acts on phenotype rather than the genotype of an organism.
- 7d. Students know variation within a species increases the likelihood that at least some members of a species will survive under changed environmental conditions.
- 8a. Students know how natural selection determines the differential survival of groups of organisms.
- 8b. Students know a great diversity of species increases the chance that at least some organisms survive major changes in the environment.
- 8c. Students know the effects of genetic drift on the diversity of organisms in a population.

Procedure:

1. Distribute and explain copies of Instructions for Natural Selection Simulation (see below).
2. Divide the students into groups of 5 or 6, depending on class size, and distribute materials.
3. Scatter food (seed) in a common area and begin the simulation as per student instruction sheet.
4. Use the following summary and test preparations sections to review the main ideas of the lesson.

Evaluation:

The following questions are listed under the Analysis section of the student handout and may be used as part of a report, class discussion or assessment

1. How does genetic variation allow a population to survive during environmental changes?

2. How does natural selection control the genetic diversity found in populations?
3. Using your knowledge of natural selection, explain how extinction occurs.

Extension Activities:

1. Read The Beak of the Finch by Jonathan Weiner. Write a detailed report that illustrates the similarities between your simulation of natural selection in a bird population with the actual research being done on the Galapagos Islands.
2. Write a detailed report on adaptive radiation of either *Opuntia* or the *Scalesia* plant genera in the Galapagos Islands, or the Silversword family of the Hawaiian Islands. Focus on what pressures created their adaptations and how this differs from the pressures on animals.
3. Use library and Internet sources to:
 - A) Investigate how Charles Darwin arrived at his theory of evolution and write a detailed report.
 - B) Using a drawing or a replication of a world map, trace Charles Darwin's voyage on the H. M. S. Beagle. Include on the map the key locations and a brief note regarding what Darwin observed that led him to his theory of evolution.

Test Preparation:

1. Which statement about the rates of evolution for different species is in agreement with the theory of evolution?
 - (A) They are identical, since the species live on the same planet.
 - (B) They are identical, since each species is at risk of becoming extinct.
 - (C) **They are different, since each species has different adaptations that function within a changing environment.**
 - (D) They are different, since each species has access to unlimited resources.
2. Which concept is not a part of the theory of evolution?
 - (A) Present- day species developed from earlier species.
 - (B) Some species die out when environmental changes occur.
 - (C) Complex organisms develop from simple organisms over time.
 - (D) **Changes occur according to the needs of an individual organism to survive.**
3. Even though the environment changes, a population that occupies a given geographic area will most likely continue to be found in this area if the
 - (A) variations in the population decrease over time.
 - (B) members of the population decrease in numbers.
 - (C) members of the population exceed the carrying capacity.
 - (D) **population passes on those genes that result in favorable adaptations**
4. Which situation would most likely result in the highest rate of natural selection?
 - (A) reproduction of organisms by an asexual method in an unchanging environment
 - (B) reproduction of a species having a very low mutation rate in a changing environment

- (C) reproduction of organisms in an unchanging environment with little competition and few predators.
 - (D) **reproduction of organisms exhibiting genetic differences due to mutations and genetic recombination in a changing environment.**
5. In his theory, Lamarck suggested that organisms will develop and pass on to offspring variations that they need in order to survive in a particular environment. In a later theory, Darwin proposed that changing environmental conditions favor certain variations that promote the survival of organisms. Which statement is best illustrated by this information?
- (A) Scientific theories that have been changed are the only ones supported by scientists.
 - (B) **All scientific theories are subject to change and improvement.**
 - (C) Most scientific theories are the outcome of a single hypothesis
 - (D) Scientific theories are not subjected to change.

Name: _____

Student Sheet—Natural Selection: for the Birds

Each of you is a member of a bird population with a wide variety of genetic variations with respect to beak type. Each group of 5 or 6 students represents one of the beak types found in the population.

Procedure

1. Your teacher will ring a bell to initiate the start of feeding.
2. All the groups collectively, using only their beaks, will be given one minute to obtain food from a common feeding area and place the food into the “mouth” (test tube).
3. Your teacher will ring a bell to terminate the feeding period.
4. The pieces of food “eaten” by each “bird” will be counted, a group total calculated and recorded in the appropriate column on Table 1.
5. The total “eaten” by the group will be reported to the teacher to obtain a class total. This figure is needed to determine the number of survivors (parents and offspring).
6. Calculate the number of birds your group has earned by using the following formula:
Survivors= total pieces eaten by your group/total pieces eaten by the population X total # of birds in the population
7. If your group ate relatively little food and thus earned fewer “birds” than you started with, some “birds” will die, turn in their beaks, and become offspring for other groups. If your group ate a lot of food, it will earn more “birds”. These “birds” will be drawn from the group of extras and get a beak that is the same as the group they will be joining.
8. Steps 1 through 6 will be repeated 4 more times, thus accumulating five generations of data.
9. Record data in Table 2.
10. Graph all results, showing how the percentages of beak type in the total population changed over time.
11. Write a summary of your observations.
12. Submit report including written summary, data, and graph.

Table 1: Total Seeds Eaten Per Generation in Simulation

	Generation 1	Generation 2	Generation 3	Generation 4	Generation 5
Beak 1					
Beak 2					
Beak 3					
Beak 4					
Beak 5					

Identify each of your “beak” types.

Beak 1 _____

Beak 2 _____

Beak 3 _____

Beak 4 _____

Beak 5 _____

Table 2: Percentage “Beak” Type in Total Population

	Generation 1		Generation 2		Generation 3		Generation 4		Generation 5	
	# Beaks	% Beaks	# Beaks	% Beaks	# Beaks	% Beaks	# Beaks	% Beaks	# Beaks	% Beaks
Beak 1										
Beak 2										
Beak 3										
Beak 4										
Beak 5										
total										

Survivors= total pieces eaten by your group/total pieces eaten by the population X total # of birds in the population

Analysis

1. How does genetic variation allow a population to survive during environmental changes?
2. How does natural selection control the genetic diversity found in populations?
3. Using your knowledge of natural selection, explain how extinction occurs.