Appendix A

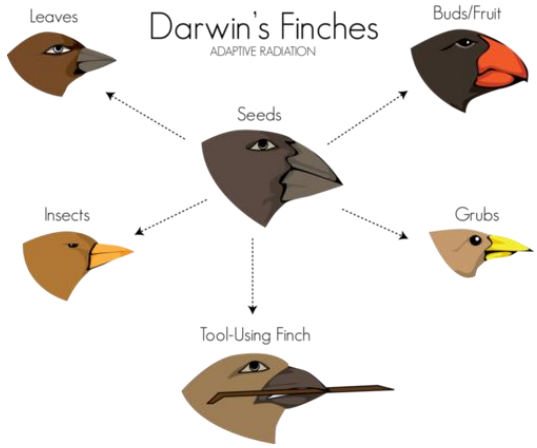
Lesson Plan for Evolution and Natural Selection:

- Introductory Presentation on Evolution, Artificial Selection, Natural Selection, and evidence for evolution.
- Introductory presentation on evidence for evolution using Darwin's finches as an example.
- Video explaining Darwin's finches. http://www.mhhe.com/biosci/bio_animations/MH12%20MechOfEvolution_Web/index.html
- In-class application worksheet using questions from the CINS
- After the students work on the questions by themselves or in a group, assessment occurs as the instructor goes through each of the questions and has them explain their answers.

Name_____

Worksheet on Natural selection and Galapagos finches *(modified from D.L. Anderson and K.M. Fisher's conceptual inventory of Natural Selection)*

Scientists have long believed that the 14 species of finches on the Galapagos Islands evolved from a single species of finch that migrated to the islands one to five million years ago (Lack, 1940). Recent DNA analyses support the conclusion that all of the Galapagos finches evolved from the warbler finch (Grant, Grant & Petern, 2001; Petren, Grant & Grant, 1999). Different Species live on different islands. For example, the medium ground finch and the cactus finch lived on one island. The large cactus finch occupies another island.



1. In the finch population what are the primary changes that occur over time?

A. The traits of each finch within a population gradually change
B. the proportions of finches having different traits within a population change.
C. Successful behaviors learned by finches are passed on to offspring
D. mutations occur to meet the needs of the finches as the environment changes

2. How did the different beak types <u>first</u> arise in the Galapagos finches?

A. The changes in the finches' beak size and shape occurred because of their need to be able to eat different kinds of food to survive
B. Changes in the finches' beak occurred by chance, and when there was a good match between beak structure and available food, those birds had more offspring.
C. The changes in the finches' beaks occurred because the environment induced the desired genetic changes
D. The finches' beaks changed a little bit in size and shape with each successive generation, some getting larger and some getting smaller.

3. Depending on their beak size and shape, some finches get nectar from flowers, some eat grubs from bark, some eat small seeds, and some eat large nuts. Which statement best describes the interactions among the finches and the food supply?

A. Most of the finches on an island cooperate to find food and share what they find.
B. Many of the finches on an island fight with one another and the physically strongest ones win.
C. There is more than enough food to meet all the finches' needs so they don't need to compete for food.
D. Finches compete primarily with closely related finches that eat the same kinds of food, and some may die from lack of food.

4. What type of variation in finches is passed to the offspring?

A. any behaviors that were learned during a finch's lifetime
B. Only characteristics that were beneficial during a finch's lifetime
C. All characteristics that are genetically determined
D. Any characteristics that were positively influenced by the environment during a finch's lifetime.

5. What caused populations of birds having different beak shapes and sizes to become distinct species distributed on the various islands?

A. The finches were quite variable, and those whose features were best suited to the available food supply on each island reproduced most successfully.
B. All finches are essentially alike and there are not really fourteen different species.
C. Different foods are available on different islands and for that reason, individual finches on each island gradually developed the beaks they needed.
D. Different lines of finches developed different beak types because they needed them in order to obtain the available food.

Appendix B

13

BIOLOGY LABORATORY
NATURAL SELECTION & COMPETITION

Objectives:

- Model the changes in **genotypes**, **phenotypes**, and **allele frequencies** of a species over several generations in response to **natural selection.**
- Model changes in a population's gene pool in a changing environment.

Material to bring to lab:
Calculator

Introduction:

Evolution can be described as a change in the frequency of alleles (version of the gene) in the gene pool of a population. The frequency of alleles in a population would remain the same as long as the following conditions are met:

- No natural selection occurs
- No mutations occur
- No genetic drift occurs (the population is infinitely large)
- No mate selection (all mating is totally random)
- No gene flow (no gametes or organisms enter or leave the population)

However in real populations at least one, often more, of these conditions are not met. When the above conditions are not met the frequency of alleles in the population changes, thus evolution occurs.

In today's lab we will focus on the process of natural selection. Natural selection occurs when the following conditions are met:

- organisms vary in their heritable characteristics
- a population can produce more offspring than the environment can support
- some individuals survive and reproduce better than others.

Different biotic (living) and abiotic (nonliving) features of the environment act as selective pressure. Examples of selective pressures include environmental conditions, temperature, predation, and disease.

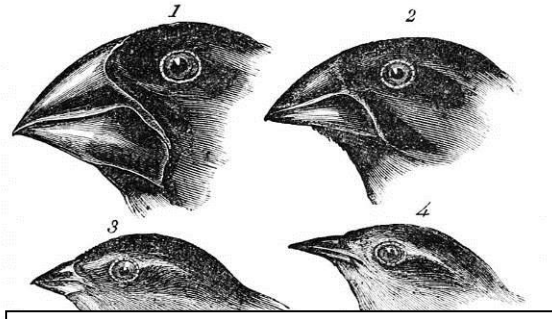


Figure 1. Note the different beak types on the various Galapagos finches. 1 large ground finch, 2 medium ground finch, 3 small tree finch, 4 green warbler-finch.

Charles Darwin is famous for his contributions to evolutionary theory. He observed that finches living on different Galapagos Islands had different beaks. He also observed that the environment on different islands was quite different. Darwin developed a hypothesis that the finches had all been the mostly the same at one time, (probably blown over from the coast of South America) with some variations in their

beaks. If different beak types could better collect food on each island then birds with those particular beaks survived and reproduced.

In this laboratory activity, we will model natural selection and microevolution. You will work with different tools that will serve as a model for finch "beaks" and objects that will serve as "seeds". You will compete with other "finches" to see which beak is best adapted for obtaining a specific food.

Materials:

Drinking cup **(Stomach)**
Plastic spoons, knives, and forks (**Beak type/fi phenotype)**
Soybeans (**Seeds)**
Red and Yellow colored beads **(Alleles)**
Lunch Tray (or similar container) (**Habitat**)
River rocks (to alter habitat)
Gene pool (beaker or similar container) to choose alleles from
Eco. Recycling bin (beaker or similar container) to discard alleles in at the end of each round

Procedure:

1**.** Distribute "seeds" and rocks throughout "habitat".
2. Choose "genotypes" (colored beads Red=R, Yellow =Y) at random from the "gene pool" at the front of the room (no peeking!).
3. Record your genotype the "My genotype" column (e.g.: YY, YR, or RR).
4. Obtain "beak" based on genotype from the front of the room.
YY= Spoon YR= Fork RR=Knife
5. Obtain "stomach" (cup) before collecting prey.
6. Record beak type (spoon, knife, or fork) in lab notebook under "# beaks at Start of Round".
7. Record number of alleles (Y, R) of each type in lab notebook under "# of Alleles at Start of Round".
8. At a signal from your instructor, collect "seeds" for 30 seconds. To collect your "seeds" you will have your "beak" in one hand and the "stomach" in other hand. You can only use the "beak" to collect seeds, **do not scoop or shovel** "seeds" from edge of table into "stomach".
9. If any of the rocks make it to your "stomach" you die and your seeds are not used to calculate the mean.
10. At a signal from your instructor, stop collecting seeds.
11. Count the total number of seeds collected per finch and compute the classroom's mean.
    a. Record your number of seeds collected in the column under "# of seeds I collected".
    b. Record the mean number of seeds collected in a data table in your lab notebook under "Mean # Seeds Captured".
12. Every finch that captured the mean number of prey or more "survives" this round.
    a. Record surviving beak types (spoon, knife, fork) in your lab notebook under "# beaks surviving at End of Round".
    b. Record number of surviving alleles (Y, R) of each type in your lab notebook under "# of Alleles at end of Round".
13. Every surviving finch produces 8 gametes. Add these to the gene pool:

a. Surviving Fork (YR) would add 4 yellow beads and 4 red beads to the gene pool.
b. Surviving Spoon (YY) would 8 yellow beads to the gene pool.
c. Surviving Knife (RR) would add 8 red beads to the gene pool.

14. Repeat 4 times.
15. At the **start** of each round:
    a. Everyone draws a new genotype from the gene pool.
    b. Record beak types (spoon, knife, or fork) and allele frequency in the report section of your lab.
16. At the **end** of each round:
    a. Count the total number of seeds captured per finch, provide this data to your instructor to compute the mean.
    b. Record finches and allele frequency in lab notebook.
    c. Surviving finches produce offspring and add them to the gene pool.
    d. Everyone returns their alleles to the ecological recycling bin.
17. Compare initial allele frequencies to end allele frequencies at the end of the final round.
18. Provide a Bar Graph of your results.
    Figure 1. Allele frequency by generation with rocks.
    X-axis Plot generations (rounds).
    Y-axis- Plot number of alleles (R/Y) at start of round (plot each beak allele using a different color or symbol).
19. Answer questions in the lab report.

Results:

1. If all of the knives died in one generation, is it possible for knives to be "born" into the next generation? Explain. **(1 point)**

2. Compare the allele frequencies in the first generation to the allele frequencies in the last generation. Were the allele frequencies in the last generation the same or different? Why do you think this is? **1 point**

Data Table (2 points)													
Round #	My Geno-type	# of seeds I collected	Mean # Seeds Collected at the End of Round	# Beaks at Start of Round			# Alleles at Start of Round		# Beaks at End of Round			# Alleles at End of Round	
				Knife (RR)	Fork (YR)	Spoon (YY)	R	Y	Knife (RR)	Fork (YR)	Spoon (YY)	R	Y
1													
2													
3													
4													
5													

Figure 1. Allele frequency by generation. 2 points

3. Form a hypothesis about how a change in a variable of the experimental ecosystem will affect the numbers of genotypes and alleles in the population. Describe how you could test this and what you predict would happen. **1 point**

*Answer the following questions based on your understanding of the actual Galapagos finch populations **(1 point each)**.* (Questions taken from Conceptual inventory of Natural selection by D.L. Anderson and K.M. Fisher)

_____4. What would happen if a breeding pair of finches was placed on an island under ideal conditions with no predators and unlimited food so that all individuals survived? Given enough time

A. The finch population would stay small because birds only have enough babies to replace themselves.
B. The finch population would double and then stay relatively stable.
C. The finch population would increase dramatically.
D. The finch population would grow slowly and then level off.

_____5. Finches on the Galapagos Islands require food to eat and water to drink.

A. When food and water are scarce, some birds may be unable to obtain what they need to survive.
B. When food and water are limited, the finches will find other food sources, so there is always enough
C. When food and water are scarce, the finches all eat and drink less so that all birds survive.
D. There is always plenty of food and water on the Galapagos Islands to meet the finches' needs.

_____6. Once a population of finches has lived on a particular island for many years,

A. The population continues to grow rapidly.
B. The population remains relatively stable, with some fluctuations
C. The population dramatically increases and decreases each year
D. The population will decrease steadily

_____7. In the Galapagos finch population what are the primary changes that occur over time?

A. The traits of each finch within a population gradually change
B. the proportions of finches having different traits within a population change.
C. Successful behaviors learned by finches are passed on to offspring
D. mutations occur to meet the needs of the finches as the environment changes

_____8. How did the different beak types <u>first</u> arise in the Galapagos finches?

A. The changes in the finches' beak size and shape occurred because of their need to be able to eat different kinds of food to survive

B. Changes in the finches' beak occurred by chance, and when there was a good match between beak structure and available food, those birds had more offspring.

C. The changes in the finches' beaks occurred because the environment induced the desired genetic changes

D. The finches' beaks changed a little bit in size and shape with each successive generation, some getting larger and some getting smaller.

_____9. Depending on their beak size and shape, some finches get nectar from flowers, some eat grubs from bark, some eat small seeds, and some eat large nuts. Which statement best describes the interactions among the finches and the food supply?

A. Most of the finches on an island cooperate to find food and share what they find.

B. Many of the finches on an island fight with one another and the physically strongest ones win.

C. There is more than enough food to meet all the finches' needs so they don't need to compete for food.

D. Finches compete primarily with closely related finches that eat the same kinds of food, and some may die from lack of food.

_____10. What type of variation in finches is passed to the offspring?

A. any behaviors that were learned during a finch's lifetime

B. Only characteristics that were beneficial during a finch's lifetime

C. All characteristics that are genetically determined

D. Any characteristics that were positively influenced by the environment during a finch's lifetime.

_____11. What caused populations of birds having different beak shapes and sizes to become distinct species distributed on the various islands?

A. The finches were quite variable, and those whose features were best suited to the available food supply on each island reproduced most successfully.

B. All finches are essentially alike and there are not really fourteen different species.

C. Different foods are available on different islands and for that reason, individual finches on each island gradually developed the beaks they needed.

D. Different lines of finches developed different beak types because they needed them in order to obtain the available food.