Natural Selection Lab
BIOL 1107

Introduction

Biological **evolution** can be defined as the change in the frequency of genetic traits in a population over time. There are several recognized mechanisms of evolution, including evolution by **natural selection**. Charles Darwin and Alfred Russell Wallace first described the process of natural selection in the 1850s. Darwin outlined several requirements necessary for natural selection to occur, including 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. If all of these conditions are present, individuals in the population that have the favored traits are more likely to survive and successfully reproduce, and thus pass down those traits to their offspring.

The reproductive success of an individual relative to others in the population is known as the organism's **biological fitness**. Any heritable trait that increases the fitness of an individual is known as an **adaptation**. Individuals that are best adapted to their environment have higher fitness and thus more offspring than others in the population. Subsequent generations will therefore have a higher frequency of the successful traits. In this manner, the entire population evolves and becomes better adapted to the environment.

In this lab, we will simulate the process of natural selection and track the frequency of certain heritable traits in predator and prey populations over several generations.

Simulation

You and your fellow students will represent members of a population of a single predatory species. Beans will represent a population of a prey species. Both the predator and prey populations have heritable variation. In the predator population, variation consists of different utensils that can be used to "capture" prey: a fork, a spoon, chopsticks, or forceps. The prey population varies in size, shape, and color of bean: black beans, large lima beans, or lentils.

Your instructor will divide the class into 2-3 groups of students (with 7-10 students each). Each group will represent members of a predator population that exists in a different environment than the other group(s). The uncovered black lab bench will represent one environment; and towels laid across the lab bench will represent the others (using two different color towels – one light, one dark – if you have a total of three groups).

The simulation will consist of three rounds of prey capture, in which the predators will attempt to capture as many prey as they can in 1 minute. The number of prey captured will be used to determine each predator's **fitness** (reproductive success), which will determine the makeup of the next generation of predators. Before beginning the simulation, and following each round, each group will calculate the percentage of the predator and prey populations that have each trait.

Setting Up the Simulation

Each member of the group will be given one of the four types of utensils for capturing prey. Try to distribute the utensils as evenly as possible, then calculate the percentage of the population that has each trait. For example, if you have eight students in your group, and two students are given forks, then the fork trait is present in 25% of the population [(2/8)*100].

Record the percentage for each trait in the "Generation 0" row in Table 1.

Beans (the prey) are scattered through each "environment". In the initial prey population, there are 100 of each type of bean present. Therefore, each trait (different bean types) is present in 33.3% of the population [(100/300)*100] Record these percentages under Generation 0 in Table 2.

Before beginning, answer the following questions as a class:

1. Which predators do you think will be the most successful in each environment?
2. Which prey do you think will be most successful in each environment?

Round One

To perform the simulation, each group member will attempt to capture as many prey items (beans) as possible in 1 minute, using the following rules:

- You can only use your utensil to capture prey.
- Each student will be given a cup to collect their captured prey, and the cup must be kept on the table at all times.
- You can only capture one prey item at a time and each prey item must be successfully placed in your cup to be considered a successful capture.

Perform the first round of prey capture.

When the one-minute period of prey capture is complete, each group member should tally the number of prey items that they successfully captured. The number of prey captured determines how many offspring each individual will have. In other words, the number of captured prey determines fitness. Offspring will have the same trait (utensil type) as the parent.

≤15 prey captured = predator dies/no offspring
16-25 prey captured = 1 offspring
26-35 prey captured = 2 offspring
≥36 prey captured = 3 offspring

Fill in the table below with the total number of offspring produced by individuals with each trait, and the percentage of the next generation that will have each trait.
For example, if you had two forks in Generation 0 and each fork produced 3 offspring, then 6 fork offspring are present in Generation 1. If Generation 1 consists of 20 total offspring, then forks represent 30% of Generation 1. [(6/20)*100].

	No. of Offspring	% of Generation 1
Forks		
Spoons		
Chopsticks		
Forceps		
Total		100%

Record the percentage information for Generation 1 in Table 1.

Determine the number of prey items of each type that remain on the table. (The easiest way to do this is to tally the total number of each type of prey that were captured, and deduct it from the number you started with). Each surviving prey item will have three offspring of the same type that will be present in the next generation. So, for each prey that remains on the table, add two additional prey items of the same type. (For example, if 25 black beans remain on the table, add 50 more for a total of 75 black beans). These new prey numbers will represent Generation 1 of the prey population. Fill in the table below with the total numbers of prey in Generation 1, and calculate the percentage of the Generation 1 prey population that contains each trait. Record the information in Table 2.

	No. of offspring	% of Generation 1
Black beans		
Lima beans		
Lentils		
Total		100%

<u>Round 2</u>

Redistribute the utensils to represent the percentage of each trait in Generation 1. For example, if 40% of the population has the fork trait and you have a total of eight students, 3 students should now hold forks. (8*0.40) (You may have to round your numbers. Just try and approximate the percentages as closely as possible).

Repeat the simulation as Generation 1. Use the same rules and time limit (one minute).

Use the table below to tally your results for the predator population and fill in the corresponding row (Generation 2) in Table 1.

	No. of Offspring	% of Generation 2
Forks		
Spoons		
Chopsticks		
Forceps		
Total		100%

Replenish the prey population as before, and fill in the row for Generation 2 in Table 2.

	No. of offspring	% of Generation 2
Black beans		
Lima beans		
Lentils		
Total		100%

Round 3

Redistribute the utensils and repeat the simulation one more time. Fill in the information for Generation 3 in Tables 1 and 2.

	No. of Offspring	% of Generation 3
Forks		
Spoons		
Chopsticks		
Forceps		
Total		100%

	No. of offspring	% of Generation 3
Black beans		
Lima beans		
Lentils		
Total		100%

Each group will now write their data on the board so that the different environments can be compared. Record the data from the other groups in the tables below, then answer the following questions. *Your instructor may also require you to produce a graph of this data.

Answer the following questions.

1. Which trait(s) in the predator population was/were the best adapted to each environment?

2. Which trait(s) in the prey population was/were the best adapted to each environment?

3. Explain the importance of the environment in determining which traits are better adapted.

4. Did the predator and prey populations evolve?

5. Did the populations become better adapted to their environment? How so? (Remember, the predators are part of the prey population's environment, and vice versa).

Environment 1 – Uncovered Lab Bench

Table 1a. Percentage of predator population with each trait

	Fork	Spoon	Chopsticks	Forceps
Generation 0				
Generation 1				
Generation 2				
Generation 3				

Table 2a. Percentage of prey population with each trait.

	Black Bean	Lima Bean	Lentil
Generation 0			
Generation 1			
Generation 2			
Generation 3			

Environment 2 – Light Colored Towel

Table 1b. Percentage of predator population with each trait

	Fork	Spoon	Chopsticks	Forceps
Generation 0				
Generation 1				
Generation 2				
Generation 3				

Table 2b. Percentage of prey population with each trait.

	Black Bean	Lima Bean	Lentil
Generation 0			
Generation 1			
Generation 2			
Generation 3			

Environment 3 – Dark Colored Towel

Table 1c. Percentage of predator population with each trait

	Fork	Spoon	Chopsticks	Forceps
Generation 0				
Generation 1				
Generation 2				
Generation 3				

Table 2c. Percentage of prey population with each trait.

	Black Bean	Lima Bean	Lentil
Generation 0			
Generation 1			
Generation 2			
Generation 3			