Evolution by Natural Selection[1]

Introduction: **Genes** act as blueprints that determine how organisms will be shaped (their anatomy) and how they will function (their physiology). **Evolution** is defined as a change in the genetic makeup of a population of organisms. In other words, evolution happens when the proportion of various genes, or sets of instructions, changes in a population.

Among evolutionary biologists the term **fitness** refers to an individual's reproductive success. **Natural selection** occurs when individuals are not all equally successful in terms of reproduction (when they are not all equally "fit"). Those particular individuals with traits that allow them to do well in a specific environment will have greater reproductive success than others with less useful traits. Consequently, those "good" traits will become relatively more common in the population. Think about this example:

Four female mice are living in a beach area that is mostly tan sand and some scattered plants. Mice in this habitat face predation from owls and hawks. Below is a list of how successful each mouse is in this environment.

Color of Fur	Brown	Tan	Black	White
Age at Death	6 months	8 months	4 months	2 months
# of pups produced	6	12	2	0
Running Speed	8 m/min	6 m/min	7 m/min	6 m/min

Which mouse has the highest fitness? Why?

If a mouse's fur color is generally similar to its mother's color, what color fur would be the most common among the pups?

The original population of mice consisted of 25% brown, 25% tan, 25% black, and 25% white mice. After the pups are born, and assuming the mothers die, what proportion of the population is brown, tan, black, and white?

Brown_____ + Tan _____ + Black _____ + White _____ = 100%

Assuming fur color in mice is a genetically controlled trait, has there been a change in the genetic makeup of the population, or in other words, has evolution happened?

[1] Adapted from labs written by Linda Van Thiel, S. M. Lawrence et al. 1998, and J. Doherty and I. Waldron.

The above example demonstrates the three prerequisites for evolution by natural selection:

1) Individuals have different traits.
2) Offspring tend to have the same traits as their parents (traits are heritable).
3) Traits determine individual's fitness.

Whenever these three things are true, not all individuals are going to be equally fit. That means some will reproduce more than others, and the traits of those most fit individuals will become more common in the population in the following generations….evolution will happen.

Methods: We are going to simulate a real-world example of evolution by natural selection. Predators profoundly influence the survival of their prey, and because the traits of prey individuals determine how likely they are to become lunch to a predator, predators can be a strong force driving the evolution of prey organisms.

In our simulation students will act as the predators and will "feed" on dried beans. Not all beans will have the same traits – they will vary in size and shape and color. We will see if the predators "select" for prey with certain traits, and whether the population of prey organisms changes through time. To make things more interesting, we are going to conduct this simulation in different environments and with different predator types. Will populations in different environments or facing different predators evolve in the same way or in opposite ways????

Foraging Rules:

1. Use utensils only – NO HANDS!
2. **Beans can only be captured one at a time – no mass capture!**
3. A captured bean must be placed into the predator's cup before it counts – and before the predator can continue foraging.
4. Any dropped bean is replaced in the habitat.
5. Predators can't directly interfere with other predators.

Simulation Instructions:

1) Randomly distribute the prey (the beans) across your habitat (either white paper {artic tundra}, or multi-colored rug {prairie}).
2) Pick three people to be predators; each should grab a utensil (fork, knife, or spoon). Pick one person to watch the clock.
3) The timekeeper says "*begin*" and allows the predators to forage for **three** minutes.
4) Each predator should count and record how many prey of each type they captured in Tables 1-3 (depending on what generation you are on). The group should fill in the rest of the table.
5) Take your data to your instructor, who will calculate how many prey of each type will be born into the population this generation. The number of births of each type is proportional to the number that still remain in your population (for instance, if the population after your foraging is now 50% peas and 50% black beans, the new births will be 50% peas and 50% black beans).

6) Put the appropriate number (what it says on the sheet your instructor gives you) of beans of each type back into the habitat.
7) Return to step 2.

Table 1. First Generation.

Predator Type	Number of Each Prey Type Killed by the Predators				
	Black	White	Pea	Pinto	**TOTAL**
Knife					
Fork					
Spoon					
TOTAL					*

*Total number of prey caught by all predators.

Table 2. Second Generation.

Predator Type	Number of Each Prey Type Killed by the Predators				
	Black	White	Pea	Pinto	**TOTAL**
Knife					
Fork					
Spoon					
TOTAL					*

*Total number of prey caught by all predators.

Table 3. Third Generation.

Predator Type	Number of Each Prey Type Killed by the Predators				
	Black	White	Pea	Pinto	**TOTAL**
Knife					
Fork					
Spoon					
TOTAL					*

*Total number of prey caught by all predators.

Table 4. The abundance of each prey type in the population through time.

Generation #	Abundance of Each Prey Type at the Beginning of Each Generation				
	Black	White	Pea	Pinto	**TOTAL**
1	150	150	150	150	600
2					
3					
4					

Answer the questions below on a separate sheet:

1.) What prey type became the most common in the “prairie” habitat? In the “artic tundra” habitat? Why did those prey types succeed in their environments?
2.) What do you think would happen to the prey populations if we ran our simulations for 50 generations?
3.) Did any individual beans change from being peas to black beans, or from being white beans to being pinto beans? If they had, what biological process would that represent?
4.) Could evolution by natural selection have happened if all of the beans were of one type (e.g., all pinto beans)?
5.) What predator type (e.g., knife, fork, spoon) was most effective in each habitat? If predator populations were represented more realistically in our simulation, with births and deaths being dependent on feeding success, what would have happened to the predator population?
6.) What do you think would have happened to the prey (bean) population if the predators had been blindfolded?