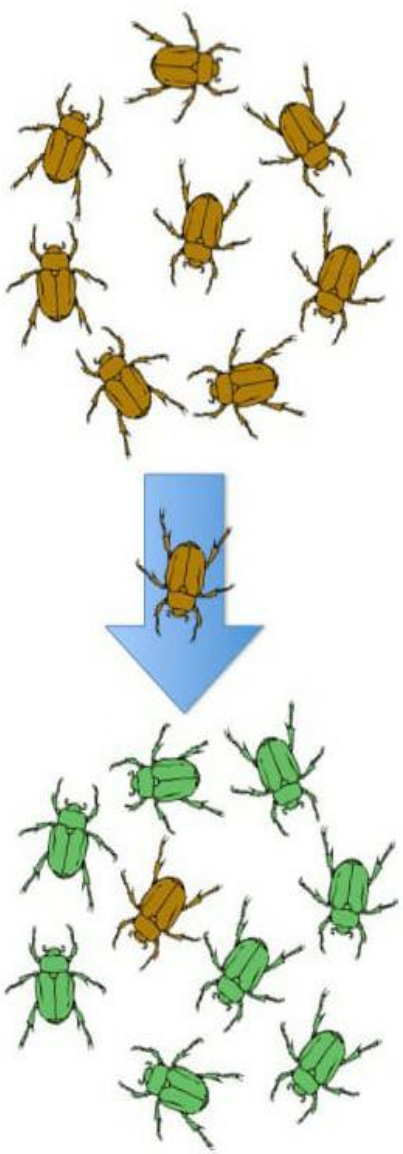
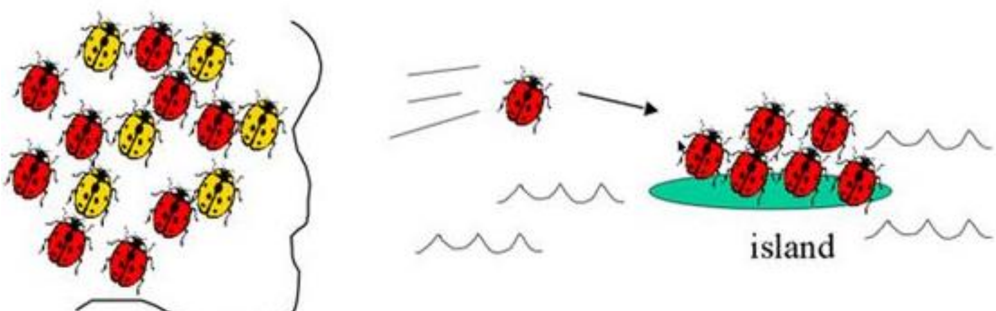
Other Mechanisms of Evolution

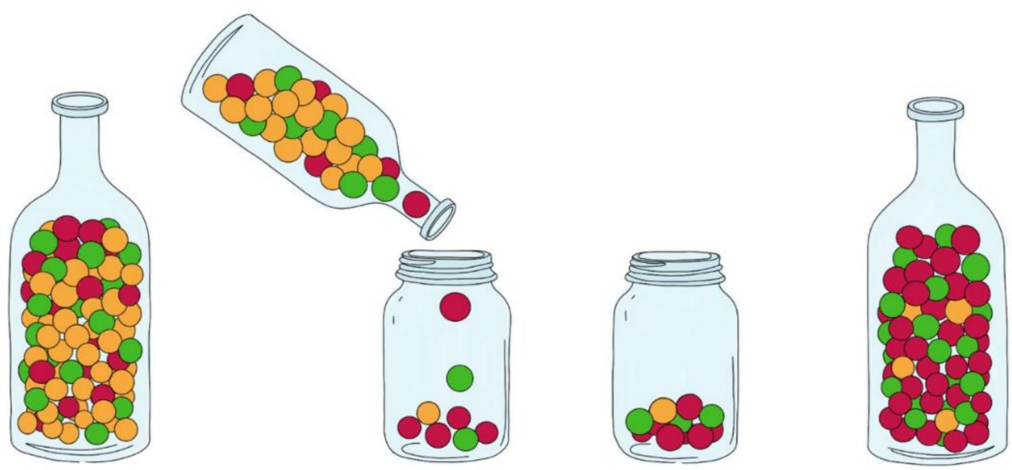
Natural selection is the primary mechanism by which evolution occurs. Evolution by natural selection results when certain individuals within a population are selected for, and others are selected against, by some natural selection force acting as an agent of nature. This natural selection force might be a predator, the availability of a food supply, or even a contagious pathogen. Those with a greater probability of survival, and by extension a greater likelihood of reproduction, are said to have greater fitness. A key component of natural selection is the "selection" itself – individuals are *chosen*, by nature, resulting in greater or diminished fitness.

However, the possibility exists that, due to random events, individuals aren't chosen based on their fitness, but rather by sheer luck. Being in the right place at the right time, or the wrong place at the wrong time, might result in an individual's survival or demise, regardless of their quantitative fitness. For example, natural disasters like hurricanes and volcanic eruptions may result in the deaths of large numbers of individuals within a population, yet any given individual's fitness played no role in its chance at survival.

In this series of activities, you'll investigate four main random drivers of evolution: gene flow, genetic drift, the bottle neck effect, and the founder effect.







Gene Flow

When an organism joins a new population and reproduces, its alleles become part of that population's gene pool. At the same time, these alleles are removed from the gene pool of its former population. The movement of alleles from one population to another is called gene flow. For many animals, gene flow occurs when individuals move between populations. Gene flow can occur in fungi and plant populations when spores or seeds are spread to new areas.

Materials

3 colors of small chips (green, blue, red)

Directions

1. Set up 3 populations in front of you. Set up the populations in any way you like, but each population must have *at least* 20 individuals and representatives *at least* 2 colors.
   a. Recreate the following table.

Before Gene Flow

	Population A	Population B	Population C
% of Green			
% of Blue			
% of Red			

2. Complete the following migrations:
   a. Randomly select 5 individuals from Population A and move them to one of the others.
   b. Move, at random, 5 individuals from Population C to Populations A and/or B.
   c. Randomly select 5 individuals from Population B and move them to Population A.
   d. Randomly select 3 individuals from *each* population and move them to any other population(s).
3. Observe what happened and recreate the table below, then record the results.

After Gene Flow

	Population A	Population B	Population C
% of Green			
% of Blue			
% of Red			

4. Return to the chips to their original location.

Analysis Questions

1. What do each of the colors represent in this model?
2. How does gene flow affect neighboring populations?
3. What do you think happens if gene flow does not occur?
4. Describe gene flow.
5. What is the connection between gene flow, the Hardy-Weinberg equation, and Hardy-Weinberg equilibrium?

Genetic Drift

Small populations, like small sample sizes, are more likely to be affected by chance. Due to chance alone, some alleles will likely decrease in frequency and become eliminated. Other alleles will likely increase in frequency and become fixed. These changes in allele frequencies that are due to chance are called genetic drift. Genetic drift causes a loss of genetic diversity in a population.

Materials

deck of cards

Directions

Use a deck of cards to represent a population of island birds. The four suits represent different alleles for tail shape. The allele frequencies in the original population are 25% spade, 25% heart, 25% club, and 25% diamond tail shapes.

	Spade	Heart	Club	Diamond
Initial %	25	25	25	25
New Population %				

1. Shuffle the cards and hold the deck face down. Turn over 40 cards to represent the alleles of 40 offspring produced by random matings in the initial population.
2. Separate the 40 cards by suit. Find the allele frequencies for the offspring by calculating the percentage of each suit.
3. Suppose a storm blows a few birds to another island. They are isolated on this island and start a new population. Reshuffle the deck and draw 10 cards to represent the traits of 10 offspring produced in the smaller population.
4. Repeat step 2 to calculate the resulting allele frequencies.

Analysis Questions

1. Analyze Compare the original allele frequencies to those calculated in steps 2 and 4. How did they change?
2. Did step 1 or 3 demonstrate genetic drift?
3. Does this activity demonstrate evolution? Why or why not? Does it demonstrate natural selection? Explain.
4. Describe genetic drift.
5. What is the connection between genetic drift, the Hardy-Weinberg equation, and Hardy-Weinberg equilibrium?

Bottleneck Effect

The bottleneck effect is genetic drift that occurs after an event greatly reduces the size of a population. One example of the bottleneck effect is the overhunting of northern elephant seals during the 1800s. By the 1890s, the population was reduced to about 20 individuals. These 20 seals did not represent the genetic diversity of the original population.

Materials

small flask, 4 colors of beads (black, white, red, green), tray

Directions

1. Count out 40-50 beads. You can include as many beads of a given color as you like, but each color must be represented. Calculate the percent of each bead color in the population you created.
2. Put all of the beads into the flask.
3. GENTLY shake the flask to mix up the beads.
4. Pour out **exactly** 5 beads into the tray. If you accidentally pour more than 5 beads, return them to the flask and try again.
5. Calculate the frequency of the new population of beads in the tray and record in your chart.
6. Repeat steps 2-5 four more times for a total of 5 trials.
7. Return to the beads to their original location.

		% Black	% White	% Red	% Green
	Initial Population %				
Final Population %	Trial 1				
	Trial 2				
	Trial 3				
	Trial 4				
	Trial 5				

Analysis Questions

1. What do each of the colors of beads represent in this model?
2. How do each of the trials compare and contrast with one another? Describe how each compares to the original population.
3. Describe the bottleneck effect and how it affects genetic diversity.
4. What is the relationship between the bottleneck effect and genetic drift?
5. Predict what will happen to the alleles in the new population as the population starts to grow.
6. What impact can the bottleneck effect have on populations that have rebounded after near extinction?

Founder Effect

The founder effect is genetic drift that occurs after a small number of individuals colonize a new area. The gene pools of these populations are often very different from those of the larger populations. The founder effect can be studied in human populations such as Old Order Amish communities. These communities were founded in North America by small numbers of migrants from Europe. For example, the Amish of Lancaster County, Pennsylvania, have a high rate of Ellis–van Creveld syndrome. Although this form of dwarfism is rare in other human populations, it has become common in this Amish population through genetic drift.

Materials

3 colors of small chips (green, blue, red)

Directions

1. Set up a population in front of you. Set it up in any way you like, but the population must have at least 60 individuals and representatives of all 3 colors.
2. Have one partner close their eyes and select 6 organisms at random.
3. Separate those 6 individuals to represent their migration to a new, unpopulated habitat … like an island.
4. Calculate the color frequency of the new population on the island.
5. Return to the chips to their original location.

	Green	Blue	Red
Initial Population %			
Final Population %			

Analysis Questions

1. What do each of the colors represent in this model?
2. Describe the founder effect and how it affects genetic diversity.
3. What is the relationship between the founder effect and genetic drift?
4. Predict what will happen to the alleles in the new population as the population starts to grow.
5. Ellis–van Creveld syndrome is a recessive trait. Explain why it has become common in the Amish of Lancaster County while remaining very rare in other human populations.