Name: __________________ Date: ______________
Class: __________________ Period: ____________

Mechanisms of Evolutions: Genetic Drift and Gene Flow

Natural selection is a non-random process that favors adaptive traits, which are traits that increase survival and reproduction. If these adaptive traits have a genetic basis, natural selection can result in evolution—a change in the frequency of a heritable trait as it passes from one generation to the next.

In contrast, two random processes, the **bottleneck effect** and the **founder effect**, cause **genetic drift**, random changes in the genetic status of a population. The bottleneck effect is a reduction in the size of a population as a result of mortality that is not due to the quality of an individual's traits, but is simply a result of bad luck. The founder effect is the separation of a few individuals into a new population by a random process that is also not due to the quality of their traits. Although genetic drift is not due to the influence of a particular trait on reproduction or survival, it can change the frequency of alleles from one generation to the next, and hence, can cause evolutionary change. In some cases, genetic drift changes the frequency of traits that are important. Genetic drift can, for example, cause alleles that are harmful to reach a frequency of 100% and it can cause beneficial alleles to reach a frequency of 100%. As this example suggests, genetic drift is "blind" to the adaptive value of alleles and hence it can lead to the fixation of harmful or beneficial alleles.

The size of a population determines the influence of random events, such as bottleneck or founder effects. For example, if you flip a coin twice, the frequency of "heads" could easily range from 0/2 (0%) to 2/2 (100%); however, if you flipped the coin 100 times, the frequency of "heads" would be much more likely to stay near 50%. To put this same process into a biological context, individual random events determining the assignment of chromosomes to gametes, the combination of gametes at fertilization, or the survival of individuals, have a stronger influence on small populations. As a result, genetic drift has a much larger effect in small populations than in large populations.

In today's activities, you will perform a simulation experiment to observe evolutionary effects of genetic drift on allele frequencies within a population.

Experiment: Simulation of Genetic Drift

In this simulation, you will use **black beans** to represent **dark-colored moths** and **white beans** to represent **light moths**. You will randomly determine which individual moths survive to produce the next generation. In some generations many individuals will survive to produce the next generation; in other generations only a few individuals will be lucky enough to survive and contribute to the next generation. This will allow you to contrast genetic drift in small versus large populations.

Each group of students will share their results with the entire class. When you compare the evolutionary results (changes in the frequencies of dark moths between generations) between groups, you will be able to determine if genetic drift produces a consistent response or if it varies, and how it varies, between groups.

<u>Methods for the Genetic Drift Simulation:</u>

You first will simulate three rounds of genetic drift associated with survival and reproduction of a large random sample (50 individuals) of the population. You will then simulate three rounds of genetic drift associated with survival and reproduction of a small random sample (5 individuals) of the population.

1. Select 50 light and 50 dark moths, and set them in a mixed pile on the table. Record the number of dark and light moths in Generation One of Table 6.1.

2. Simulate the first round of genetic drift by closing your eyes and randomly picking 50 moths from the pile of 100 on the table. These 50 selected moths are the ones that have survived a bottleneck effect during Generation One. Record the numbers of surviving light and dark moths in Table 6.1.

3. Build the population back up to 100, assuming the fifty parents you selected produced offspring similar to themselves. For example if you happened to pick 30 dark and 20 light moths (60% dark and 40% light), your 2ndgeneration should begin with 60 dark and 40 light moths.

4. Starting with this 2nd generation of moths, repeat steps 2 and 3 to determine which moths survived Generation Two and started Generation Three. Repeat steps 2 and 3 again to determine who survived Generation Three and entered Generation Four. Finally, repeat steps 2 and 3 a third time to determine who survived Generation Four and entered Generation Five.

5. Now you are ready to implement genetic drift using a small sample size. Repeat steps 2 and 3 for the last 3 generations, except in these simulations, only allow 5 individuals to survive each bottleneck. Still start each population with 100 individuals. In this step, you will multiply the surviving moths by 20 in order to simulate reproduction and calculate the next generation's beginning population.

6. Enter your group's numbers of dark moths at the beginning of each of the 7 generations in a table that your instructor will draw on the board. Record each group's data into Table 6.2.

Table 6.1. Individual Group Results--Numbers of light and dark moths in Experiment 1

Generation	Number of moths at the beginning of the generation (out of 100)		Number of surviving moths (out of a sample of 5 or 50)	
	Light	Dark	Light	Dark
One (50)				
Two (50)				
Three (50)				
Four (50)				
Five (5)				
Six (5)				
Seven (5)				

Table 6.2. Class Results from Genetic Drift Simulation

	Number of Dark Moths at the Beginning of Each Generation					
Generation	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6
One						
Two						
Three						
Four						
Five						
Six						
Seven						

Extension Activity: Gene Flow

Genetic Flow:

Objective: To illustrate the effects of gene flow on allele frequencies within a population of white and dark colored moths.

Conceptual Overview:

Gene flow is the exchange of genes between populations. Unless the two populations have exactly the same frequencies of a particular gene the overall composition of the resulting population will be altered. Remembering that evolution is defined as a change in gene frequencies over time, we see how gene flow can be an evolutionary force.

Procedure:

1) Randomly select a 20 bean (allele) sample of light and dark colored moths.
2) Each lab group from the genetic drift activity should combine with another group to form a larger group. Each larger group should now have two distinct 20 bean moth samples and a record of the bean (allele) frequencies for their sample.

3) These samples are genetically distinct populations. It is important to note that these genetically distinct populations do not represent different species and that the two distinct theoretical populations can interbreed.

4) Each sample population from the genetic drift activity which split away from the original parent population in that activity have all encountered another split off population and decided to live together. The two populations become effectively one breeding population, tell students to combine both 20 bean moth samples into one bowl which makes one population of 40 beans. Students should count the number of each type of bean (allele) for this new population and determine the frequencies of each. Students should then compare these new bean (allele) frequencies with those of the two original 20 bean populations and note how they have changed.

5) Ask students to discuss these new results among themselves and then report back to the class.

<u>Example of Data Table</u>

		Original Parent Population
Dark Bean (allele *B*)	Count	
	Frequency	
Light Bean (allele *b*)	Count	
	Frequency	

Lab Assignment-Data Analysis

1. In your lab notebook identify the Independent and Dependent Variables, the control group, and 3 constants.

2. Make a graph of the class results from the genetic drift and Gene Flow simulations. Make a line graph with Time (generations) across the horizontal axis and Dark Moths (beginning population size for each generation) on the vertical axis. Represent each group with a separate line within your graph.

3. Describe the results of the genetic drift and gene flow simulations. In written form, describe the pattern or lack of pattern in your results. Pay special attention to the slopes of your lines and how they are influenced by sample size. Are the lines generally parallel or are they heading in different directions? Did any of the populations reach **fixation** (when either trait, light or dark moths, reaches 100%)?

4. Draw a cartoon or write a news story detailing the differences between genetic drift and gene flow.

5. For each simulation, write a concluding statement(s) with evidence from your analysis of the data to justify your concluding statement(s).

6. How can genetic drift and gene flow affect natural selection/evolution rates?

7. Ticket out: Drawn on the board are 3 columns under each of the two mechanisms of evolution (1. Causes populations to become similar to each other; 2. Causes populations to become more diverse/varied; 3. Causes one population to die out). Place one half of the sticky note provided under the column that best represents the result of Gene Flow. Do the same for Genetic Drift using the other half of your sticky note.