**Mechanisms of Evolution: Genetic Drift**

**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.***

**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’s data will be compiled to create class data. When you compare the evolutionary results (changes in the frequencies of dark moths between generations) between groups (by looking at class data), you will be able to determine if genetic drift produces a consistent response or if it varies, and how it varies, between groups.

**Procedure for Genetic Drift Simulation on a Large Population:**

In this part of the lab, you will simulate three rounds of genetic drift associated with survival and reproduction of a large random sample (50 individuals) of the population. Select 50 light and 50 dark moths, and put them in the cup at your lab station. Gently shake the cup to mix up the beans. Record the number of dark and light moths in Generation One of Table 6.1.

1. Simulate the first round of genetic drift by closing your eyes and randomly picking 50 moths from the cup. These 50 selected moths are the ones that have survived a bottleneck effect (due to a hurricane, volcano, tsunami, etc.) during Generation One. Record the numbers of surviving light and dark moths in Table 6.1.
2. Build the population back up to 100, assuming the fifty parents you selected reproduced and produced offspring similar to themselves. For example if you happened to pick 30 dark and 20 light moths (60% dark and 40% light), your 2nd generation should begin with 60 dark and 40 light moths.
3. Starting with this 2nd generation of moths, repeat steps 1 and 2 to determine which moths survived Generation Two and started Generation Three. Repeat steps 1 and 2 again to determine who survived Generation Three and started Generation Four. Repeat steps 1 and 2 again to determine who survived Generation Four.

**Procedure for Genetic Drift Simulation on a Small Population:**

In this part of the lab, you will simulate three rounds of genetic drift associated with survival and reproduction of a small random sample (5 individuals) of the population. Select 50 light and 50 dark moths, and put them in the cup at your lab station. Gently shake the cup to mix up the beans. Record the number of dark and light moths in Generation One of Table 6.2.

1. Simulate the first round of genetic drift by closing your eyes and randomly picking 5 moths from the cup. These 5 selected moths are the ones that have survived a bottleneck effect (due to a hurricane, volcano, tsunami, etc.) during Generation One. Record the numbers of surviving light and dark moths in Table 6.2.
2. Build the population back up to 100, assuming the 5 parents you selected reproduced and produced offspring similar to themselves. To accomplish this, you will multiply the surviving moths by 20 in order to simulate reproduction and calculate the next generation’s beginning population.
3. Starting with this 2nd generation of moths, repeat steps 1 and 2 to determine which moths survived Generation Two and started Generation Three. Repeat steps 1 and 2 again to determine who survived Generation Three and started Generation Four. Repeat steps 1 and 2 again to determine who survived Generation Four.
4. When you are finished with both simulations, record your group’s data for the number of dark moths at the beginning of each of the four generations on the Class Data table on the white board at the front of the room. Then, copy the class data on your Data Table 6.3 and 6.4.
5. Answer the analysis questions on the back of your lab sheet.

**Name \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Date\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Per\_\_\_\_\_\_\_\_\_\_\_\_**

**Mechanisms of Evolution: Genetic Drift**

**Data:**

**Table 6.1 Individual Group Results – Genetic Drift in a Large Population of Light and Dark Moths**

|  |  |  |
| --- | --- | --- |
|  | **Number of moths at the beginning of the generation (out of 100)** | **Number of surviving moths (out of a sample of 50)** |
| **Generation** | **Light** | **Dark** | **Light** | **Dark** |
| **1** |  |  |  |  |
| **2** |  |  |  |  |
| **3** |  |  |  |  |
| **4** |  |  |  |  |

**Table 6.2 Individual Group Results – Genetic Drift in a Small Population of Light and Dark Moths**

|  |  |  |
| --- | --- | --- |
|  | **Number of moths at the beginning of the generation (out of 100)** | **Number of surviving moths (out of a sample of 50)** |
| **Generation** | **Light** | **Dark** | **Light** | **Dark** |
| **1** |  |  |  |  |
| **2** |  |  |  |  |
| **3** |  |  |  |  |
| **4** |  |  |  |  |

**Table 6.3 Class Results – Genetic Drift in a Large Population – Number of Dark Moths at the Beginning of Each Generation**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Group** | **Generation 1** | **Generation 2** | **Generation 3** | **Generation 4** |
| **1** |  |  |  |  |
| **2** |  |  |  |  |
| **3** |  |  |  |  |
| **4** |  |  |  |  |
| **5** |  |  |  |  |
| **6** |  |  |  |  |
| **7** |  |  |  |  |
| **8** |  |  |  |  |
| **9** |  |  |  |  |
| **10** |  |  |  |  |
| **11** |  |  |  |  |
| **12** |  |  |  |  |
| **13** |  |  |  |  |
| **14** |  |  |  |  |
| **15** |  |  |  |  |
| **Average** |  |  |  |  |

**Table 6.3 Class Results –**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Group** | **Generation 1** | **Generation 2** | **Generation 3** | **Generation 4** |
| **1** |  |  |  |  |
| **2** |  |  |  |  |
| **3** |  |  |  |  |
| **4** |  |  |  |  |
| **5** |  |  |  |  |
| **6** |  |  |  |  |
| **7** |  |  |  |  |
| **8** |  |  |  |  |
| **9** |  |  |  |  |
| **10** |  |  |  |  |
| **11** |  |  |  |  |
| **12** |  |  |  |  |
| **13** |  |  |  |  |
| **14** |  |  |  |  |
| **15** |  |  |  |  |
| **Average** |  |  |  |  |

**Genetic Drift in a Small Population – Number of Dark Moths at the Beginning of Each Generation**

**Analysis:**

1. Make a line graph of the class averages from the genetic drift simulations. Make a line graph with time (generations) across the horizontal axis and number of dark moths (beginning population size for each generation) on the vertical axis. Use two different colored pencils – one for the large population and one for the small population. Include a title, labels for the axis, and a key.



***Refer to the lab intro and answer the following questions in complete sentences that re-state the question.***

1. Define genetic drift.
2. What is bottleneck effect?
3. What is founder effect?

***Complete the following on a separate sheet of paper and staple to your lab data sheet.***

Describe the results of the genetic drift 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%)? Your answer must be in complete sentences and in paragraph format. Elaborate!!!