Student Guide
17-1200 Natural Selection BioKit®

Name _____
Date _____

Purpose

To examine the principles of genetic equilibrium and natural selection as processes related to evolution in populations.

Background

The Hardy-Weinberg Law states that if different forms of a gene (alleles) are present in a large randomly breeding population, the gene frequencies will remain in equilibrium from generation to generation if other forces (mutation, migration, and selection) are not operating. If one or more of these factors is operating within a population, the equilibrium may be disturbed and the gene frequencies may change. If there is continued selection for a particular phenotype (actually selection against an unfavorable phenotype), the gene frequencies will be altered in a directed manner and evolution will occur. Although genetic equilibrium with respect to all combinations of genes in a population rarely if ever occurs, such an equilibrium can be used as a basic model against which we can measure genetic change.

PART A. HARDY-WEINBERG EQUILIBRIUM

The colors of beads provided represent alleles of a gene. All of the beads in the cup represent all such alleles in the gene pool of a population. Each cup should contain 60 white beads (allele A) and 40 red beads (allele a). Thus, the gene frequencies expressed as decimal fractions would be: $A = 0.6 = p$ and $a = 0.4 = q$. Because only two alleles are considered in this example, the mathematical expression can be written: $p + q = 1$. By expanding this binomial we get: $(p + q)^2 = p^2 + 2pq + q^2 = 1$. In this representation p^2 is the proportion of AA individuals, $2pq$ the Aa individuals, and q^2 the aa individuals in the population.

1. Cover the cup with your hand and shake it to randomly distribute the beads. Withdraw one pair of beads from the cup *without looking* in order to avoid selecting a particular combination. This pair simulates the diploid combination of alleles in an individual of the next generation.
2. Record the gene pair (genotype) in Table 1 (Data Sheet). Return the beads to the cup and shake to distribute them. Repeat this procedure to obtain a total of 100 individual genotypes.
3. From the genotypes recorded in Table 1, compute the gene and genotype frequencies using the following equations. Enter the results in Table 1.

$$\text{Frequency of } AA = \frac{\text{Total } AA}{\text{Total } AA + \text{Total } Aa + \text{Total } aa}$$

$$\text{Frequency of } Aa = \frac{\text{Total } Aa}{\text{Total } AA + \text{Total } Aa + \text{Total } aa}$$

$$\text{Frequency of } aa = \frac{\text{Total } aa}{\text{Total } AA + \text{Total } Aa + \text{Total } aa}$$

4. Calculate the theoretical (expected) frequency of each genotype using the expression: $p^2 + 2pq + q^2 = 1$. Record the results in the space provided below Table 1.
5. Assuming A dominant to a, compute the theoretical phenotypic ratio $(p^2 + 2pq)$ (q^2) and record in the space provided below Table 1.

PART B. NATURAL SELECTION

1. Place all of the beads in the cup as at the beginning of Part A. Remove them in pairs as before and record a total of 100 resulting genotypes in Table 2 (Data Sheet).
2. *Immediately* report your results to the instructor. When all class results for this generation have been reported, total them and complete the information for this generation in Table 2 using the equations given in Part A.
3. Because natural selection operates only on the phenotype, the less favorable genes must be expressed in order for selection to occur. Thus if *A* is dominant to *a* and *aa* produces an unfavorable phenotype, selection will eliminate a greater proportion of the *aa* individuals than *AA* or *Aa* individuals. Simulate selection against 1/2 of the *aa* phenotypes by removing 1/2 of the red beads (*a*) present in the percent of *aa* individuals based on the class total. For example; if 17% of the individuals were *aa*, you would remove 17 red beads from your cup and set them aside.
4. Withdraw the beads pairwise as before to obtain a total of 100 offspring and record the number of each genotype for generation 2 in Table 2.
5. *Immediately* report these results to your instructor. Again total the class results and complete Table 2 for generation 2.
6. Continue selection through additional generations as time permits and observe the changes in gene frequencies which result.

What is happening to the frequencies of the two alleles as selection against *aa* individuals continues to operate through successive generations?_____

_____

_____

_____

If this selection continues will all of the a genes eventually be eliminated from the population?_____ Why (Why not)?_____

_____

_____

Carolina Biological Supply Company

2700 York Road, Burlington, North Carolina 27215

CB210469509