Overview:
In this activity you will learn about the Hardy-Weinberg Law of genetic equilibrium and study the relationship between evolution and changes in allele frequency by using your class to represent a sample population.

Objectives: Before doing this laboratory you should understand:
- How natural selection can alter allelic frequencies in a population;
- The Hardy-Weinberg equation and its use in determining alleles in a population; and
- The effects on allelic frequencies of selection against the homozygous recessive or other genotypes.

After doing this laboratory you should be able to:
- Calculate the frequencies of alleles and genotypes in the gene pool of a population using the Hardy-Weinberg formula, and
- Discuss natural selection and other causes of microevolution as deviations from the conditions required to maintain Hardy-Weinberg equilibrium.

Introduction:
In 1908, G.H. Hardy and W. Weinberg independently suggested a scheme whereby evolution could be viewed as changes in the frequency of alleles in a population of organisms. In this scheme, if \( A \) and \( a \) are alleles for a particular gene locus and each diploid individual has two such loci, the \( p \) could be designated as the frequency of the \( A \) allele and \( q \) as the frequency of the \( a \) allele. Thus, in a population of 100 individuals (each with two loci) in which 40% of the alleles are \( A \), \( p \) would be 0.40. The rest of the alleles (60%) would be \( a \), and \( q \) would equal 0.60 (i.e. \( p+q = 1.0 \)). These are referred to as allele frequencies. The frequency of the possible diploid combinations of these alleles (AA, Aa, and aa) is expressed by \( p^2 + 2pq + q^2 = 1.0 \). Hardy and Weinberg also argued that if five conditions are met, the population’s allele and genotype frequencies will remain constant from generation to generation. These conditions are as follows:
1. The breeding population is large. (The effect of chance on changes in allele frequencies is thereby greatly reduced.)
2. Mating is random. (Individuals show no mating preference for a particular phenotype.)
3. There is no mutation of the alleles.
4. No differential migration occurs. (No immigration or emigration.)
5. There is no natural selection. (All genotypes have an equal chance of surviving and reproducing.)
The Hardy – Weinberg Theorem and Teddy Grahams

Introduction:
Charles Darwin’s contribution to biology was not that he “discovered evolution”, but rather that he proposed a mechanism for evolutionary change – natural selection, the differential survival and reproduction of individuals in a population. In On the Origin of Species, published in 1859, Darwin described natural selection and provided abundant evidence in support of evolution, the change in populations over time. However, at the turn of the century, geneticists and naturalists still disagreed about the role of selection and the importance of small variations in natural populations. How could these variations provide a selective advantage that would result in evolutionary change? It was not until evolution and genetics became reconciled with the advent of population genetics that natural selection became widely accepted.

Ayala (1982) define evolution as “changes in the genetic constitution of populations”. A population is defined as a group of organisms of the same species that occur in the same area and interbreed or share a common gene pool, all the alleles at all gene loci of all individuals in the population. Populations evolve, individuals do not.

In 1908, English mathematician, G. H. Hardy and German physician, W. Weinberg independently developed models of population genetics that showed that the process of heredity by itself did not affect the genetic structure of a population. The Hardy – Weinberg theorem states that the frequency of alleles in the population will remain the same regardless of the starting frequencies. Furthermore, the equilibrium genotypic frequencies will be established after one generation of random mating. In this scheme, if A and a are alleles for a particular gene locus and each diploid individual has two such loci, the p can be designated as the frequency of the A allele and q as the frequency of the a allele. Thus, in a population of 100 individuals (each with two loci) in which 40% of the alleles are A, p would be 0.40. The rest of the alleles, 60% would be a, and q would equal 0.60 (p + q = 1.0). These are referred to as allele frequencies. The frequency of the possible diploid combinations of these alleles (AA, Aa, aa) is expressed as:

\[ p^2 + 2pq + q^2 = 1.0 \]

This theorem is valid only if certain conditions are met:
1. The population is large. (The effect of chance on changes in allele frequencies is hereby greatly reduced.)
2. Mating is random. (Individuals show no mating preference for individuals of a particular genotype.)
3. There are no net changes in the gene pool due to mutation, that is mutation from A to a must be equal to mutation from a to A.
4. There is no migration of individuals into and out of the population.
5. There is no selection; all genotypes are equal in reproductive success.

Basically, the Hardy – Weinberg theorem provides a baseline model in which gene frequencies do not change and evolution does not occur. By testing the fundamental
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AP Lab 8 – Population Genetics and Evolution

Hypothesis of the Hardy – Weinberg theorem, evolutionists have investigated the roles of mutation, migration, population size, non-random mating and natural selection in effecting evolutionary change in natural populations. Although some populations maintain genetic equilibrium, the exceptions are intriguing to scientists.

**Activity:** Natural Selection in Teddy Grahams.

You are a bear eating monster. There are two kinds of bears that you like to eat: happy bears and sad bears. You can tell the difference between them by the way they hold their hands. Happy bears hold their hands high in the air, and sad bears hold their hands down low. Happy bears taste sweet and are easy to catch. Sad bears taste bitter and are devious and hard to catch. Because of this you eat only eat happy bears. The happy trait in bears is caused by the expression of a recessive allele. The homozygous recessive condition being happy. The sad trait is caused by a dominant allele. New bears are born every year (when they are hibernating in their den (box)) and the birth rate is one new bear for every old bear left from last year.

**Materials:**  
Box of Teddy Grahams  
Calculator  
Ruler

**Procedure:**

Obtain a population of 10 bears and record the number of happy and sad bears and the total population number. Using the same equations for Hardy – Weinberg equilibrium, calculate the frequencies of both the dominant and recessive alleles and the genotypes present in the population.

The happy bears would be the $q^2$ genotype.

Ex: If 5 out of 10 bears are happy, then 10 out of 20 alleles would be happy alleles. Therefore, the $q^2$ number would be 0.5. You must then determine the q number by taking the square of 0.5.

1. Now go hunting. Eat 3 happy bears. (If you do not have 3 happy bears then eat the difference in sad bears)

2. Once you have consumed the bears, obtain a new generation from your den (the box). You should only remove 7 additional bears from the den for a total number of 14 bears.

3. Repeat the procedures again, be sure to record the number of each type of bear and the total population.
Data:
Extend the data table to accommodate class cumulative results for the 4 generations

<table>
<thead>
<tr>
<th>Generation</th>
<th>p^2 (sad)</th>
<th>2pq (sad)</th>
<th>q^2 (happy)</th>
<th>p</th>
<th>q</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. (initial)</td>
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<td>2.</td>
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<td>5.</td>
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</tbody>
</table>

Results:
1. Describe what is happening to the genotype and the allele frequencies in the population of Teddy Grahams?

2. What would you expect to happen if you were to now select for the sad bears?

3. Do the class results favor the evolution more than your individual data? Explain.

Conclusion:
Why doesn’t the recessive allele disappear from the population? How is it protected?