

The Hardy-Weinberg Theorem & Teddy Grahams

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Introduction: Charles Darwin's unique 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) defines 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. The population is considered to be the basic unit of evolution. Populations evolve, not individuals.

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:

*frequencies 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, then **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 (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 as:

$$p^2 + 2pq + q^2 = 1$$

This theorem is valid only if certain conditions are met:

- The population is very large. (The effect of chance on changes in allele frequencies is hereby greatly reduced).
- Matings are random. (Individuals show no mating preference for a particular phenotype).
- There are no net changes in the gene pool due to mutation. (Mutation from **A** to **a** equals mutation from **a** to **A**.)
- There is no migration of individuals into and out of the population.
- There is no selection; all genotypes are equal in reproductive success.

Purpose: To study the Hardy Weinberg theorem using Teddy Bear Grahams.

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, are devious and hard to catch. Because of this you only eat happy bears. The happy trait in bears is caused by the expression of a recessive allele. The homozygous recessive condition is being happy. The sad trait is caused by a dominant allele. New bears are born every year (when they are hibernating in their den, the cardboard box) and the birth rate is one new bear for every old bear left from last year.

Materials: Teddy Bear Grahams, and the lab worksheet.

Procedure:

1. Obtain a population of 10 bears and record the number of happy and sad bears and the total population number. Using the equation for Hardy-Weinberg equilibrium, calculate the frequencies of both the dominant and recessive alleles and the genotypes that are represented in the population.

Example: If 5 of the 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.

2. Now, go hunting! Eat 3 happy bears. (If you do not have 3 happy bears then eat the difference in sad bears.)
3. 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 of 14 bears.
4. Repeat the procedures again, be sure to record the number of each type of bear and the total population.

Materials: Teddy Bear Grahams, lab.

Table:

Generations	P^2 (sad)	$2pq$ (sad)	q^2 (happy)	p	q
1. Initial					
2.					
3.					
4.					

Questions:

1. Describe what is happening to the genotype and allele frequencies in the population of Teddy Grahams?
2. What would you expect to happen if you continued the selection process for additional generations?
3. How would the frequencies change if you were to now select for the sad bears?
4. Why doesn't the recessive allele disappear from the population? How is it protected?