Introduction

Hardy, Weinberg and Castle determined that the frequencies of alleles and genotypes in a population remain the same over time, given that certain assumptions are met:

• Organisms are diploid
• Generations are non-overlapping
• Population must be large
• No immigration or emigration
• No mutation in the gene of interest
• No natural selection occurs (individuals reproduce at equal rates)
• Mating is random

Overview

How to solve Hardy-Weinberg Problems:

1. Determine the alleles.
   1. Frequency of the dominant allele is designated as 'p'
   2. Frequency of the recessive allele is designated as 'q'

2. Allelic Frequency Rule (Frequency of a SINGLE ALLELE in the population):
   \[ p + q = 1 \]

3. Genotype Frequency Rule (Frequency of a GENOTYPE in the population):
   \[ (p+q) (p+q) = 1 \]
   Simplify this statement using the FOIL rule:
   \[ p^2 + pq + pq + q^2 = 1 \]
   \[ p^2 + 2pq + q^2 = 1 \]

   - \( p^2 \) = frequency of homozygous dominant genotype
   - \( 2pq \) = frequency of heterozygous genotype
   - \( q^2 \) = frequency of homozygous recessive genotype
Sample Problem

In a population of 130,000 magical mice, green fur is dominant over orange. If there are 300 orange mice in a population of 130,000, find the following (assume population is in Hardy-Weinberg equilibrium):

1. Frequency of dominant (green) allele
2. Frequency of recessive (orange) allele
3. Frequency of homozygous dominant, heterozygous and homozygous recessive genotypes

Step 1: Assign the Alleles

• By convention, we use the dominant phenotype to name the alleles. In this case, green is dominant over orange, so we'll use 'G' for green fur and 'g' for orange fur.
• Assign 'p' to be the frequency of G, the green fur allele
• Assign 'q' to be the frequency of g, the orange fur allele
Step 2: Calculate q

The number of homozygous recessive individuals is $q^2$, NOT $q$. To find $q$, take the square root of $q^2$.

\[
q^2 = \frac{300}{130,000} = 0.002 \\
q = \sqrt{0.002} = 0.04
\]

Step 3: Calculate p

Once you have $q$, finding $p$ is easy! The sum of the frequencies of both alleles must equal 1.

\[
p + q = 1 \\
p = 1 - q \\
p = 1 - 0.04 \\
p = 0.96
\]

Step 4: Use $p$ and $q$ to calculate the remaining genotypes

I always suggest that you calculate $q^2$ even though that's what you started with. Realize that rounding will give you slightly different values and all 3 genotype frequencies may not EXACTLY equal 1 because of this. It's fine.

\[
p^2 = 0.96 = 0.92 \\
2pq = 2(0.96)(0.04) = 0.08 \\
q^2 = 0.04^2 = 0.0016 \\
\text{(= 0.002)}
\]
That's it! Answer the questions:

1. Frequency of dominant (green) allele = 0.96
2. Frequency of recessive (orange) allele = 0.04
3. Frequency of each genotype:
   • homozygous dominant = 0.92
   • heterozygous = 0.08
   • homozygous recessive = 0.002

Need More Help?

Check out my video "The Hardy-Weinberg Principle" on the Penguin Prof YouTube channel. Good luck!