# The Hardy-Weinberg Rule

How Populations Evolve

# Terms to Know

- **Population genetics**:  the study of the properties of genes in populations
- **Alleles**:  alternative forms of a gene
- **Allele frequencies**:  the genotype proportions
- **Frequency**:  the proportion of individuals falling within a category in relation to the total number of individuals being considered   (f = Individuals/Total pop.)

# Historical Background

- Since the 1920s scientists have been formulating ideas on how populations evolve.
- Genetic variation within natural populations puzzled the minds of scientists such as Darwin.
- Scientists thought selection meant that the optimal form (dominant)was always favored.

# Hardy and Weinberg

- In 1908 G.H. Hardy and G. Weinberg claimed that allele frequencies could remain constant from generation to generation (the dominant allele would not replace the recessive allele in large populations).
- Their model analyzes what happens to the frequencies of two alleles when there are NO evolutionary forces acting on the population.

# Five Assumptions

1.) large population size

2.) random mating between individuals

3.) no mutation

4.) no input of new copies of any allele from any extraneous source

5.) natural selection is not occurring

**For an animation illustrating the Hardy-Weinberg Principle – click the link below and it will in a different window. Refresh to restart, it will continue to loop:**

**http://zoology.okstate.edu/zoo_lrc/biol1114/tutorials/Flash/life4e_15-6-OSU.swf**

- HOW LIKELY IS IT THAT ALL FIVE ASSUMPTIONS WILL BE MET BY A POPULATION OF ORGANISMS IN THE NATURAL ENVIRONMENT????

# Hardy-Weinberg Equation

$$(p+q)^2 = p^2 + 2pq + q^2$$

$p^2$ = Individuals homozygous for allele B

$2pq$ = Individuals heterozygous for alleles B and b

$q^2$ = Individuals homozygous for allele b

Because there are only two alleles, the sum of p and q always equal to one.

# Example Problem

In a population of 100 rabbits, if we assume the black color to be the dominant trait, then 25 black rabbits would represent the individuals homozygous for the dominant allele B. Therefore, in this case, $p^2 = 0.25$.

a.) Find what p must equal

b.) Find what q must equal

c.) Find what 2pq must equal

# Find what p must equal

If $p^2 = 0.25$ then p must equal the square root of 0.25.

Thus, $p = 0.5$

# Find what q must equal

Recall that $(p+q) = 1$

Thus, $q = 1 – p$

$q = 1 – 0.5$

$q = 0.5$

# Find what 2pq must equal

Since we know the values for both p and q, we can simply multiply 2 x p x q.

Thus, $2pq = 2 \times 0.5 \times 0.5$

$2pq = 0.5$

# Basic Relations

- Two alleles at a gene: A and a
- Frequency of the A allele: p
- Frequency of the a allele: q
- At genetic equilibrium:
  - $p^2 + 2pq + q^2 = 1$
- $p + q = 1$
- $1 – q = p$

# The purpose of the Hardy-Weinberg Rule

- Biologists are able to predict how allele frequencies will change in the absence of evolutionary forces.
- For many genes, predictions made by the Hardy-Weinberg equation are very accurate.
  - Human disease: cystic fibrosis

# Cystic Fibrosis

- The recessive allele responsible for this disease is present in Caucasian North Americans at a frequency of about 0.022 (q).
- You can find the proportion of heterozygous carriers by using this rule.

# Calculating the frequency of heterozygous individuals (2pq)

We know that q = 0.022.

Thus, p = 1- 0.022 = 0.978

2pq = 2 x 0.978 x 0.022 = 0.043032

Therefore, about 43 in every 1,000 individuals are heterozygous carriers of this disease, which is very close to the real estimate.