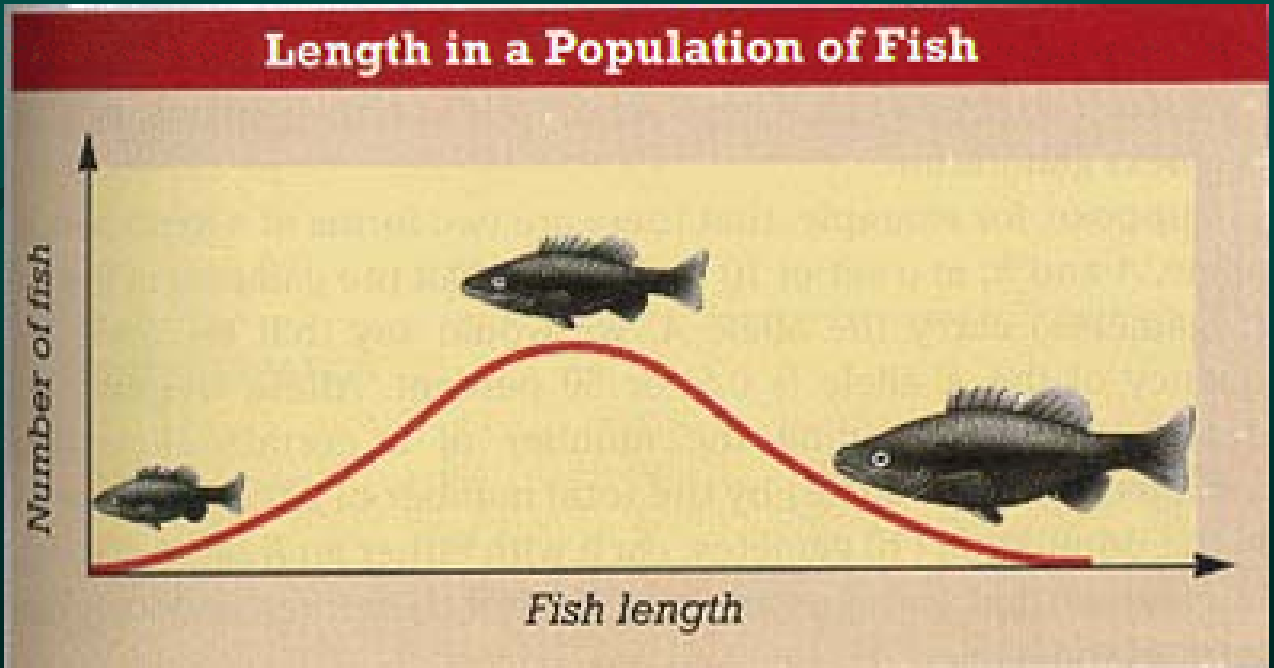
Population Genetics and Hardy-Weinberg Equilibrium

The Birth of Population Genetics

- When Mendel's work was rediscovered in the early 1900's, biologists began to investigate how alleles might increase or decrease in numbers.
- **Population genetics** is the study of evolution from a genetic point of view.
- Evolution can be defined as a gradual change in the genetic material of a population.

Variation of Traits in a Population

- Within a population individuals vary in observable traits.
- Often these traits cover a range that can be represented by a **bell curve**.

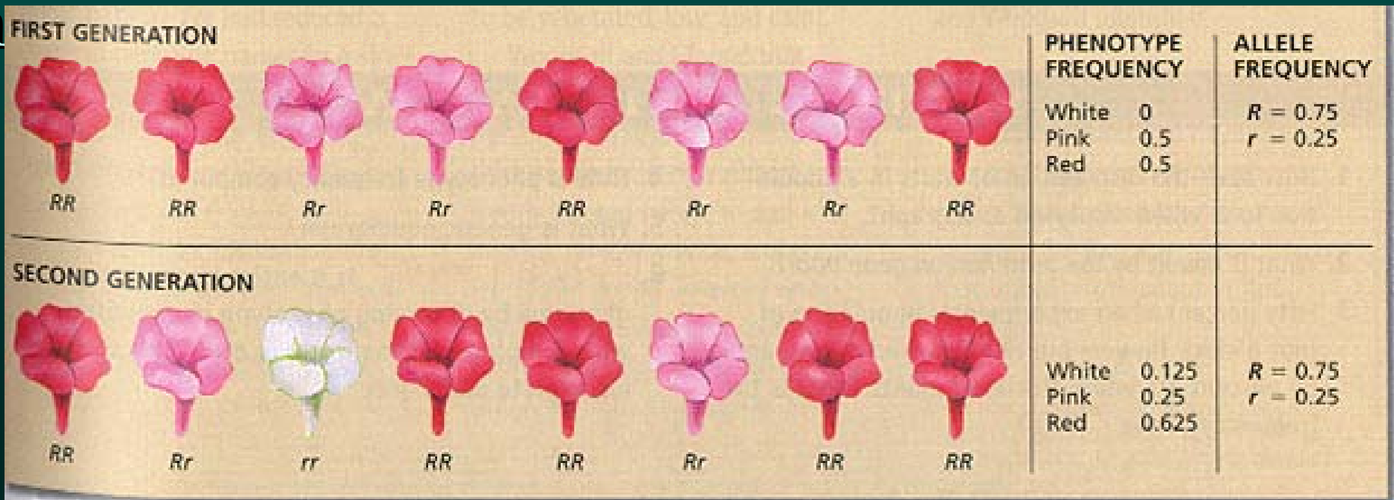


Allele Frequencies and The Gene Pool

- A **gene pool** is the total genetic information available in a population.
- **Allele frequency** is determined by dividing the number of a certain allele by the total number of alleles of all types.
- For example – two alleles **A** and **a** in a set of 10 gametes. If half the gametes carry the A, we would say the frequency of that allele is 0.5 or 50%. (Remember the gametes are haploid!)

Predicting Phenotype

- The population of four o'clock flowers below illustrate how phenotypes can change from generation to generation.
- RR = red; rr = white; Rr = pink
- The phenotypic frequency is equal to the number of individuals with a particular phenotype divided by the total number of individuals in the population.



Hardy-Weinberg Genetic Equilibrium

- In 1908, **Hardy and Weinberg** independently demonstrated that allele frequencies in a **<u>hypothetical,</u>** **<u>ideal</u>** population do not change
- The Hardy-Weinberg principle states that **the frequencies of alleles and genotypes in a population remain constant unless evolutionary forces act upon them.**

Hardy-Weinberg Genetic Equilibrium

The Hardy-Weinberg principle holds true only for **large** populations with:

- No natural selection
- No mutation
- No immigration or emigration
- Random mating

- These requirements are usually not met in natural populations.

Hardy - Weinberg

- The importance of Hardy Weinberg equation is that it allows you to predict the frequency of each genotype in a population if you know the allele frequencies.
- **Hardy-Weinberg equation is only valid when nature is blind to which allele an individual carries.**
- When natural selection operates - HW no longer applies.

Hardy - Weinberg

- Hardy Weinberg principle is usually stated as a pair of equations:

Equation 1: $p + q = 1$

where p = frequency of the dominant allele

q = the frequency of the recessive allele

eg. $p=A/(A + a) = .6$; $q=a/(A+a) = .4$;

$p + q = .6 + .4 = 1$

Hardy - Weinberg

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

where p^2 = the frequency of the homozygous dominant individuals

q^2 = the frequency of the homozygous recessive individuals

$2pq$ = the frequency of the heterozygotes

Hardy - Weinberg

- Where does this equation come from?
- Punnett Squares

	A	a
A	AA	Aa
a	Aa	aa

	p	q
p	p*p	p*q
q	p*q	q*q

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

Sample Problems

- If the frequency of a recessive allele in a population of panda bears is .6.
  - What is the frequency of the dominant allele?
    - p + q = 1
    - p = 1-q = 1 - .6 = .4
  - What is the frequency of heterozygotes in the population?
    - Heterozygotes = 2pq = 2*.4*.6 = .48
  - If there are 200 individuals in the population, how many are heterozygous?
    - 200(.48) = 96

Sample Problems

- If the frequency of falcons that are homozygous recessive is .25,
  - what is the recessive allele frequency?
    - q2 = .25, so q = .5
  - what is the frequency of the dominant allele?
    - p + q = 1 so p = 1-q = 1-.5 = .5
  - What is the frequency of all genotypes?
    - q2 = .5*.5 = .25 (already knew this)
    - 2pq = 2*.5*.5 = .5
    - p^2 = .5*.5 = .25
    - does $p^2 + 2pq + q^2 = 1$? Yes!