Darwin
- characteristics that provide the best adaptation to environment have better chance of being represented in the following generation

Some Early Skeptics
- If a fitter variant arises, will it not, out of necessity, have to mate with a less fit individual, which eventually would then lead to a dilution of the new characteristic and hence a dilution of the beneficial characters?

Mendel
- characteristics passed on as discrete units (genes) which do not lose their integrity Hardy-Weinberg law
- A blending process does not occur

Fleming Jenkins
- Shouldn’t the dominant phenotype swamp the recessive one?
- Wouldn’t an advantageous character in the blood become diluted?
Genotype frequencies of offspring are determined from the gene (allele) frequencies of their parents.

Hardy-Weinberg

The Hardy-Weinberg equilibrium is a fundamental principle in population genetics stating that the genotype frequencies and gene frequencies of a large, randomly mating population remain constant provided migration, mutation, and selection do not take place. 

Mendelian & Population Genetics

Mendelian genetics
  - families
Populations genetics
  - study of the distribution of genes in larger aggregates, or populations
  - Population/Mendelian pop./breeding pop.
    - genetically related or, share a common gene pool
    - endogamy: preference to mate within own group

CONDITIONS FOR HARDY-WEINBERG EQUILIBRIUM

The population must be infinitely large
Mating must be random
No migration/gene flow
No natural selection
No mutation
e.g., 2 alleles: A, a

<table>
<thead>
<tr>
<th>paternal/maternal</th>
<th>sperm/ova</th>
<th>A</th>
<th>a</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>AA</td>
<td>Aa</td>
<td></td>
</tr>
<tr>
<td>a</td>
<td>Aa</td>
<td>aa</td>
<td></td>
</tr>
</tbody>
</table>

AA : Aa : aa
1 : 2 : 1

<table>
<thead>
<tr>
<th>Freq. of alleles</th>
<th>p_A</th>
<th>q_a</th>
</tr>
</thead>
<tbody>
<tr>
<td>p_A</td>
<td>p^2_{AA}</td>
<td>p_{Aa}</td>
</tr>
<tr>
<td>q_a</td>
<td>p_{Aa}</td>
<td>q^2_{aa}</td>
</tr>
</tbody>
</table>

$p^2$ = chance of A combining with A (AA)
2pq = chance of A combining with a (Aa)
$q^2$ = chance of a combining with a (aa)

AA : Aa : aa
p^2 + 2pq + q^2
1 : 2 : 1

p^2 = frequency of A (dominant) allele
q = frequency of a (recessive) allele
$p + q = 1.0$ or 100%

p = 0.9 and q = 0.1

<table>
<thead>
<tr>
<th>p_A</th>
<th>q_a</th>
</tr>
</thead>
<tbody>
<tr>
<td>.9</td>
<td>.1</td>
</tr>
</tbody>
</table>

p_A = .9  AA = .81  Aa = .09
q_a = .1  Aa = .09  aa = .01

81% AA  18% Aa  1% aa
p^2  2pq  q^2
.81  .18  .01
### Mating Combinations

<table>
<thead>
<tr>
<th>Mating</th>
<th>Frequency</th>
<th>AA</th>
<th>Aa</th>
<th>aa</th>
</tr>
</thead>
<tbody>
<tr>
<td>AA x AA</td>
<td>.81 x .81</td>
<td>.6561</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>AA x Aa</td>
<td>2(.1458)</td>
<td>.1458</td>
<td>.1458</td>
<td>--</td>
</tr>
<tr>
<td>AA x aa</td>
<td>2(.0081)</td>
<td>--</td>
<td>.0162</td>
<td>--</td>
</tr>
<tr>
<td>Aa x AA</td>
<td>.18 x .18</td>
<td>.0081</td>
<td>.0162</td>
<td>.0081</td>
</tr>
<tr>
<td>Aa x Aa</td>
<td>2(.0018)</td>
<td>--</td>
<td>.0018</td>
<td>.0018</td>
</tr>
<tr>
<td>aa x aa</td>
<td>.01 x .01</td>
<td>--</td>
<td>--</td>
<td>.0001</td>
</tr>
</tbody>
</table>

\[
(p+q+r)^2 = .0651 + 2(.1458) + 2 (.0081) + .0324 + 2(.0018) + .0001
\]
Summary

- No matter what the original values of $p$ and $q$, in a randomly mating population, genotypes will remain in the ratio: $p^2 : 2pq + q^2$
- Hardy Weinberg Equilibrium
- Memorize Two Formulae:
  - $p^2 : 2pq + q^2$
  - $p + q = 1$

Calculation of gene and genotype frequencies for autosomal dominant traits

- E.g., ability to taste PTC
- Tasters = dominant (TT or Tt)
- Non-tasters = recessive (tt)

Given that 16% of population are non-tasters (tt) and 84% are tasters (TT, Tt):
1. What is the frequency of T and t alleles?
2. What is the frequency of TT and Tt genotypes?
Calculation of gene frequencies when dominance and recessiveness is lacking (i.e. co-dominant traits)

<table>
<thead>
<tr>
<th>Genotype</th>
<th>n</th>
<th>M</th>
<th>N</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>MM</td>
<td>197</td>
<td>394</td>
<td>-</td>
<td>394</td>
</tr>
<tr>
<td>MN</td>
<td>131</td>
<td>131</td>
<td>131</td>
<td>262</td>
</tr>
<tr>
<td>NN</td>
<td>22</td>
<td>0</td>
<td>44</td>
<td>44</td>
</tr>
<tr>
<td></td>
<td>350</td>
<td>525</td>
<td>175</td>
<td>700</td>
</tr>
</tbody>
</table>

Gene frequencies:
- frequency of M = 525/700 = .75
- frequency of N = 175/700 = .25

Genotype frequencies:
- frequency of MM = 197/350 = 0.563
- MN = 131/350 = 0.374
- NN = 22/350 = 0.063

Using the formula, $p^2 = 2pq + q^2$, fill in the blanks
- $p$ = frequency of the ______ allele in the population
- $q$ = frequency of the _____ allele in the population
- $p^2$ = percentage of _______ individuals
- $q^2$ = percentage of _______ individuals
- $2pq$ = percentage of _______ individuals
Problem 1

If the percentage of the homozygous recessive genotype (aa) is 36% in a population, calculate the following:

- The frequency of the "aa" genotype.
- The frequency of the "a" allele.
- The frequency of the "A" allele.
- The frequencies of the genotypes "AA" and "Aa."
- The frequencies of the two possible phenotypes if "A" is completely dominant over "a."

Solution

Problem 2

In a population with two alleles for a particular locus, B and b, the allele frequency of B is 0.7. What would be the frequency of heterozygotes if the population is in Hardy-Weinberg equilibrium?
Problem 3

In a population that is in Hardy-Weinberg equilibrium, 16% of the individuals show the recessive trait. What is the frequency of the dominant allele in the population?

Solution
New Problem

If 9% of an African population is born with a severe form of sickle-cell anemia (ss), what percentage of the population will be more resistant to malaria because they are heterozygous (Ss) for the sickle-cell gene?

Solution

Hardy-Weinberg

In this example, pink color is dominant and black is the recessive condition. How many pigs are heterozygous for pink color in this population?
**Solution**

- First, count the individuals that are homozygous recessive (black) in the illustration above and then calculate the percent of the total population they represent. This will give you $q^2$.
  
  $q^2 = ?$

**Solve for 2pq**

- To find $q$: take the square root of $q^2$, the frequency of the recessive allele.
  
  $q = ?$

- To find $p$: Since the sum of the frequencies of both alleles = 100%, $p + q = 1$ and you know $q$, $p = 1-q$, the frequency of the dominant allele?
  
  $p = ?$

- To find $2pq$, the frequency of the heterozygotes, solve for $2pq$. This gives you the percent of the population that is heterozygous for pink coat.
  
  $2pq = ?$

**Extra Problem**

- Within a population of butterflies, the color brown (B) is dominant over the color white (b). And, 40% of all butterflies are white. Calculate the following:
  
  - The percentage of butterflies in the population that are heterozygous.
  - The frequency of homozygous dominant individuals.