After *On the Origin*…

When Darwin and Wallace jointly published their paper on natural selection, they began a new era of evolutionary study. While their work was important, they were still wrong about inheritance, a process which they believed was the result of blending of genetic factors.

**Mendel’s Principles**

- Alternative forms of genes, known as alleles, account for variation
- Offspring individuals inherit two copies of genes, one from each parent, in most cases (these are known as diploid organisms)
- If the possible alleles of a gene differ, one *may* be dominant (meaning that it would mask the phenotypic expression of the other allele)
- Two alleles for a heritable trait segregate during meiosis, usually independently of other traits (except for case of linked genes, which are close together on the chromosome)
- Dominant alleles mask all other phenotypes (known as recessive), but there is also the case of co-dominance—think of one red and one white flower making a pink flower, or look at the examples below
Alleles | Genotypes | Possible Phenotypes
--- | --- | ---
A | AA | Dominant
| AB | Codominant
B | BB | Dominant

In this case, AA and BB are known as *homozygous* (same allele type) and AB is known as *heterozygous*.

**Population Genetics**
- A population, in genetic terms, is a randomly breeding group of individuals that is largely isolated from others
- Key evolutionary processes: mutation (the only source of variation), sampling processes (also known as genetic drift), the various forms of natural selection, exchange of genes through migration, and non-random mating

**Mathematical Models—Hardy-Weinberg Equilibrium**
Example of a natural population of flowers:
Figure 23.7 (pg. 474, 8th edition)

Now, the general case:

**General Case**

- **Male Gametes**
  \[ f(A_1) = p \text{ and } f(A_2) = q \]

- **Female Gametes**
  \[
  \begin{array}{c|c|c}
  \text{Gamete} & P^2 & pq \\
  \hline
  A_1A_1 & P^2 & pq \\
  A_1A_2 & pq & q^2 \\
  \end{array}
  \]

**Expected Proportions:**
\[ P^2 + 2pq + q^2 = 1 \]

Also, \( p + q = 1 \) because there are only two possible alleles (in this case).

\[ f(A_1) = P^2 + 1/2(2pq) = p(p+q) = p, \text{ meaning that the next generation will in theory have the same gene frequency as that of the parents} \]

**Expected Genotype Frequencies**
- \( A_1A_1 = p^2 \)
- \( A_1A_2 = 2pq \)
- \( A_2A_2 = q^2 \)

Conclusions from Hardy-Weinberg math: Inheritance alone does not cause the frequency allele changes of evolution.

<table>
<thead>
<tr>
<th>Phenotype Frequency</th>
<th>Genotype Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red Flowers</td>
<td>( C^R C^R )</td>
</tr>
<tr>
<td></td>
<td>0.64</td>
</tr>
<tr>
<td>Pink Flowers</td>
<td>( C^R C^W )</td>
</tr>
<tr>
<td></td>
<td>0.32</td>
</tr>
<tr>
<td>White Flowers</td>
<td>( C^W C^W )</td>
</tr>
<tr>
<td></td>
<td>0.04</td>
</tr>
</tbody>
</table>

Allele Frequency
- \( p = f(C^R) = 0.8 \)
- \( q = f(C^W) = 0.2 \)
This is because Hardy-Weinberg acts on these assumptions:

- Random mating only - for this gene/trait
- No mutation or selection on population in question
- This is an isolated population with no gene flow from outside (i.e. no migration)
- This is only true for a large population with no sampling error

Based on these assumptions, we can call Hardy-Weinberg a null hypothesis for evolution. That means that if a population does not conform to Hardy-Weinberg Equilibrium for a certain trait, then evolution has occurred.

Example of HWE as a Null Hypothesis:
Wild Oats—

<table>
<thead>
<tr>
<th>Genotype</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>$A_1A_1$</td>
<td>0.548</td>
</tr>
<tr>
<td>$A_1A_2$</td>
<td>0.071</td>
</tr>
<tr>
<td>$A_2A_2$</td>
<td>0.381</td>
</tr>
</tbody>
</table>

Note that there are far fewer heterozygotes than HWE would predict. Some explanations for this would be that the wild oats do not practice non-random mating, or that heterozygotes are selected against in the environment the oats inhabit.