**POPULATION GENETICS**

**Gregor Mendel** did his research with pea plants that have simple **dominant/recessive** characteristics. He used capital letters to represent the dominant "factor" (gene) for a trait, and the same letter stated in lower-case to represent the recessive "factor" for the same trait. The possible patterns of inheritance his research revealed for such simple dominant v. recessive traits were: AA, aa or Aa. One question people asked as research proceeded over the years was, "Why don't the recessive traits disappear over generations of breeding within a given population?" If one *allele* for a characteristic is dominant, and another allele for the same body feature is recessive, then you would expect that the recessive gene would disappear from a given population over time. In fact, recessives do *not* vanish from most normal populations.

In 1908 Godfrey Hardy and Wilhelm Weinberg proposed a mathematical explanation for the stability of successive generations of populations, specifically populations that might be in a state of **genetic equilibrium**. The **Hardy-Weinberg Principle** represents an ideal situation that probably never occurs in the natural world, but it allows us to study the expression of traits mathematically it also proves the existence of **natural selection** within a population.

| Hardy Weinberg Equation | Frequency of AA = p^2 | Frequency of Aa = 2pq | Frequency of aa = q^2 | p^2 + 2pq + q^2 = 1 |

**EXERCISE #1:**

**PART A:**

Work in teams of two to set up a "model" population containing male and female gametes that carry either a dominant or recessive trait.

Black and white beans will be used to represent the alleles; with black beans representing the dominant allele (A) and white beans representing the recessive allele (a).

One person will use a bag labeled "Male" and the other person will use a bag labeled "Female". Each bag should contain 19 white and 41 black beans.

Count the beans in your bag to make certain you have the correct number of white and black beans. Each bag should contain a total of 60 alleles: 19 represent a recessive (white beans) trait and 41 represent the dominant allele (black beans) for the same trait.

Close each bag and shake the "alleles" around. One individual person should be in charge of each separate bag.

Without looking, select one allele from each bag. These two alleles represent a mating that forms a *zygote*. 


Return the beans to their respective containers after noting the results of the mating in Chart #1.

Repeat the selection process fifty-nine times so that you have a total of sixty results. Record each mating in Chart #1, and return the beans to their respective containers each time you use them. For a heterozygote, note which allele was (A or a) was donated by the male and female.

<table>
<thead>
<tr>
<th>GENOTYPE</th>
<th>TALLY MARKS</th>
<th>TOTAL</th>
<th>MALE ALLELES</th>
<th>FEMALE ALLELES</th>
</tr>
</thead>
<tbody>
<tr>
<td>AA</td>
<td></td>
<td></td>
<td>A</td>
<td>A</td>
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<tr>
<td>Aa</td>
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<tr>
<td>aa</td>
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QUESTIONS FOR PART A:

- What are the three possible genotypes for this characteristic? What are the possible phenotypes?
- Why did you return the "alleles" to their respective containers each time?
- What is the total population of individuals produced in the F<sub>1</sub> generation?
- Use this equation to determine the frequency of each allele within your population:

\[
\text{frequency of the genotype} = \frac{\text{number of individuals of one genotype}}{\text{number of individuals of all genotypes}}
\]

PART B: Review that data on Chart #1 and repeat the entire experiment using adjusted numbers of beans to represent the outcomes recorded in Chart #1.

Example: If Chart #1 reveals a total of 18 pairs of AA, then place 9AA (black/black) beans in the male bag for the second part of the experiment, and 9 AA (black/black) beans in the female bag. If Chart #1 shows 10 pairs of aa, then place 5aa (white/white) beans in the male bag and 5aa (white/white) beans in the female bag.
After adjusting the number of black and white beans (alleles) in the "parental bags", repeat 60 trials for part two of the experiment. This provides information regarding the possible outcomes for the F\textsubscript{2} generation. Identify which allele (A or a) the male and female donated for the heterozygote. Record your results in Chart #2.

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<thead>
<tr>
<th>GENOTYPE</th>
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<th>TOTAL</th>
<th>MALE ALLELES</th>
<th>FEMALE ALLELES</th>
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<tbody>
<tr>
<td>AA</td>
<td></td>
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<td>Aa</td>
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<td>aa</td>
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QUESTIONS FOR PART B:

- What are the possible genotypes and phenotypes?

- Was the representation of each allele possibility the same as in the F\textsubscript{1} experiment? Why?

EXERCISE #2:

Sickle-cell disease is a genetic disorder that causes erythrocytes (red blood cells; RBC's) to assume a sickled shape instead of their normal biconcave shape. It is caused by a genetic error that substitutes the amino acid valine for glutamic acid in the formation of the hemoglobin for RBC's. The sickled shape imparts partial immunity to a parasitic disease known as malaria that affects RBC's, but also prevents a healthy oxygen distribution to body cells, therefore causing symptoms of sickle-cell disease.

Malaria was a deadly plague in Africa years ago, and persons who were \textit{Ss} for the sickle-cell characteristic had some immunity to the malarial parasite. Persons who were born \textit{SS} had no immunity to malaria and died from the malarial infection; persons who were \textit{ss} for the characteristic had immunity to malaria, but also expressed all the symptoms of sickle-cell disease. Therefore, the \textit{ss} individuals usually died of sickle-cell disease when they were still children, without reaching adulthood and reproducing. Hence, the genes of the \textit{ss} individuals were "removed" from the population.

How do your observations from Exercise #1 explain the frequency of the sickle-cell gene within populations?