SKILL FOCUS

- Predicting
- Performing and recording
- Communicating results

Population Genetics and the Hardy-Weinberg Principle

There are several characteristics that you can easily measure to determine some of the genetic variability that exists within your classroom. Eye and hair colour, the presence or absence of freckles, hair on your fingers, and even how you cross your hands are all genetic traits.

Studies like this investigation often involve interviewing or examining people. All those involved must respect the confidentiality of the subjects of the study. This confidentiality should be maintained in all studies unless permission has been obtained from the subjects.

Pre-lab Question

- Does your class meet all the requirements to maintain the Hardy-Weinberg equilibrium? (Consider your class as a population.)

Problem

How can genetic variety among the students in your classroom be measured?

Prediction

If there are three possible genotypes (and two possible phenotypes) for a particular characteristic, predict the frequency of each allele in your class.

Part A

Trait	Dominant	Recessive
hairline	pointed on forehead	straight across forehead
freckles	present	absent
thumb joint	last joint bends out	last joint is straight
finger hair	present	absent
folded hands	left thumb over right	right thumb over left
tongue rolling	can be rolled in U-shape	cannot be rolled

Procedure

1. Choose one of the traits from the table shown here. (Your entire class should test the same trait.) Copy the table below into your notebook, and fill in the genotype and phenotype for the three possible combinations of alleles. (Use A for the dominant allele, and a for the recessive allele.)

Trait	Possible genotypes	Possible phenotypes

2. Survey the class to determine the total number of students with each phenotype of the selected trait. Copy the following table into your notebook and record these results as percentages. Change each percentage into decimal form.

	Class Phenotypes				Allele Frequency	
	Dominant phenotype $p^2 + 2pq$		Recessive phenotype q^2			
	Number of students	Percentage of students	Number of students	Percentage of students	p	q
class population						
larger population						

3. Use the Hardy-Weinberg equation to calculate the frequency of each allele in your class. Record your calculated frequencies in the last two columns of your table.

4. (Optional) Repeat steps 2 and 3 for a larger population of two or more classes.

Post-lab Questions

1. What is the frequency of homozygous dominant students, p^2, in your classroom? What is the frequency of heterozygous students, $2pq$?

2. What is the frequency of homozygous recessive students, q^2, in your classroom?

3. What are the percentages of the three genotypes in your classroom?

4. (Optional) How did genotype and allele frequencies change when you sampled a larger population size?

Conclude and Apply

5. Explain the relationship between population size and genotype and allele frequency.

6. What does the answer to question 5 imply about the need for an appropriate sample size in order to obtain an accurate picture of what is occurring within a population?

7. Explain how the Hardy-Weinberg equation can be used to study genetic diversity in populations.

Part B
Materials

4 playing cards for each participant (2 from red suits and 2 from black suits)

Procedure

1. Each playing card represents an allele. Cards from red suits are recessive alleles, and cards from black suits are dominant alleles.

2. Find a partner. Place your four cards face down randomly on your desk, but do not mix your cards with your partner's.

3. Each person in this partnership, or random mating, should turn over one card. This is the offspring of the first generation. Copy this table into your notebook and record the genotype of the first offspring.

Generations		Class total for each phenotype		
		AA	Aa	aa
first generation mating	first offspring			
	second offspring			
second generation mating	first offspring			
	second offspring			
third generation mating	first offspring			
	second offspring			
fourth generation mating	first offspring			
	second offspring			
fifth generation mating	first offspring			
	second offspring			
	Class Totals			

4. Retrieve your card and shuffle your four original cards again. Repeat step 3. This is the second offspring of the first generation. Record the genotype of the second offspring in your table.

5. You and your partner must now each assume the genotype of one of your offspring. For example, if the first offspring was AA, one partner now begins with four black cards. The other partner should assume the genotype of the second offspring. If this offspring was Aa, for example, this person now begins with two red cards and two black cards.

6. Randomly select a different partner in your class. Repeat steps 3 and 4 and record the first and second offspring from the second generation.

7. Repeat step 5, selecting new cards if necessary to reflect the alleles of the offspring from the second generation.

8. Continue choosing a different partner at random to create third, fourth, and fifth generation mating, with two offspring from each generation.

9. Collect and record class totals for each genotype from each mating in each generation.

Post-lab Questions

1. What is the initial allele frequency in your class population? Express this as a percentage converted to a decimal.

2. Consider the data you collected over the five generations as a single large population, so your class totals in the last row of your table are the genotypes of an entire population. Calculate the frequency of each genotype as a percentage converted to decimal form. Calculate the allele frequency in the population.

3. Use the Hardy-Weinberg equation to determine the genotype frequencies of the beginning population where $p = 0.5$ and $q = 0.5$.

4. Calculate the genotype and allele frequencies of the class population for the fifth generation only.

Conclude and Apply

5. How do the allele frequencies change from generation to generation? Explain whether this population is in Hardy-Weinberg equilibrium.

6. Predict what would happen if you completed this activity with only half of your class.

Exploring Further

7. Repeat this activity with only half of your class. Compare the results between the two populations of different sizes.

8. What limitations does this simulation have in imitating what is actually occurring in the population?

9. Describe how this activity could be changed to replicate an actual, natural population that is evolving rather than a hypothetical, non-evolving population.