Modeling Monohybrid & Dihybrid Crosses

Background

The inheritance of any given set of alleles depends on probability. Therefore, the mathematical laws of probability can be used to predict the genotypes and phenotypes of offspring resulting from specific crosses.

The simplest form of a test is called a monohybrid cross. It is used to show the probability that one particular trait would be present in offspring. A simple, 2 x 2 Punnett square could be used to determine the likelihood that an offspring inherits a given set of alleles.

However, an organism's characteristics are the result of many sets of alleles being inherited. To determine the probability of an offspring inheriting a specific set of alleles for *two* characteristics, a larger, 4 x 4 Punnett square is required. This type of test cross is called a dihybrid cross.

In this investigation, you will use the mathematical laws of probability and a simple sampling technique to discover the likelihood of producing offspring with a specific set of alleles and traits.

Objective(s)

- ✓ to practice building monohybrid crosses
- ✓ to analyze the results of a monohybrid cross; genotypes and phenotypes
- ✓ to practice building dihybrid crosses
- ✓ to analyze the results of a dihybrid cross; genotypes and phenotypes
- ✓ to express the results of mono- and di-hybrid crosses in terms of genotypic and phenotypic ratios

Materials

- blue plastic chips (x4)
- green plastic chips (x4)
- red plastic chips (x4)
- yellow plastic chips (x4)
- plastic cups (x4)

Pre-Lab Questions

Answer the following questions below in your science notebook. For actual questions, you must either write out the questions, or include the questions in your responses. Be sure to use complete sentences.

1. How many alleles does any given individual possess for a single gene (characteristic)? Explain.
2. How many alleles does any given individual possess for two genes? Explain.
3. Explain Mendel's law of segregation in your own words.
4. What is a ratio? If you had 28 apples and 14 oranges, what is the ratio of apples to oranges? If you also had 7 pears, what is the ratio of apples to oranges to pears?

✓ Use a ruler to recreate the Data Table(s) below neatly in your notebook, and be sure they are drawn approximately the same size

Safety

★ *There are no special safety precautions for this activity.*

Procedure A - Probability

1. Obtain two plastic cups, one labeled "male" and the other "female." Each cup should contain 2 blue chips and 2 green chips.
2. Answer the following questions on your paper: (number your responses appropriately)
   - **a.** What is the probability that you will draw a green chip from either cup?
   - **b.** What is the probability that you will draw one blue chip from each cup at the same time?
   - **c.** What is the probability that you will draw one green chip from each cup at the same time?
   - **d.** What is the probability that you will draw a blue chip and a green chip in any combination?

3. Mix the chips in each cup thoroughly. Without looking in the cups, pull out one chip from each cup and place them as a pair on the table.

   a. What combination of chips did you draw?
   b. What was the probability that you would draw that particular combination?
4. Return each chip to its cup.

Procedure B – Monohybrid Cross

5. The plastic cup labeled "male" represents an individual male animal, and the one labeled "female" represents a female of the same species.
6. Suppose a blue chip represents the allele (*B*) for blue fur color and a green chip represents the allele (*b*) for green fur color. Assume that blue fur color is dominant.
   a. What are the genotypes for each of the individuals represented by the cups? (remember that each cup contains both blue and green chips)
   b. Complete a Punnett square on your paper to show the possible combinations of alleles that could occur in offspring of a cross between these two animals.
   c. List the possible allele combinations, along with their respective phenotypes.
7. Use the data from the Punnett square to determine what proportion of offspring are expected to have a given allele combination.
8. Use the proportion to calculate the number of offspring are expected to have each allele combination. To do this, multiply the fraction expected for each allele combination by the total number of offspring. The total number of offspring, or trials, for the group will be 40.
   a. What is the prediction, out of 40, for each genotype?
9. Shake the cups to mix the chips thoroughly.
10. Without looking in the cups, pull one chip out from each cup. Record a tally mark in the appropriate space in **Data Table 1**. Return each chip to the cup it was drawn from.
11. Repeat steps #**10** and **11** to perform another 39 trials. Be sure to record a tally mark for each trial, and return the chips to the cups they came from.
12. After completing all 40 trials, total up the tally marks and record the value in **Data Table 1**.
13. Combine all other group's data to complete **Data Table 1**.

Procedure C – Dihybrid Cross

14. Obtain two more plastic cups, one labeled "male" and the other labeled "female." Each cup should contain 2 red chips and 2 yellow chips.
15. The red chips represent the allele (*R*) for long fur, and the yellow chips represent the allele (*r*) for short fur. Assume that long fur is dominant over short fur.
16. You and a partner will perform 48 trials. However, in addition to the red and yellow chips, you will use the blue and green chips from the earlier part of this activity. So, you will draw one chip from each of the "male" cups, and one chip from each of the "female" cup, for a total of 4 chips.
   a. What are the genotypes for each of the individuals represented by the cups? (remember that each individual has two alleles for each gene)
   b. Complete a Punnett square on your paper to show the possible combinations of alleles that could occur in offspring of a cross between these two animals.
   c. List the possible genotype combinations, along with their respective phenotypes.
17. Use the data from the Punnett square to determine what proportion of offspring are expected to have a given phenotype combination.
18. Use the proportion to calculate the number of offspring that are expected to have each phenotype combination. To do this, multiply the fraction expected for each phenotype combination by the total number of offspring. The total number of offspring, or trials, for the group will be 48.
   a. What is the prediction, out of 48, for each phenotype combination?
19. Shake the cups to mix the chips thoroughly.
20. Without looking in the cups, pull one chip out from each cup. Record a tally mark in the appropriate space in **Data Table 2**. Return each chip to the cup it was drawn from.
21. Repeat steps #**10** and **11** to perform another 47 trials. Be sure to record a tally mark for each trial, and return the chips to the bags they came from.

22. After completing all 48 trials, total up the tally marks and record the value in **Data Table 2**.
23. Combine all other group's data to complete **Data Table 2**.

Data Table 1

Possible Allele Combinations	Predicted Number	Tally of Trials	Tally Totals	Class Totals

Total class trials: _____

Data Table 2

Possible Phenotypes	Predicted Number	Tally of Trials	Tally Totals	Class Totals

Total class trials: _____

Clean Up

- ✓ everything returned to its original location

Results & Analysis

Answer the following questions in your science notebook. For actual questions, you must either write out the questions, or include the questions in your responses. Be sure to use complete sentences and show your work for math problems.

1. Why was it important to return each chip to its cup before the next trial?
2. How did your group's actual results compare with the predicted results in **Procedure B**? What was your predicted phenotypic ratio? What was the actual phenotypic ratio?
3. How did your group's actual results compare with the predicted results in **Procedure C**? What was your predicted phenotypic ratio? What was the actual phenotypic ratio?
4. Why were the blue and green chips kept separately from the red and yellow chips?
5. How did the predicted phenotypic ratios compare with your group's actual phenotypic ratios in the dihybrid cross?
6. How did the predicted phenotypic ratios compare with the class' actual phenotypic ratios in the dihybrid cross?
7. What conclusions can you draw about actual results versus predicted results based on probability?