

Name _____

A coin marked S on one side and s on the other has a 50:50 chance of landing on either side when tossed. A gamete cell of a person who is heterozygous has a 50:50 chance of being either an S or s. Thus, coins can substitute for gamete cells

Finding Phenotypes And Genotypes For One Trait

18

and two coins tossed together represent offspring combinations.

In genetics, it is possible to calculate the results that should appear in offspring if the genotypes of both parents are known. These are called expected results. Expected results can be calculated by mathematics or use of Punnett squares. Thus, expected results are specific numbers and are not the result of random events. Observed results are those that appear in offspring in actual crossings. They are due to chance combinations of certain genes. Thus, observed results are always due to chance.

Expected and observed results may not always agree exactly, but there should be some agreement. Expected results are used to predict the results of a cross before the cross is done. If the expected results indicate that a certain type of offspring is likely, the cross can be carried out with some certainty that the type of offspring will appear in the observed results.

In this investigation, you will

- substitute properly marked coins for gamete cells.
- toss the marked coins 100 times to represent 100 offspring.
- determine the expected numbers of genotypes for 100 offspring and compare them with the observed numbers of genotypes obtained through 100 coin tosses.
- determine the numbers of expected phenotypes for a genetic cross, and compare them with the numbers of observed phenotypes obtained through coin tossing.

Students should learn to distinguish genotype from phenotype and observed data from expected data.

Materials



2 pennies
adhesive tape
pencil
scissors

Note: This lab allows students to master, by the use of coins, the same concepts as labs which usually require fruit flies or wasps. This technique is less expensive and eliminates the need for equipment and teacher preparation which is necessary when using living materials. Living organisms do not allow for a genotypic ratio comparison between observed and expected data; coins do.

Procedure

Part A. Determining Numbers of Expected Genotypes

How many of each genotype combination are expected in the offspring of a cross if both parents are Ss for a trait?

FIGURE 18-1

	S	s
S	SS	Ss
s	Ss	ss

Students may not be familiar with the use of Punnett squares. This may require some explanation.

- Use the Punnett square in Figure 18-1 to determine the genotypes. Record the number of each genotype in column A of Table 18-1.
- How many of each genotype combination are expected if there are 100 offspring? Multiply each number in column A by 25. Record this number in column B of Table 18-1.

Part B. Determining Numbers of Observed Genotypes

- Cover both sides of two pennies with adhesive tape. Trim off any excess tape with scissors. **CAUTION:** Always be careful with scissors. Print an S on one side of each coin and an s on the other side of each coin.

• Place both coins in cupped hands, shake, and then toss the coins onto your desk. Read and record the letter combination in column C (Toss Results) of Table 18-1. Make a slash (/) in the proper row of column C to indicate the letter combination. Repeat this process until the coins have been tossed 100 times. Record the coin combinations for each toss in Table 18-1.

• Record in column D the totals for each.

Part C. Determining Numbers of Expected Phenotypes

• Assume that *S* represents the dominant gene for normal skin pigment. Assume that *s* represents a recessive condition called albinism, no skin pigment. From the Punnett square (Figure 18-1),

list in column A of Table 18-2 the number of offspring expected to have normal skin color (*SS* and *Ss*) and the number expected to be albino (*ss*).

• Calculate the number expected to have each trait if there are 100 offspring. Do this by multiplying column A figures by 25. Record these numbers in column B of Table 18-2.

Part D. Determining Numbers of Observed Phenotypes

From your data in column D of Table 18-1, total and record in column C of Table 18-2 the number of offspring who will have normal skin pigment (*SS*, *Ss*, and *sS*) and those who will be albino (*ss*).

GENE COMBINATION	(A) EXPECTED GENOTYPE FOR 4 OFFSPRING	(B) EXPECTED GENOTYPE FOR 100 OFFSPRING	(C) TOSS RESULTS	(D) OBSERVED GENOTYPE FOR 100 OFFSPRING
<i>SS</i>	1	25	HHH HHH HHH HHH II	22
<i>Ss</i> or <i>sS</i>	2	50	HHH HHH HHH HHH HHH HHH HHH HHH HHH HHH	55
<i>ss</i>	1	25	HHH HHH HHH HHH III	23

Student data will vary. Note that columns B and D are very similar.

PHENOTYPE POSSIBLE	(A) EXPECTED PHENOTYPE FOR 4 OFFSPRING	(B) EXPECTED PHENOTYPE FOR 100 OFFSPRING	(C) OBSERVED PHENOTYPE FOR 100 OFFSPRING
Normal Skin (<i>SS</i> , <i>Ss</i> , or <i>sS</i>)	3	75	77
Albino (<i>ss</i>)	1	25	33

Student answers will vary but column C should be very close to column B.

Analysis

- (a) What is meant by expected genotypes? Exact, ideal genotypes

(b) Are expected results due to chance or are they arrived at mathematically? Mathematically
- (a) What is meant by observed genotypes? Actual counted data

(b) Are observed results due to chance or are they arrived at mathematically? Chance
- Note: In living organisms, exact genotypic ratios are not observed (except by chance happening).

3. What does each side of each coin represent? A gamete with a specific gene.

4. How does the chance of a coin landing on each side compare to the chance that a gamete cell will receive a particular gene* at meiosis? The chance is the same (50:50).
5. (a) Why must two coins be used to determine the genotypes for the offspring? An offspring receives two genes for each trait. Each coin represents the gamete from one parent.
- (b) What does the use of two coins compare to at fertilization? The union of an egg and a sperm cell.
6. Compare the expected genotypes of 100 offspring with the observed genotypes. Student answers will vary. Expected and observed genotypes should be close.
- (a) Do they agree or disagree? observed genotypes should be close.
- (b) If they disagree, how much do they disagree? Student answers will vary.
7. Are your results wrong if they do not agree? no Explain. In any cross, expected and observed data may not exactly agree.
8. What is the advantage of comparing the 100 expected offspring with the 100 observed offspring rather than comparing only four expected offspring with four observed offspring? The more offspring observed, the closer the data usually is to the expected.
9. Compare the expected phenotypes for 100 offspring with the observed phenotypes.
- (a) Do they agree or disagree? Answers will vary, but values should be close.
- (b) If they disagree, how much do they disagree? Answers will vary.
10. Are your results wrong if they do not agree? no Explain. In any cross, expected and observed data may not exactly agree.
11. If expected and observed results are never in close agreement, then our understanding of the law of dominance and the chance combination of genes cannot be correct.
- (a) Are expected and observed results in close agreement after many offspring are counted? yes
- (b) Does our understanding of genetics seem to have support as illustrated in this investigation? yes
- (c) Would you have good evidence if only one or two offspring were examined? no
- (d) Explain. This sample size is too small to give accurate data.
12. Class totals also may be used to show that expected and observed results will agree more closely when large numbers of offspring (coin flips) are counted. Record the total number of students participating in this investigation at the top of Table 18-3. Using expected phenotype data for 100 offspring from Table 18-2 (column B), record this same number in column A of Table 18-3. Determine and record in Table 18-3 the class total of expected phenotypes (column B) by multiplying column A by the number of students participating. In column C, record class totals from all students of observed phenotypes for 100 offspring from column C of Table 18-2.

*The gene in this investigation has two alternative forms, S and s. Some genes exist in more than two alternative forms and thus, the chance that one of these forms will appear in a gamete is less than 50%.

This part is optional. You may collect data for all students from Part C and provide them with totals the following class meeting day.

TABLE 18-3. CLASS TOTALS OF <u>30</u> STUDENTS			
	(A) EXPECTED PHENOTYPES FOR 100 OFFSPRING	(B) EXPECTED PHENOTYPES FOR CLASS TOTALS	(C) OBSERVED PHENOTYPES FOR CLASS TOTALS
Normal skin	75	2250	2258
Albino skin	25	750	742

Student data may vary. However, columns B and C should be very close.

13. What is the advantage of comparing expected offspring with the many hundreds of observed offspring (class totals)? In other words, what is the advantage of a large sample size? Observed and expected values show more agreement when large numbers of offspring are counted.

14. A number of actual families were observed that had albino children. All parents of the families had normal skin but were hybrid. The following figure shows the offspring. NOTE: A square represents a son, a circle represents a daughter, and shading indicates an albino. For example, family A has six children, two boys and four girls. One son is albino and the other five children are normal.

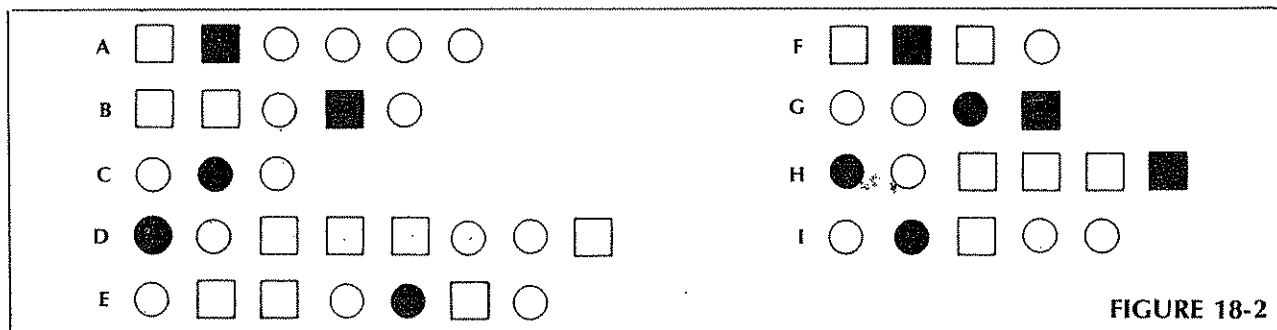


FIGURE 18-2

- (a) What is the total number of children observed in all families? 48
- (b) What is the total number of normal children observed in all families? 37
- (c) How many children are expected to be normal in all families above? (Multiply answer to question (a) by 0.75 or 3/4.) $48 \times 0.75 = 36$
- (d) Are your answers to questions (b) and (c) in close agreement? yes
- (e) What is the total number of albino children observed in all families? 11
- (f) How many children are expected to be albino in all families above? (Multiply answer to question (a) by 0.25 or 1/4.) 12
- (g) Are your answers to questions (e) and (f) in close agreement? yes
- (h) If only families D and E were used, would there be close agreement between observed and expected numbers of albinos? no ($5 \times 0.25 = 3.75$) vs 2
- (i) Is our understanding of genetics supported when observed results from these families are compared to expected results? yes (vs 2 = Doubled)