

Activity Guide for Students: Cats and Punnett Squares

Directions for students:

Background questions

Answer the following questions to assess your knowledge of some genetics terms and concepts. Use your notes or classroom resources to look up terms that are new to you.

1. Compare gene transcription and translation.
2. What is an allele? What can make alleles different?
3. What is a genotype?
4. What is a phenotype?

Analysis of mutation data on Siberian cats

Some people have claimed that Siberian cats are naturally low in the common cat allergen Fel d1 and therefore are less likely to cause allergic reactions in people. A recent genetic study investigated common alleles and mutated forms in the *Ch1* and *Ch2* genes, which are known to control production of Fel d1 in Siberian and non-Siberian cats.

The researchers identified the common alleles of the two genes and three mutated forms of the gene that may be of interest. Two of the mutated forms do not make functional Fel d1. This may result in lower amounts of the allergen in a cat with those alleles. The following table describes and gives temporary names for the alleles identified in the study.

Table 1

Gene	Allele	Allele description and distribution	Effect of mutation
<i>Ch1</i>	<i>Ch1⁺</i>	Most common form across all felines	
	<i>Ch1^H</i>	Mutated form found only in Siberian cats	Error in Fel d1
<i>Ch2</i>	<i>Ch2⁺</i>	Most common form across all felines	
	<i>Ch2^S</i>	Mutated form found in all Siberian cats and some non-Siberian cats	No error in Fel d1
	<i>Ch2^H</i>	Mutated form found only in Siberian cats	Error in Fel d1

The researchers then gathered complete data on the genotype and phenotype of two Siberian cats. Note that a previous study of a variety of cats determined that the average salivary concentration of the allergen Fel d1 ranged from 0.4 to 35 $\mu\text{g}/\text{mL}$.

Table 2

Cat	<i>Ch1</i> alleles present in the genome	<i>Ch2</i> alleles present in the genome	Salivary concentration of Fel d1 ($\mu\text{g}/\text{mL}$)
1	<i>Ch1^H</i>	<i>Ch2^S, Ch2^H</i>	0.48
2	<i>Ch1⁺</i>	<i>Ch2^S</i>	2.19

Answer the following questions about the data in the study.

5. Based on Table 1, what are the names of the most common alleles of the *Ch1* and *Ch2* genes that are found across all felines?

6. What are the names of the three mutated alleles that are found in Siberian cats? Which of these alleles affect the production of the allergen Fel d1?

7. Based on Table 2, which cat has the mutated forms of the alleles that are thought to affect the production of Fel d1? Does the presence of the mutations seem to be related to the level of Fel d1?

8. Which column(s) of the table indicate genotype information? Explain your answer.

9. Which column(s) of the table indicate phenotype information? Explain your answer.

10. Many people have claimed that Siberian cats cause fewer allergies. What data in the second table might support this observation?

11. One research goal is to identify mutations in the *Ch1* and *Ch2* genes that are common to Siberian cats but not found in non-Siberian cats. Why is this interesting?

Construct and analyze a Punnett square

Parents contribute to the DNA of their offspring. Generally for animals, one of a pair of chromosomes and its alleles comes from one parent, and the other chromosome and its alleles comes from the other parent. Each pair of alleles is the genotype for a specific trait.

The Punnett square can predict the possible genotypes of offspring from two parents. The top of the Punnett square lists all the possible combinations of alleles that could come from one parent, and the left side lists all the possible combinations from the other parent.

In this activity, you will build a Punnett square for the *Ch1* and *Ch2* genes in the two cats described above. Because two genes are involved, the Punnett square will have four columns for the genotypes of one parent and four rows for the other parent.

Two notes: In this exercise, we are assuming that the two genes are not linked. Also, you may have worked with Punnett squares in which alleles are identified as recessive or dominant. But the research on the alleles of *Ch1* and *Ch2* is still too recent to know inheritance patterns. The good news is you can still create a Punnett square by listing both alleles for each of the two genes in the cells.

12. In your small group, construct a Punnett square for a cross between cats 1 and 2. Show the possible genotypes for cat 1 on the top of the square and the possible genotypes for cat 2 on the left side of the square. Then fill in the squares for the possible genotypes of the cats' offspring.

Now analyze the results of your Punnett square.

13. Highlight the genotypes of offspring that contain BOTH of the mutated alleles that affect protein production.

14. What phenotype would you predict for cats with BOTH mutations?

15. What is the probability that a cat would have both mutations?

16. The article "[How to lick cat allergies](#)" says that only one out of 15 offspring of low-allergen parents is low-allergen. List as many factors as you can think of that could explain why this number is smaller than what your Punnett square describes?