Practice with Punnett Squares

Pilot Condition P

This worksheet covers the basics of Mendelian inheritance and Punnett squares. Practice problems, featuring traits from the *Mutt Mixer* interactive, give students a chance to apply each new idea. By the end, students should be able to fill in a Punnett square for a one-factor cross and calculate the probabilities of offspring having each genotype and phenotype.

Notes from the developers

You'll notice that the alleles in this activity don't follow a standard naming convention that clues you in to their inheritance pattern. That's because scientists don't use one. As much as possible, we used the allele abbreviations that are most common in the scientific literature. After all, these are real dog traits.

Implementation instructions

- Have student work independently or guide them as needed.
- Students will need some information about traits from Mutt Mixer to complete the practice problems. You can have them access the interactive on individual devices or give them the details they need.

Additional learning objectives

- Punnett squares are models that show the probability of offspring inheriting a particular genotype.
- A genotype is an individual's allele combination; a phenotype is a visible trait caused by the alleles.

Materials needed

- Copies
- Student devices with internet access

Reminders

- Have students take the quiz right after this activity.
- Rejoin the lesson sequence ***after*** the *Mutt Mixer Modeling* activity.
- Please do NOT use any of the other optional lessons on Mendelian inheritance below the Inheritance table.

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Practice with Punnett Squares

For more information about dog traits, visit Mutt Mixer [learn.genetics.utah.edu/content/change/muttmixer/]

A. Genotype and phenotype

Living things with two parents have two alleles for each gene.

- Genotype = an individual's allele combination
- Phenotype = the visible trait that the alleles cause

EXAMPLE

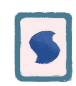
A gene in peas affects plant height. Different combinations of two alleles (T and t) can make a plant tall or short.

Genotype (allele combination)	**Phenotype** (visible trait)
T T	tall
T t	tall
t t	short

PRACTICE

1. A gene in dogs makes their coat furnished or smooth. There are two alleles for this gene. In Mutt Mixer, the alleles are shown as pictures. Another way to represent the alleles is with the letters F and f.


Furnished (F)


Smooth (f)

Fill in the table. *(Tip: Use Mutt Mixer to input the phenotype and see the genotype)*

Genotype (allele combination)	**Phenotype** (visible trait)
F F	
F f	
f f	

2. If you know an individual's genotype, you can predict its phenotype. But this doesn't always work in the reverse. That's because for some phenotypes, there is more than one possible genotype.

Fill in the table.

Phenotype	**All Possible Genotypes**
furnished	
smooth	

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B. Dominant and Recessive inheritance

Some traits follow predictable inheritance patterns. For example, for pea height, tall (T) is dominant, and short (t) is recessive. All that means is this:

- Dominant: it takes **one** T allele to cause the tall phenotype, no matter what the other allele is
- Recessive: it takes **two** t alleles to cause the short phenotype

PRACTICE

3. A gene in pea plants affects seed color. Circle the best answers:

a. It takes two y alleles to cause the green phenotype. y is (dominant / recessive)

b. It takes one Y allele to cause the yellow phenotype. Y is (dominant / recessive)

4. In dogs, furnishings is a dominant trait. What's another example from Mutt Mixer of a dominant trait?

C. Co-dominant inheritance

When a trait is co-dominant, both of an individual's alleles are visible in its phenotype. (This is sometimes called *incomplete dominance*.)

EXAMPLE

A gene in four o'clock plants affects flower color. It has two alleles (R and r) that follow a co-dominant inheritance pattern:

Genotype (allele combination)	**Phenotype** (visible trait)
R R	red
R r	pink
r r	white

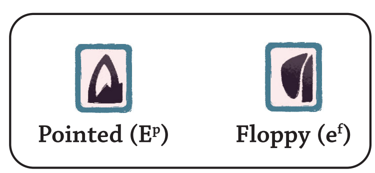
When alleles are co-dominant, it's possible to predict an individual's genotype from its phenotype. That's because each genotype has a different phenotype.

PRACTICE

5. In Mutt Mixer, ear flop has two co-dominant alleles (E^p and e^f).

Fill in the table:

Phenotype	Genotype
Floppy	
Pointed	
Semi-floppy	



6. In dogs, ear flop is a co-dominant trait. What's another example from Mutt Mixer of a co-dominant trait?

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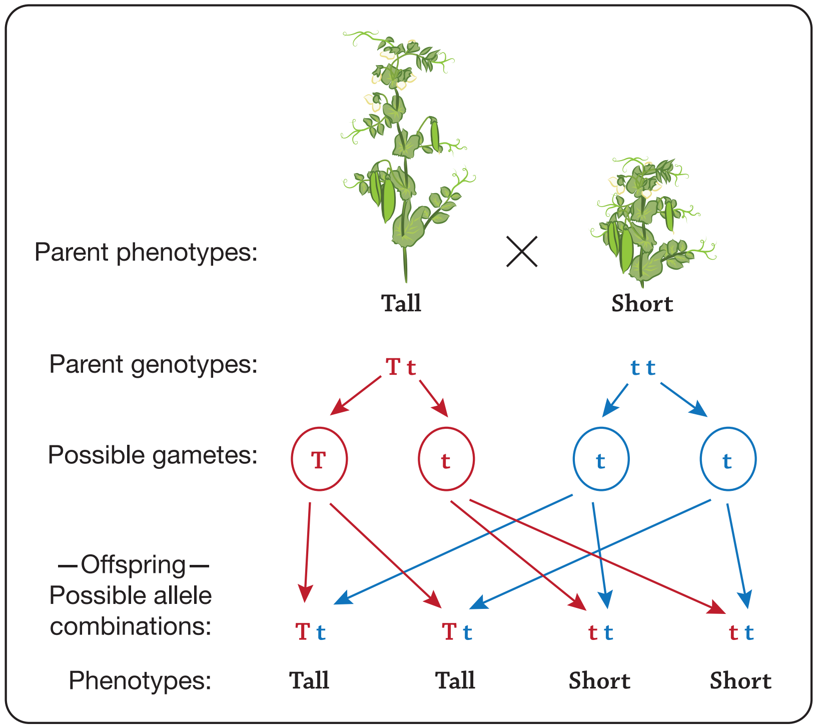
D. Modeling a cross

If you know the genotypes of two parents, you can make a model to see what the possible genotypes would be for their offspring. Then from the offspring genotypes, you can figure out the phenotypes.

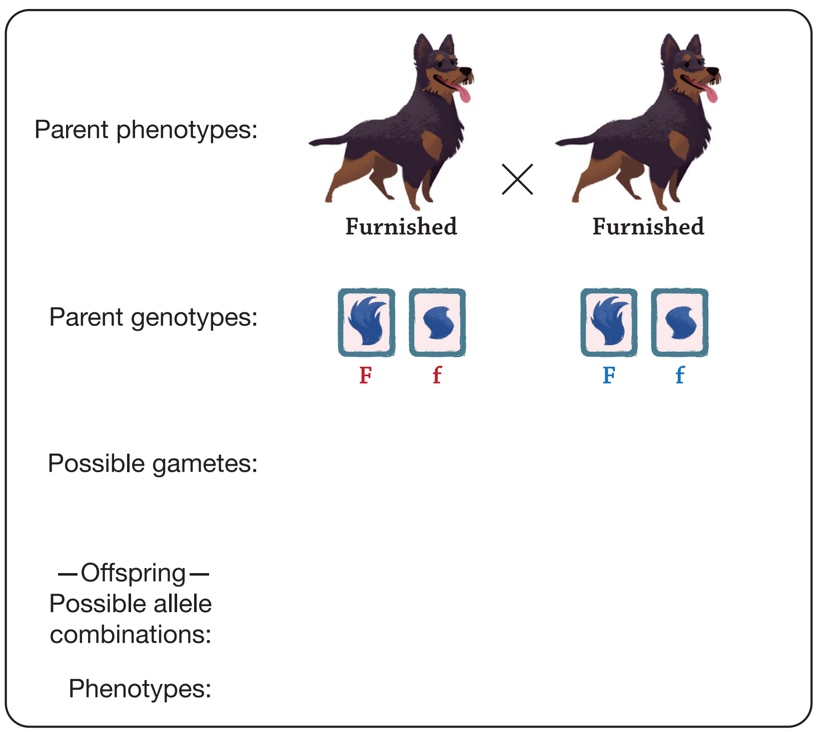
EXAMPLE

This model shows a cross between two pea plant parents:



PRACTICE

7. Fill in the model for this cross between two dog parents:



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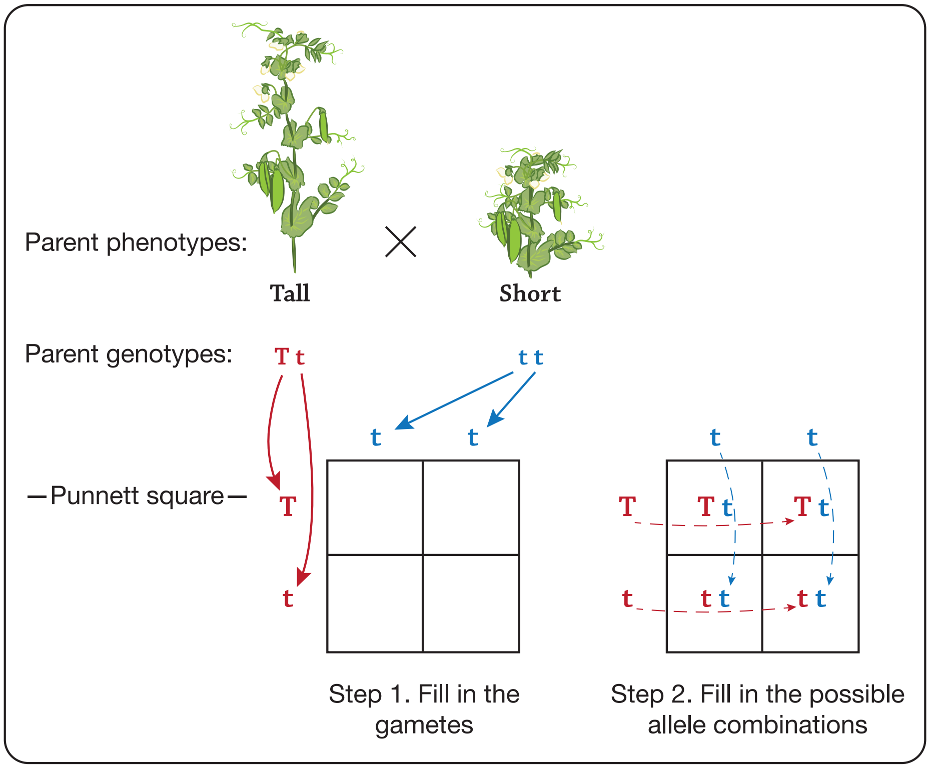
E. Punnett squares

A different way to model a cross is with a Punnett square. This model has the possible gametes from one parent along the left side, and the possible gametes from the other parent along the top. Each square shows a possible allele combination in the offspring.

EXAMPLE

This Punnett square shows another way to model the example cross from section D.



PRACTICE

8. Make a Punnett square for the cross you modeled earlier, between two furnished (Ff) dog parents. Fill in the genotypes and phenotypes for all the possible offspring.

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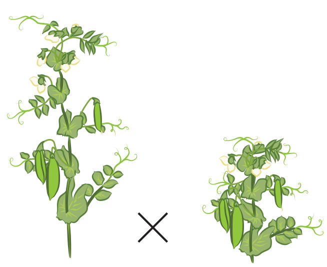
9. Make a Punnett square for a cross between two dog parents with semi-floppy ears ($E^p e^f$). Fill in the genotypes and phenotypes for all the possible offspring. *(Tip: See question 5 for more information about these alleles)*

F. Calculating probability

Dominant, recessive, and co-dominant traits follow predictable inheritance patterns. You can use a Punnett square to predict the chances (or probability) of offspring having each possible genotype and phenotype.

EXAMPLE

This Punnett square has 4 squares, which together represent all the possible genotypes for offspring from this cross. So for each possibility, the probability is ¼, or 25%. Together, the possibilities add up to 1 (¼ + ¼ + ¼ + ¼), or 100% (25% + 25% + 25% + 25%).



T t × **t t**

Probability as a fraction:

	t	t
T	**T t** tall ¼	**T t** tall ¼
t	**t t** short ¼	**t t** short ¼

or

Probability as a percent:

	t	t
T	**T t** tall 25%	**T t** tall 25%
t	**t t** short 25%	**t t** short 25%

In the Punnett square above, two squares have a Tt genotype, which makes a tall phenotype. To calculate the probability of this combination, you can add the values of the squares together.

Probability of tall phenotype (T t):

25% + 25% = **50%** (or) ¼ + ¼ = **½**

You can do the same for the short phenotype (t t):

25% + 25% = **50%** (or) ¼ + ¼ = **½**

These calculations tell us that if these two parents make an offspring, there is a 50% (or 1 in 2) chance that it will be tall, and a 50% (or 1 in 2) chance that it will be short.

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PRACTICE

10. Consider a cross between two non-dilute dogs (Dd x Dd)

a. Make a Punnett square to show all the possible genotypes for the offspring.

b. Fill in the possible phenotypes for the offspring.

c. If these two parents have a pup, what is the probability that the pup will be dilute?

d. What is the probability that the pup will be non-dilute?

e. The parents have a dilute pup. If the parents have another pup, what is the probability that it will be non-dilute? Explain your thinking.