

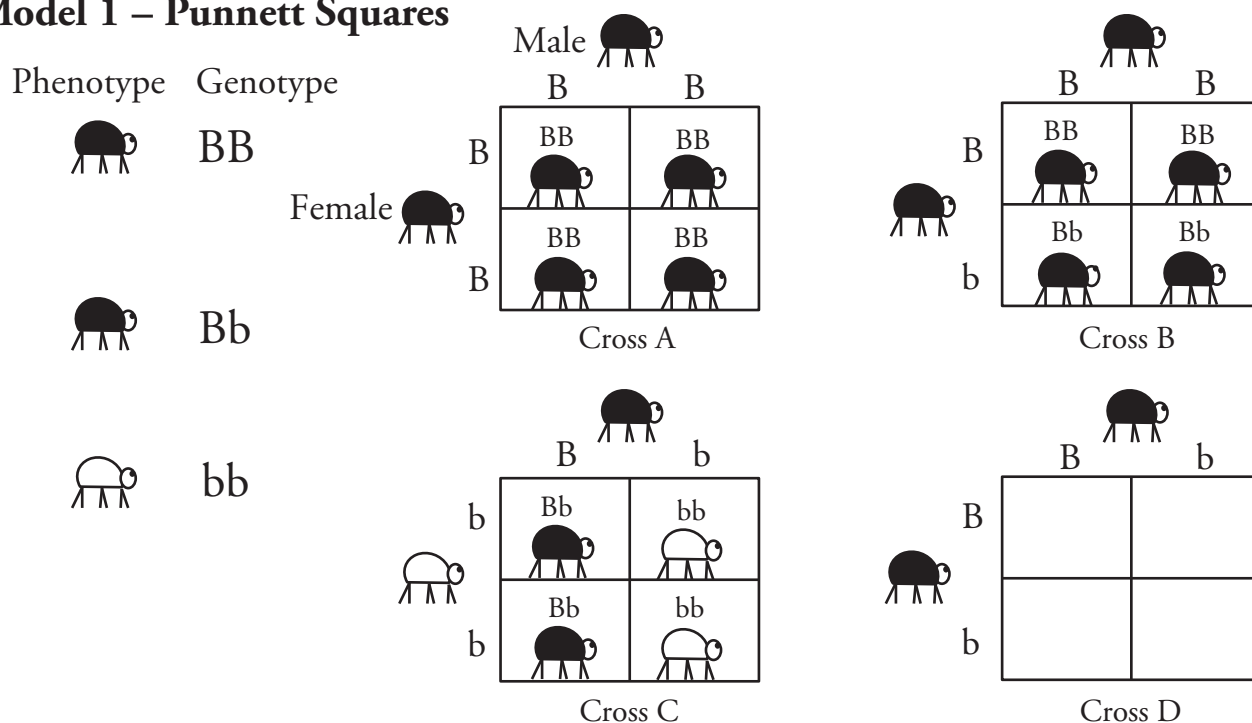
# The Statistics of Inheritance

How can statistics help predict the traits of offspring?

## Why?

The randomization of alleles from the parents' genetic material is essential to the survival and evolution of a species. If the combinations of alleles that make up the genetic material in a zygote are truly random, the laws of statistics can be used to predict what traits the offspring will have. This activity starts with a review of Punnett squares, which is one way to make predictions about simple allele combinations. Statistics will then be used to make mathematical predictions about the genotypes of offspring.

## Model 1 – Punnett Squares



1. Consider the beetle species in Model 1.
  - a. How many phenotypes for exoskeleton color are exhibited in the population?
  - b. How many genotypes for exoskeleton color are exhibited in the population?
  
2. According to Model 1, which allele, B or b, is the dominant exoskeleton color allele? Justify your answer with specific evidence from Model 1.

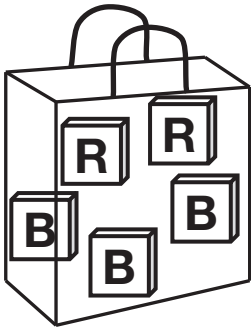
3. The Punnett squares in Model 1 show the possible outcomes for an offspring resulting from the mating of two beetles.
  - a. Which Punnett square shows a cross between two homozygous beetles?
  - b. Which Punnett square shows a cross between a heterozygous beetle and a homozygous recessive beetle?
4. Briefly describe how the genotypes inside of the Punnett squares representing the possible outcomes for an offspring are determined.
5. Complete the Punnett square for cross D in Model 1. Include drawings to show the phenotypes possible for the offspring that would result.



6. Refer to Model 1.
  - a. In which of the crosses is there a 100% chance that the beetle offspring will have a black exoskeleton?
  - b. In which of the crosses is the probability 0.75 that the beetle offspring will have a black exoskeleton?
7. For cross D in Model 1, what is the probability that the beetle offspring will have a Bb genotype? Show a mathematical calculation to support your answer.

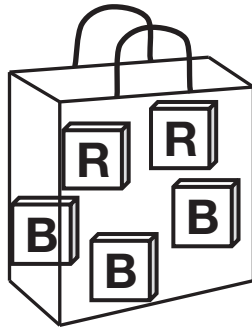


## Model 2 – Random Sampling Statistics



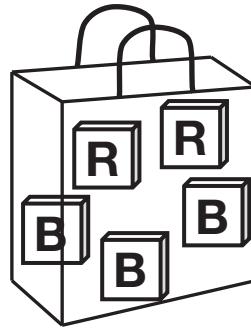
**Example A**

Probability of pulling a red tile from the bag =  
 $2/5 = 0.40$



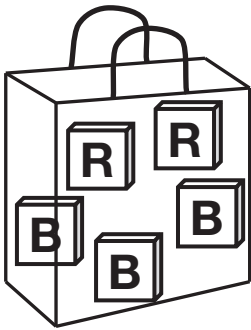
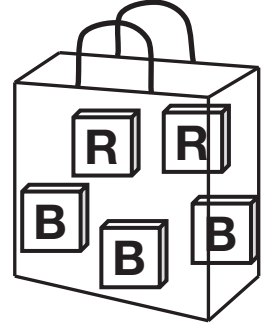
**Example B**

Probability of pulling a blue tile from the bag =  
 $3/5 = 0.60$



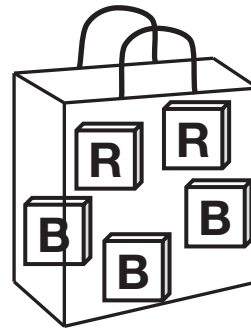
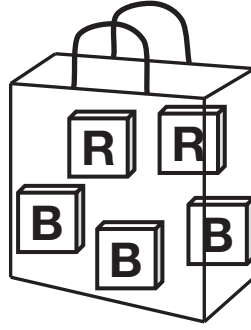
**Example C**

Probability of pulling a red tile from each bag =  
 $0.40 \times 0.40 = 0.16$



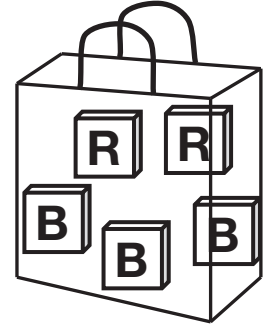
**Example D**

Probability of pulling a red tile from the first bag and a blue tile from the second bag =  
 $0.40 \times 0.60 = 0.24$



**Example E**

Probability of pulling a red tile from one bag and a blue tile from the other bag (in any order) =  
 $(0.40 \times 0.60) + (0.60 \times 0.40) = 0.48$



8. According to Model 2, what is the probability of selecting a red tile at random from one of the bags illustrated?
  
9. Imagine you have a classmate who has never had an introduction to statistics in a math course. Explain to that person how the probability of selecting a red tile is determined. Use complete sentences.

10. What is the probability of selecting either a red or blue tile from one of the bags? Show a mathematical equation to support your answer.
  
11. Consider examples C and D in Model 2. How are the probabilities from examples A and B used to calculate the probability of pulling one tile each from two bags?
  
12. Calculate the probability of pulling a blue tile from each of two bags identical to those in Model 2. Show a mathematical equation to support your answer.
  
13. Compare and contrast examples D and E in Model 2.
  
  
  
  
  
  
  
  
  
  
14. Propose an explanation for why the final probability answer in example E is twice as big as the final probability answer in example D.

15. Consider two six-sided dice.
- Calculate the probability of rolling a “3” on a single die.
  - Calculate the probability of rolling a “3” on both dice.
  - Calculate the probability of rolling a “3” on the first die and a “4” on the second die.
  - Calculate the probability of rolling a “3” and a “4” on the dice.



16. Consider cross B of Model 1.
- What is the probability that the offspring will get a B allele from the male beetle?
  - What is the probability that the offspring will get a B allele from the female beetle?
  - Calculate the probability that the offspring will have the genotype BB from this cross. Support your answer with a mathematical equation.
  - According to the Punnett square for cross B, was your answer to part *c* correct? If not, try to determine a mistake in your calculations. You may want to send a representative of your group to another group for assistance.
17. Calculate the probability that the offspring from cross B of Model 1 will have the genotype Bb. Support your answer with a mathematical equation.
18. Calculate the probability that the offspring from cross B of Model 1 will have the genotype bb. Support your answer with a mathematical equation.
19. How could your answers from Questions 16–18 be used to calculate the probability that the offspring from cross B of Model 1 would have a black exoskeleton? Support your answer with a mathematical equation.

20. Without constructing a Punnett square, show how you could calculate the probability of an offspring having each of the possible genotypes for the beetles in Model 1 when a homozygous dominant beetle mates with a homozygous recessive beetle.

prob. BB =

prob. Bb =

prob. bb =

21. Check your answers to Question 20 by drawing the appropriate Punnett square.

22. Calculate the probability of an offspring having the genotype Bb from two heterozygous beetles.



23. Check your answer to Question 22 by consulting the appropriate Punnett square in Model 1. (*Note:* If you did not get the correct answer, consider that the alleles can be selected in either order—Bb or bB.)

24. The parent beetles in cross D of Model 1 have 16 offspring. Predict the number of offspring that will have black exoskeletons.



## Extension Questions

25. Consider the beetle pair in cross D of Model 1. What is the probability for that beetle pair to have three black exoskeleton offspring in a row?

## Read This!

At times scientists want to look at the inheritance statistics of two or more genes that are related. For example, the beetles in Model 1 might have long legs (from the dominant allele, N) or short legs (from the recessive allele, n). The genotypes would then be written BbNn or BBnn. In order to determine what genotypes the offspring might have, each combination of alleles is considered. For example, if a male beetle was BbNn, he could pass on the allele sets BN, Bn, bN or bn. Both Punnett squares and statistics can still be used to determine the possible combinations in the offspring.

26. Consider a cross of beetles with exoskeleton alleles B and b and leg size alleles N and n. The male parent is heterozygous in both traits. The female parent is homozygous recessive in both traits.
- Write the four letter genotype for each parent.
  - Use the Punnett square below to find the possible allele combinations for an offspring.

		Possible allele combinations from the male			
Possible allele combinations from the female					

- What is the probability that the offspring will have a genotype of Bbnn?
- Show how statistics could be used to calculate the probability you found in part *c* without using a Punnett square.