Determining Types of Crosses

FIGURE 6: A Curly Bashkir Horse

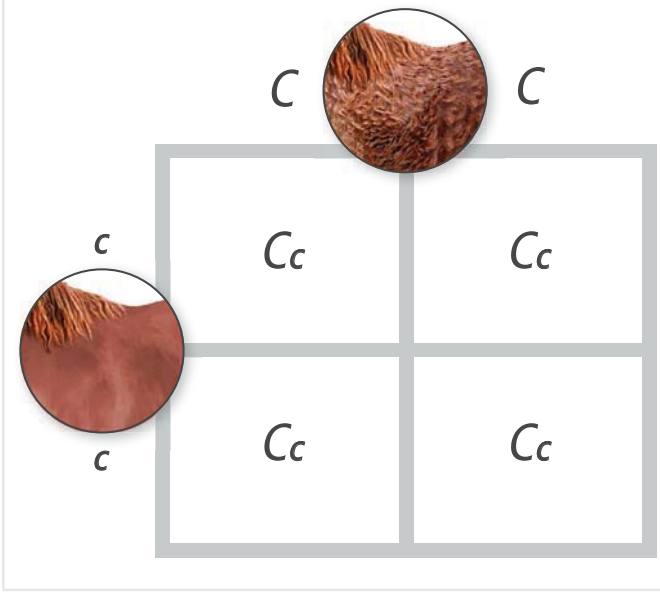
In most horse breeds, a smooth coat is dominant to a curly coat. The recessive allele is responsible for naturally curly coats that occasionally appear in some horse breeds. Because the gene is recessive, these occurrences are rare. In a few horse breeds, such as the Bashkir horse, the curly-coat allele, *C*, is dominant and the the smooth-coat allele, *c*, is recessive.

Predict Imagine you crossed a smooth-coated Bashkir horse with a curly-coated Bashkir horse. How could you determine the possible outcomes of this cross?

Analyzing the Inheritance of One Trait

All of the genetic crosses discussed so far have involved one trait, from flower color in pea plants to coat texture in dogs. A cross that examines one trait is a monohybrid cross. There are three basic types of monohybrid crosses: a homozygous-homozygous cross, a heterozygous-heterozygous cross, and a heterozygous-homozygous cross.

FIGURE 7: Homozygous-Homozygous Cross



Homozygous-Homozygous Cross

A homozygous-homozygous cross occurs when a homozygous dominant parent crosses with a homozygous recessive parent. Imagine that a Bashkir horse that is homozygous dominant for curly hair (*CC*) is crossed with a Bashkir horse that is homozygous recessive for smooth hair (*cc*).

The Punnett square in Figure 7 models the possible outcomes of the cross. As shown, a homozygous-homozygous cross always results in heterozygous offspring because one parent can donate only dominant alleles and the other can donate only recessive alleles. The sole possible outcome of the cross is one dominant allele and one recessive allele, which is a heterozygous combination. For the cross shown in Figure 7, all of the offspring would have the heterozygous genotype, *Cc*. They would have curly coats because the dominant curly-coat allele, *C*, is present in all genotypes. Each offspring would also carry the recessive smooth-coat allele, *c*.

Math Connection Probability is measured on a scale from 0 to 1. For a homozygous-homozygous cross, determine the following probabilities:

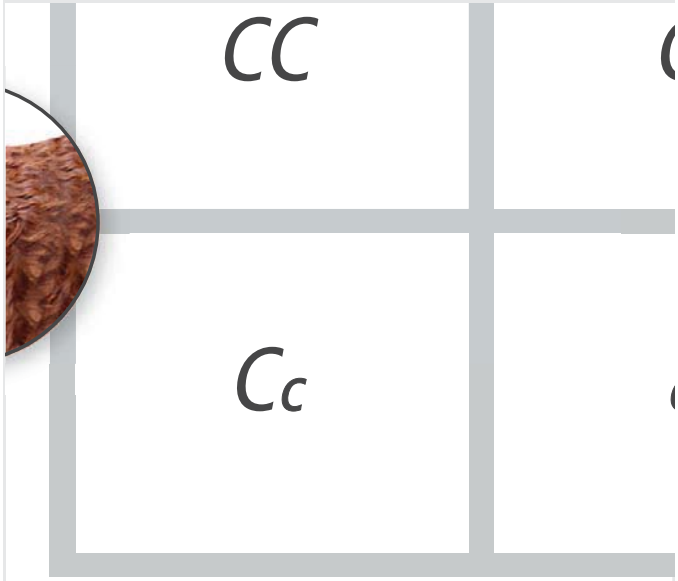
1. Probability of homozygous recessive offspring
2. Probability of homozygous dominant offspring
3. Probability of heterozygous offspring

Heterozygous-Heterozygous Cross

Imagine you wish to cross two curly-coated, heterozygous Bashkir horses. Each horse has the genotype *Cc* and can pass on either the dominant allele for curly hair or the recessive allele for smooth hair. The probability of each parent donating a dominant allele to the offspring is $\frac{1}{2}$. The probability of each parent donating a recessive allele to the offspring is also $\frac{1}{2}$.

Figure 8 shows the Punnett square for this heterozygous-heterozygous cross. From each parent, half the offspring receive a dominant allele (*C*) and half receive a recessive allele (*c*).

FIGURE 8: Heterozygous-Heterozygous Cross



Math Connection In the heterozygous-heterozygous cross modeled in Figure 8, what is the probability of offspring with homozygous dominant, heterozygous, or homozygous recessive genotypes?

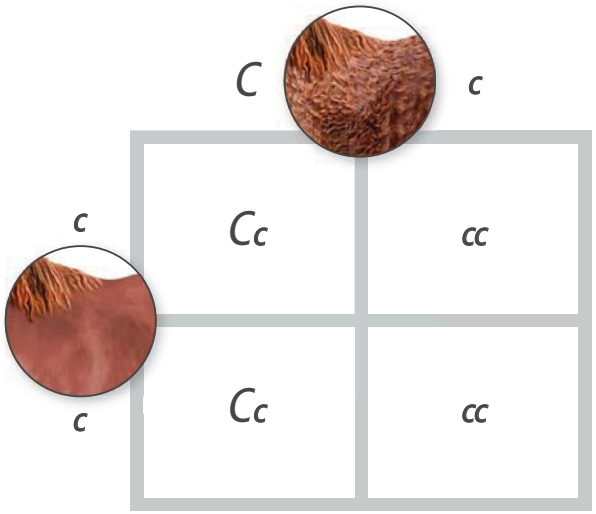
This type of cross for a single trait always results in a genotypic ratio of 1:2:1. This means that $\frac{1}{4}$ of offspring will have the homozygous dominant genotype, $\frac{2}{4}$ will have the heterozygous genotype, and $\frac{1}{4}$ will have the homozygous recessive genotype.The phenotypic ratio is 3:1 of dominant:recessive phenotypes. In other words, of the potential offspring phenotypes, $\frac{3}{4}$ will have the dominant phenotype and $\frac{1}{4}$ will have the recessive phenotype.

Heterozygous-Homozygous Cross

Now, imagine a heterozygous-homozygous cross between a heterozygous Bashkir horse with curly hair (*Cc*) and a homozygous recessive Bashkir horse with smooth hair (*cc*). From the homozygous parent, the offspring receive a recessive allele, *c*. From the heterozygous parent, half the offspring receive a dominant allele, *C*, and half receive a recessive allele, *c*.

Figure 9 shows the Punnett square for this heterozygous-homozygous cross. This cross results in two offspring with the genotype *Cc* and two offspring with the genotype *cc*.

FIGURE 9: Heterozygous-Homozygous Cross



Math Connection What is the probability the offspring in this cross will have a heterozygous genotype? What about a homozygous-recessive genotype?

A heterozygous-homozygous cross always produces parental genotypes in a 1:1 genotypic ratio. For the cross in Figure 9, the probability of offspring with the heterozygous genotype and the probability of offspring with the homozygous recessive genotype are both $\frac{1}{2}$. The phenotypic ratio in this instance is also 1:1, because the probability that each coat type will occur is $\frac{1}{2}$. So, in this cross, half of the offspring will have curly coats and half will have smooth coats.

Analyze In your Evidence Notebook, complete a cross between a heterozygous horse (*Cc*) and a homozygous-dominant horse (*CC*). Were your results the same?

Hands-On Activity

Determining a Genotype

FIGURE 10: Peaches and nectarines are the same species, *Prunus persica*.

MATERIALS

- paper
- pencil

Peaches have fuzzy skin. A nectarine is a variety of smooth-skinned peach. A dominant allele, *G*, causes fuzzy skin. All peaches have at least one copy of this allele. Nectarines come from trees that are homozygous recessive (*gg*) for fuzz.

Imagine your company sells peach and nectarine seedlings. You developed a new type of peach tree that is very popular. To meet demand, you must learn the genotypes of your breeding stock. You determine them by setting up a testcross between an individual that has a dominant phenotype but an unknown genotype and an individual that is homozygous recessive.

Predict How can a testcross help you find the unknown genotype of the plant?

PROCEDURE

1. Plant A produces peaches. You need to determine its genotype. Plant B produces nectarines that have smooth skin and a known genotype of *gg*. You cross Plant A with Plant B.
3. The resulting cross yields twelve plants. Six plants produce peaches upon the first fruiting and six plants produce nectarines upon the first fruiting.
4. Use Punnett squares to determine the genotype of Plant A.

ANALYZE

Answer the following questions in your Evidence Notebook:

1. What is the genotype of Plant A? Explain how you arrived at your answer.
2. Plant A is crossed with a plant that has a genotype of *GG*. What are the possible genotypes and phenotypes of the offspring?
3. Plant A is crossed with a plant that has a genotype of *Gg*. What is the ratio of dominant to recessive phenotypes of the offspring?
4. In terms of genotype, is Plant A the best plant to produce as many peach seedlings as possible? Why or why not? Which genotype would be best?

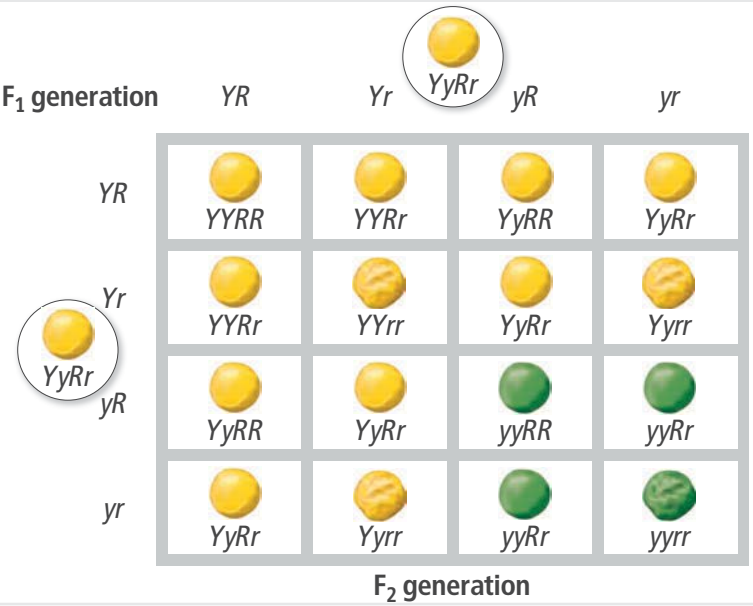
Image Credits: Georgia Department of Economic Development

Analyzing the Inheritance of Two Traits

A dihybrid cross examines the inheritance of two traits. Consider the peas shown in Figure 11, which can be yellow or green and round or wrinkled. The yellow allele, *Y*, is dominant to the green allele, *y*. The round allele, *R*, is dominant to the wrinkled allele, *r*. Figure 12 shows a cross between two heterozygous plants (*YyRr*). Each gamete receives one allele for pea color and one allele for pea shape. Each pea color allele has an equal probability of being paired with each pea shape allele. There are four possible combinations of alleles in heterozygous dihybrid gametes. The probability of producing any of the four gametes is one out of four.

FIGURE 11: Phenotypes of Peas

FIGURE 12: A dihybrid cross between two heterozygous pea plants.



Gather Evidence Determine the number of possible phenotypes in the dihybrid cross. What is the ratio for all the possibilities?

Math Connection Use the Punnett square to answer the following questions:

1. What is the probability that the cross will produce a plant that is heterozygous for both traits? What is the probability of producing a plant with yellow and round peas? Why are these two probabilities different?
2. Make a Punnett square for the dihybrid cross *YyRr* and *yyrr*. How are the probabilities of this cross different from those in Question 1?

In this cross, the chance of producing offspring that exhibit both dominant traits (yellow and round) is $\frac{9}{16}$. The chance of producing offspring that exhibit one dominant trait and one recessive trait (yellow and wrinkled or green and round) is $\frac{3}{16}$. Finally, the chance of producing offspring that exhibit both recessive traits (green and wrinkled) is $\frac{1}{16}$. Using Figure 12, you can see these possibilities. There are nine yellow and round peas, three yellow and wrinkled peas, three green and round peas, and one green and wrinkled pea. Therefore, a heterozygous-heterozygous dihybrid cross results in a phenotypic ratio of 9:3:3:1.

Explain Why are Punnett squares a useful model for scientists studying traits and genetic disorders? In which other types of careers would this model be useful?