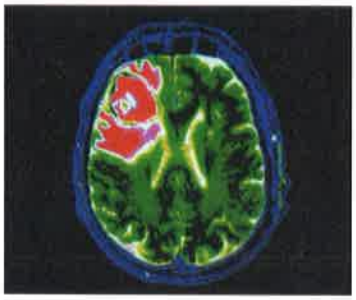
Technology and Society

• Tech & Design •

What Is Biotechnology?

A fairly new branch of science called biotechnology uses the data and techniques of engineering and technology for the study and solution of problems concerning living things and tiny parts of living things (like cells and molecules). Some biotechnology projects involve genomics, the study of genes and how they function. The word *genomics* comes from the word *genome,* which refers to all the genes in an organism.



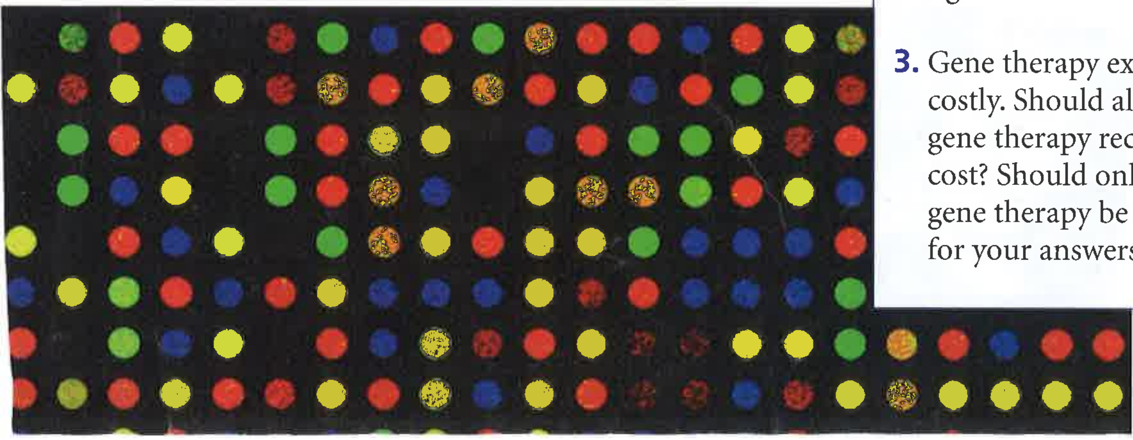
Cancerous Tumor
The bright spot on this X-ray of the brain shows where a cancerous tumor is located. Doctors remove DNA from cancer cells and normal cells to compare the genes.

Biotechnology and Disease

Some of the genomics projects currently underway are searching for links between genes and cancer. A device called a microarray helps scientists compare the genes of healthy cells with the genes of cancerous cells. Gene sequences from the cells are placed on the microarray. A computer scans the microarray and determines which genes are active.

A gene that is active in a cancer cell but not active in a healthy cell might be the cause of the cancer. By identifying such genes, scientists can focus their research on finding ways to block the function of these genes. This area of biotechnology is called gene therapy. Because each disease-causing gene is different, a specific gene therapy must be developed for each disease.

Microarray
Active genes can be identified by using a microarray. Brighter spots indicate more active genes.



What Do You Think?

1. What is one way biotechnology can be used to help people?

2. At the library or on the Internet, do research to find one disease for which scientists are trying to develop gene therapy. Write two or three paragraphs in which you describe the disease and how scientists expect gene therapy will fight it.

3. Gene therapy experiments will be very costly. Should all the people who need gene therapy receive it regardless of the cost? Should only those who can afford gene therapy be treated? Give reasons for your answers.

Section 3

Mendel's Work

Reading Preview

Key Concepts

- What were the results of Mendel's experiments, or crosses?
- What controls the inheritance of traits in organisms?

Key Terms

- heredity • trait • genetics
- fertilization • purebred • gene
- alleles • dominant allele
- recessive allele • hybrid

Target Reading Skill

Outlining As you read, make an outline about Mendel's work. Use the red headings for the main ideas and the blue headings for the supporting ideas.

Mendel's Work

I. Mendel's experiments
   A. Crossing pea plants
   B.
   C.

Lab zone Discover Activity

What Does the Father Look Like?

1. Observe the colors of the kitten in the photo. Record the kitten's coat colors and pattern. Include as many details as you can.
2. Observe the mother cat in the photo. Record her coat color and pattern.

Think It Over

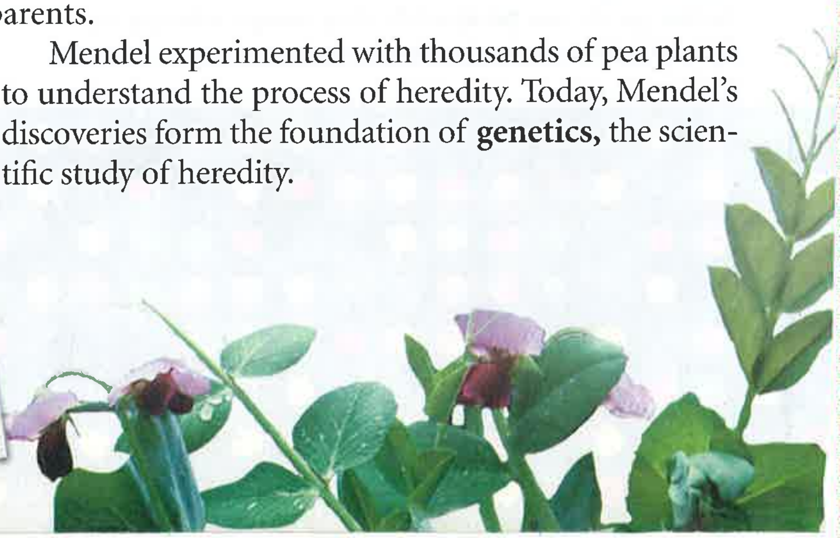
Inferring Based on your observations, describe what you think the kitten's father might look like. Identify the evidence on which you based your inference.

In the mid nineteenth century, a priest named Gregor Mendel tended a garden in a central European monastery. Mendel's experiments in that peaceful garden would one day revolutionize the study of heredity. **Heredity** is the passing of physical characteristics from parents to offspring.

Mendel wondered why different pea plants had different characteristics. Some pea plants grew tall, while others were short. Some plants produced green seeds, while others had yellow seeds. Each different form of a characteristic, such as stem height or seed color, is called a **trait.** Mendel observed that the pea plants' traits were often similar to those of their parents. Sometimes, however, the plants had different traits from those of their parents.

Mendel experimented with thousands of pea plants to understand the process of heredity. Today, Mendel's discoveries form the foundation of **genetics,** the scientific study of heredity.

Gregor Mendel ▶



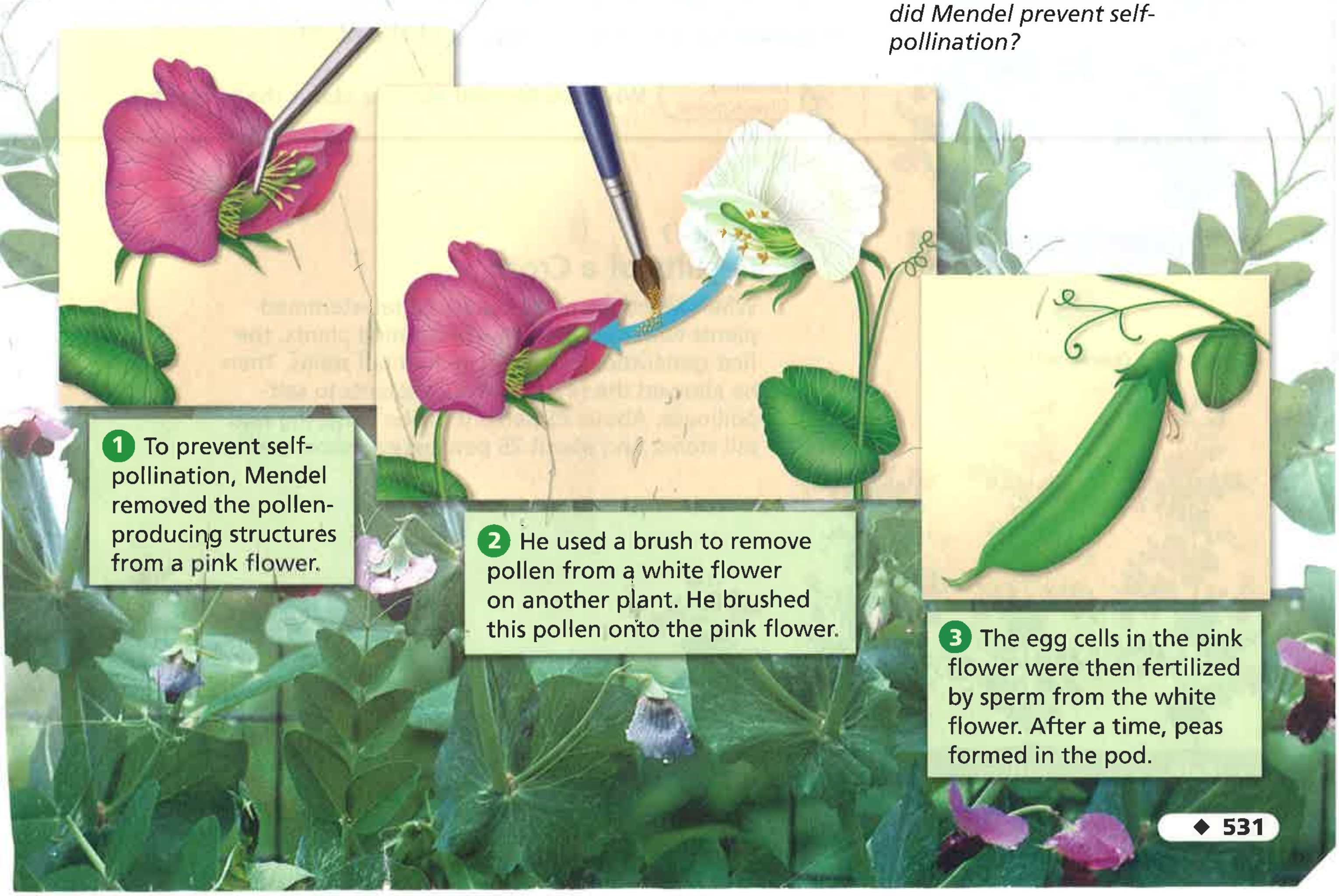
Mendel's Experiments

Figure 16 shows a pea plant's flower. The flower's petals surround the pistil and the stamens. The pistil produces female sex cells, or eggs. The stamens produce pollen, which contains the male sex cells, or sperm. A new organism begins to form when egg and sperm join in the process called **fertilization.** Before fertilization can happen in pea plants, pollen must reach the pistil of a pea flower. This process is called pollination.

Pea plants are usually self-pollinating. In self-pollination, pollen from a flower lands on the pistil of the same flower. Mendel developed a method by which he cross-pollinated, or "crossed," pea plants. To cross two plants, he removed pollen from a flower on one plant. He then brushed the pollen onto a flower on a second plant.

Crossing Pea Plants Suppose you wanted to study the inheritance of traits in pea plants. What could you do? Mendel decided to cross plants with contrasting traits—for example, tall plants and short plants. He started his experiments with purebred plants. A **purebred** organism is the offspring of many generations that have the same trait. For example, purebred short pea plants always come from short parent plants.

FIGURE 16
Crossing Pea Plants
Gregor Mendel crossed pea plants that had different traits. The illustrations show how he did this. **Interpreting Diagrams** *How did Mendel prevent self-pollination?*



The F_1 Offspring In one experiment, Mendel crossed purebred tall plants with purebred short plants. Scientists today call these parent plants the parental generation, or P generation. The offspring from this cross are the first filial (FIL ee ul) generation, or the F_1 generation. The word *filial* comes from *filia* and *filius*, the Latin words for "daughter" and "son."

In Figure 17, notice that all the offspring in the F_1 generation were tall. Even though one of the parent plants was short, none of the offspring were short. The shortness trait seemed to disappear!

The F_2 Offspring When the plants in the F_1 generation were full-grown, Mendel allowed them to self-pollinate. Surprisingly, the plants in the F_2 (second filial) generation were a mix of tall and short plants. The shortness trait had reappeared, even though none of the F_1 parent plants were short. Mendel counted the tall and short plants. About three fourths of the plants were tall, while one fourth were short.

Experiments With Other Traits Mendel also crossed pea plants with other contrasting traits. Compare the two forms of each trait in Figure 18. **In all of Mendel's crosses, only one form of the trait appeared in the F_1 generation. However, in the F_2 generation, the "lost" form of the trait always reappeared in about one fourth of the plants.**

Reading Checkpoint **What did Mendel observe about the F_2 plants?**

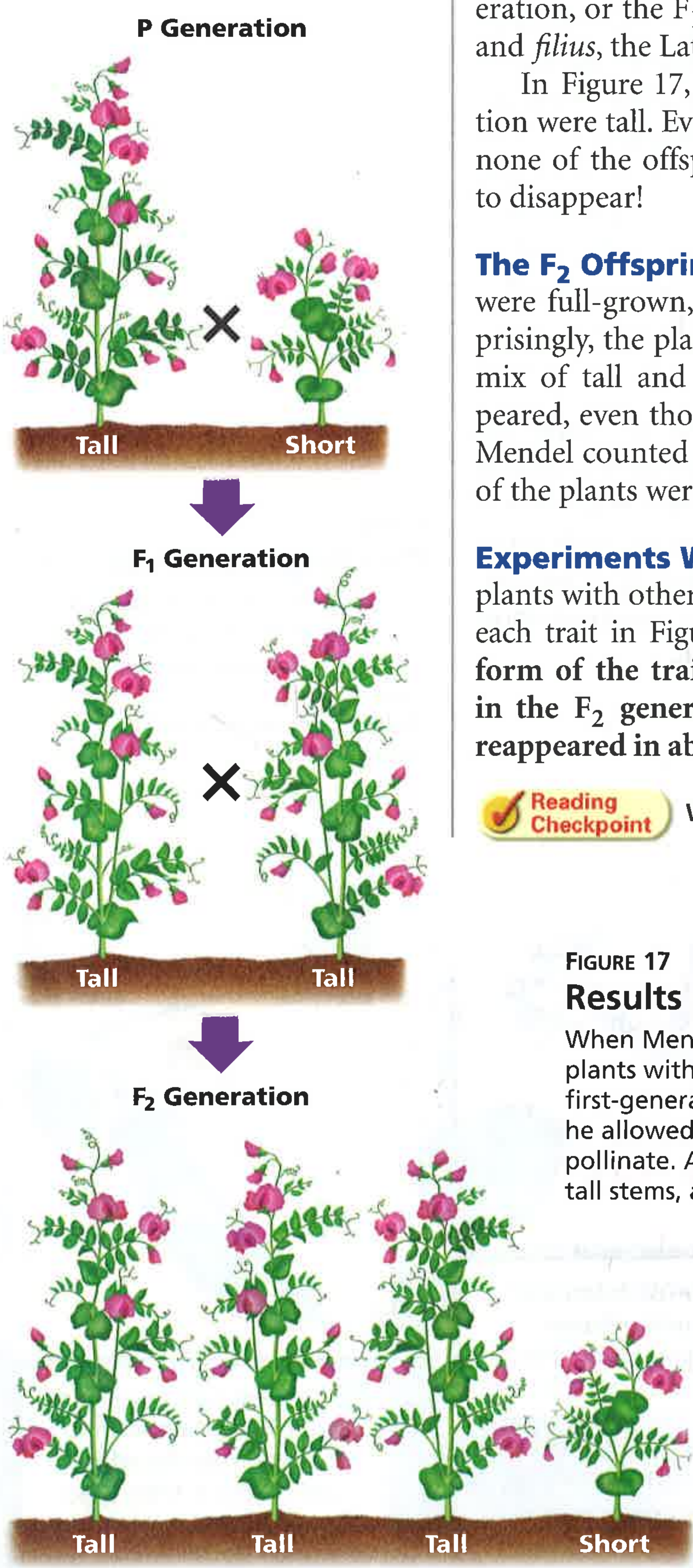


FIGURE 17
Results of a Cross
When Mendel crossed purebred tall-stemmed plants with purebred short-stemmed plants, the first-generation offspring all had tall stems. Then he allowed the first-generation plants to self-pollinate. About 75 percent of the offspring had tall stems, and about 25 percent had short stems.

Genetics of Pea Plants							
Traits	**Seed Shape**	**Seed Color**	**Seed Coat Color**	**Pod Shape**	**Pod Color**	**Flower Position**	**Stem Height**
Controlled by Dominant Allele	 Round	 Yellow	 Gray	 Smooth	 Green	 Side	 Tall
Controlled by Recessive Allele	 Wrinkled	 Green	 White	 Pinched	 Yellow	 End	 Short

Dominant and Recessive Alleles

Mendel reached several conclusions on the basis of his experimental results. He reasoned that individual factors, or sets of genetic "information," must control the inheritance of traits in peas. The factors that control each trait exist in pairs. The female parent contributes one factor, while the male parent contributes the other factor. Finally, one factor in a pair can mask, or hide, the other factor. The tallness factor, for example, masked the shortness factor.

Genes and Alleles Today, scientists use the word **gene** for the factors that control a trait. **Alleles** (uh LEELZ) are the different forms of a gene. The gene that controls stem height in peas, for example, has one allele for tall stems and one allele for short stems. Each pea plant inherits two alleles from its parents—one allele from the egg and the other from the sperm. A pea plant may inherit two alleles for tall stems, two alleles for short stems, or one of each.

An organism's traits are controlled by the alleles it inherits from its parents. Some alleles are dominant, while other alleles are recessive. A **dominant allele** is one whose trait always shows up in the organism when the allele is present. A **recessive allele,** on the other hand, is hidden whenever the dominant allele is present. A trait controlled by a recessive allele will only show up if the organism does not have the dominant allele. Figure 18 shows dominant and recessive alleles in Mendel's crosses.

FIGURE 18
Mendel studied several traits in pea plants.
Interpreting Diagrams *Is yellow seed color controlled by a dominant allele or a recessive allele?*

Lab zone Skills Activity

Predicting

In fruit flies, long wings are dominant over short wings. A scientist crossed a purebred long-winged male fruit fly with a purebred short-winged female. Predict the wing length of the F_1 offspring. If the scientist crossed a hybrid male F_1 fruit fly with a hybrid F_1 female, what would their offspring probably be like?

In pea plants, the allele for tall stems is dominant over the allele for short stems. Pea plants with one allele for tall stems and one allele for short stems will be tall. The allele for tall stems masks the allele for short stems. Only pea plants that inherit two recessive alleles for short stems will be short.

Alleles in Mendel's Crosses In Mendel's cross for stem height, the purebred tall plants in the P generation had two alleles for tall stems. The purebred short plants had two alleles for short stems. The F_1 plants each inherited an allele for tall stems from the tall parent and an allele for short stems from the short parent. Therefore, each F_1 plant had one allele for tall stems and one for short stems. The F_1 plants are called hybrids. A **hybrid** (HY brid) organism has two different alleles for a trait. All the F_1 plants are tall because the dominant allele for tall stems masks the recessive allele for short stems.

When Mendel crossed the F_1 plants, some of the offspring in the F_2 generation inherited two dominant alleles for tall stems. These plants were tall. Other F_2 plants inherited one dominant allele for tall stems and one recessive allele for short stems. These plants were also tall. The rest of the F_2 plants inherited two recessive alleles for short stems. These plants were short.

Symbols for Alleles Geneticists use letters to represent alleles. A dominant allele is represented by a capital letter. For example, the allele for tall stems is represented by *T*. A recessive allele is represented by the lowercase version of the letter. So, the allele for short stems would be represented by *t*. When a plant inherits two dominant alleles for tall stems, its alleles are written as *TT*. When a plant inherits two recessive alleles for short stems, its alleles are written as *tt*. When a plant inherits one allele for tall stems and one allele for short stems, its alleles are written as *Tt*.

FIGURE 19
Black Fur, White Fur
In rabbits, the allele for black fur is dominant over the allele for white fur. **Inferring** *What combination of alleles must the white rabbit have?*

Significance of Mendel's Contribution Mendel's discovery of genes and alleles eventually changed scientists' ideas about heredity. Before Mendel, most people thought that the traits of an individual organism were simply a blend of their parents' characteristics. According to this idea, if a tall plant and a short plant were crossed, the offspring would all have medium height.

However, when Mendel crossed purebred tall and purebred short pea plants, the offspring were all tall. Mendel's experiments demonstrated that parents' traits do not simply blend in the offspring. Instead, traits are determined by individual, separate alleles inherited from each parent. Some of these alleles, such as the allele for short height in pea plants, are recessive. If a trait is determined by a recessive allele, the trait can seem to disappear in the offspring.

Unfortunately, the importance of Mendel's discovery was not recognized during his lifetime. Then, in 1900, three different scientists rediscovered Mendel's work. These scientists quickly recognized the importance of Mendel's ideas. Because of his work, Mendel is often called the Father of Genetics.

Reading Checkpoint **If an allele is represented by a capital letter, what does this indicate?**

FIGURE 20
The Mendel Medal
Every year, to honor the memory of Gregor Mendel, an outstanding scientist is awarded the Mendel Medal.

Section 3 Assessment

Target Reading Skill Outlining Use the information in your outline about Mendel's work to help you answer the questions below.

Reviewing Key Concepts

1. a. **Identifying** In Mendel's cross for stem height, what contrasting traits did the pea plants in the P generation exhibit?
   b. **Explaining** What trait or traits did the plants in the F_1 generation exhibit? When you think of the traits of the parent plants, why is this result surprising?
   c. **Comparing and Contrasting** Contrast the offspring in the F_1 generation to the offspring in the F_2 generation. What did the differences in the F_1 and F_2 offspring show Mendel?
2. a. **Defining** What is a dominant allele? What is a recessive allele?
   b. **Relating Cause and Effect** Explain how dominant and recessive alleles for the trait of stem height determine whether a pea plant will be tall or short.
   c. **Applying Concepts** Can a short pea plant ever be a hybrid for the trait of stem height? Why or why not? As part of your explanation, write the letters that represent the alleles for stem height of a short pea plant.

Lab zone At-Home Activity

Gardens and Heredity Some gardeners save the seeds produced by flowers and plant them in the spring. If there are gardeners in your family, ask them how closely the plants that grow from these seeds resemble the parent plants. Are the offspring's traits ever different from those of the parents?

Lab zone **Skills Lab**

Take a Class Survey

Go Online
PHSchool.com
For: Data sharing
Visit: PHSchool.com
Web Code: ced-3031

Problem

Are traits controlled by dominant alleles more common than traits controlled by recessive alleles?

Skills Focus

developing hypotheses, interpreting data

Materials

- mirror (optional)

Procedure

PART 1 Dominant and Recessive Alleles

1. Write a hypothesis reflecting your ideas about the problem. Then copy the data table.
2. For each of the traits listed in the data table, work with a partner to determine which trait you have. Circle that trait in your data table.
3. Count the number of students in your class who have each trait. Record that number in your data table. Also record the total number of students.

PART 2 Are Your Traits Unique?

4. Look at the circle of traits on the opposite page. All the traits in your data table appear in the circle. Place the eraser end of your pencil on the trait in the small central circle that applies to you—either free ear lobes or attached ear lobes.
5. Look at the two traits touching the space your eraser is on. Move your eraser onto the next description that applies to you. Continue using your eraser to trace your traits until you reach a number on the outside rim of the circle. Share that number with your classmates.

Analyze and Conclude

1. **Observing** The traits listed under Trait 1 in the data table are controlled by dominant alleles. The traits listed under Trait 2 are controlled by recessive alleles. Which traits controlled by dominant alleles were shown by a majority of students? Which traits controlled by recessive alleles were shown by a majority of students?

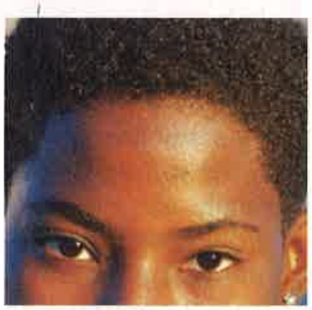
Free ear lobe

Widow's peak

Cleft chin

Dimple

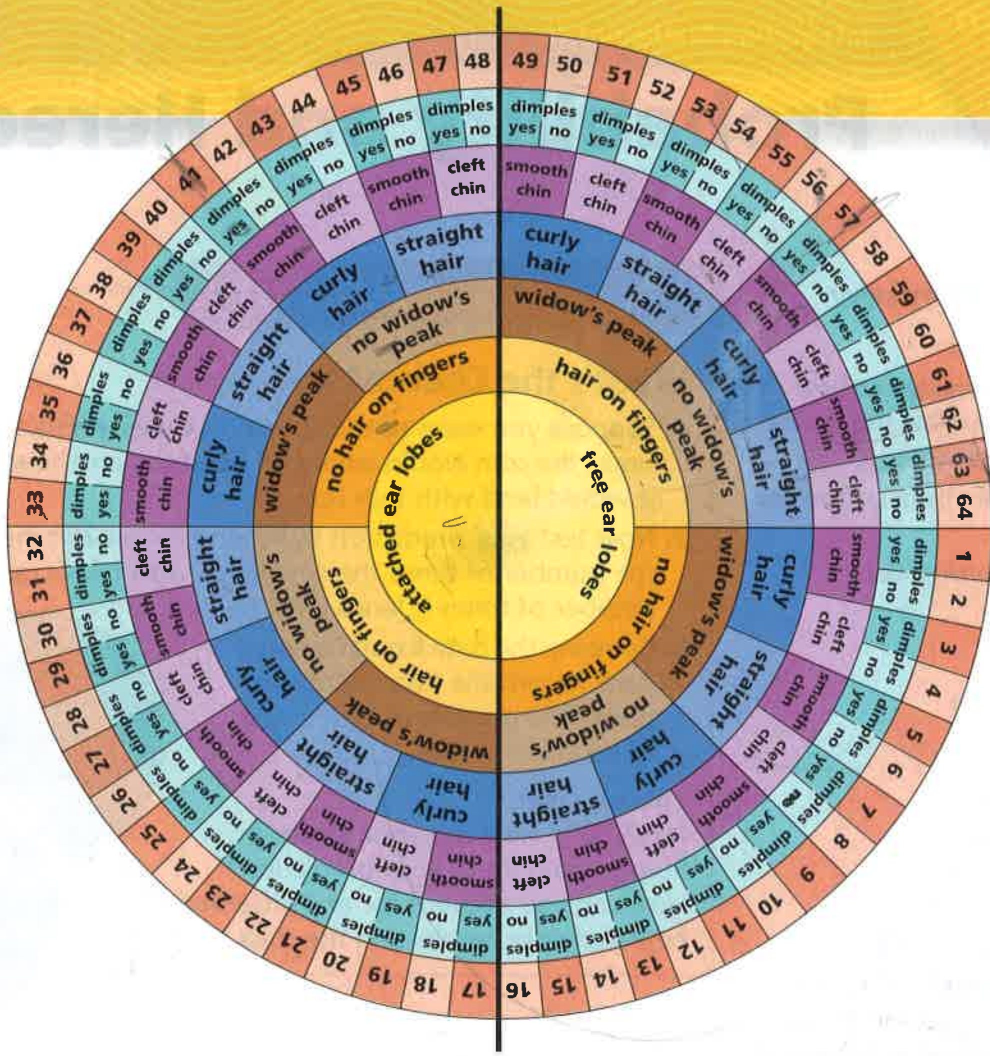
Attached ear lobe



No widow's peak

No cleft chin

No dimple



2. **Interpreting Data** How many students ended up on the same number on the circle of traits? How many students were the only ones to have their number? What do the results suggest about each person's combination of traits?

3. **Developing Hypotheses** Do your data support the hypothesis you proposed in Step 1? Write an answer with examples.

Design an Experiment

Do people who are related to each other show more genetic similarity than unrelated people? Write a hypothesis. Then design an experiment to test your hypothesis. *Obtain your teacher's permission before carrying out your investigation.*

Data Table

Total Number of Students ________

	Trait 1	Number	Trait 2	Number
A	Free ear lobes		Attached ear lobes	
B	Hair on fingers		No hair on fingers	
C	Widow's peak		No widow's peak	
D	Curly hair		Straight hair	
E	Cleft chin		Smooth chin	
F	Smile dimples		No smile dimples	

Section 4

Integrating Mathematics

Probability and Heredity

Reading Preview

Key Concepts

- What is probability and how does it help explain the results of genetic crosses?
- What is meant by genotype and phenotype?
- What is codominance?

Key Terms

- probability
- Punnett square
- phenotype
- genotype
- homozygous
- heterozygous
- codominance

Target Reading Skill

Building Vocabulary After you read the section, reread the paragraphs that contain definitions of Key Terms. Use all the information you have learned to write a definition of each Key Term in your own words.

Go Online SCI LINKS NSTA

For: Links on probability and genetics
Visit: www.SciLinks.org
Web Code: scn-0332

Lab zone Discover Activity

What's the Chance?

1. Suppose you were to toss a coin 20 times. Predict how many times the coin would land with heads up and how many times it would land with tails up.
2. Now test your prediction by tossing a coin 20 times. Record the number of times the coin lands with heads up and the number of times it lands with tails up.
3. Combine the data from the entire class. Record the total number of tosses, the number of heads, and the number of tails.

Think It Over

Predicting How did your results in Step 2 compare to your prediction? How can you account for any differences between your results and the class results?

On a brisk fall afternoon, the stands are packed with cheering football fans. Today is the big game between Riverton's North and South high schools, and it's almost time for the kickoff. Suddenly, the crowd becomes silent, as the referee is about to toss a coin. The outcome of the coin toss will decide which team kicks the ball and which receives it. The captain of the visiting North High team says "heads." If the coin lands with heads up, North High wins the toss and the right to decide whether to kick or receive the ball.

What is the chance that North High will win the coin toss? To answer this question, you need to understand the principles of probability.

Principles of Probability

If you did the Discover activity, you used the principles of **probability** to predict the results of a particular event. In this case, the event was the toss of a coin. **Probability is a number that describes how likely it is that an event will occur.**

Mathematics of Probability Each time you toss a coin, there are two possible ways that the coin can land—heads up or tails up. Each of these two events is equally likely to occur. In mathematical terms, you can say that the probability that a tossed coin will land with heads up is 1 in 2. There is also a 1 in 2 probability that the coin will land with tails up. A 1 in 2 probability can also be expressed as the fraction $\frac{1}{2}$ or as a percent—50 percent.

The laws of probability predict what is likely to occur, not necessarily what will occur. If you tossed a coin 20 times, you might expect it to land with heads up 10 times and with tails up 10 times. However, you might not get these results. You might get 11 heads and 9 tails, or 8 heads and 12 tails. The more tosses you make, the closer your actual results will be to the results predicted by probability.

Reading Checkpoint What is probability?

Independence of Events When you toss a coin more than once, the results of one toss do not affect the results of the next toss. Each event occurs independently. For example, suppose you toss a coin five times and it lands with heads up each time. What is the probability that it will land with heads up on the next toss? Because the coin landed heads up on the previous five tosses, you might think that it would be likely to land heads up on the next toss. However, this is not the case. The probability of the coin landing heads up on the next toss is still 1 in 2, or 50 percent. The results of the first five tosses do not affect the result of the sixth toss.

Math Skills

Percentage

One way you can express a probability is as a percentage. A percentage (%) is a number compared to 100. For example, 50% means 50 out of 100.

Suppose that 3 out of 5 tossed coins landed with heads up. Here's how you can calculate what percent of the coins landed with heads up.

1. Write the comparison as a fraction.

   $$3 \text{ out of } 5 = \frac{3}{5}$$

2. Multiply the fraction by 100% to express it as a percentage.

   $$\frac{3}{5} \times \frac{100\%}{1} = 60\%$$

Practice Problem Suppose 3 out of 12 coins landed with tails up. How can you express this as a percent?

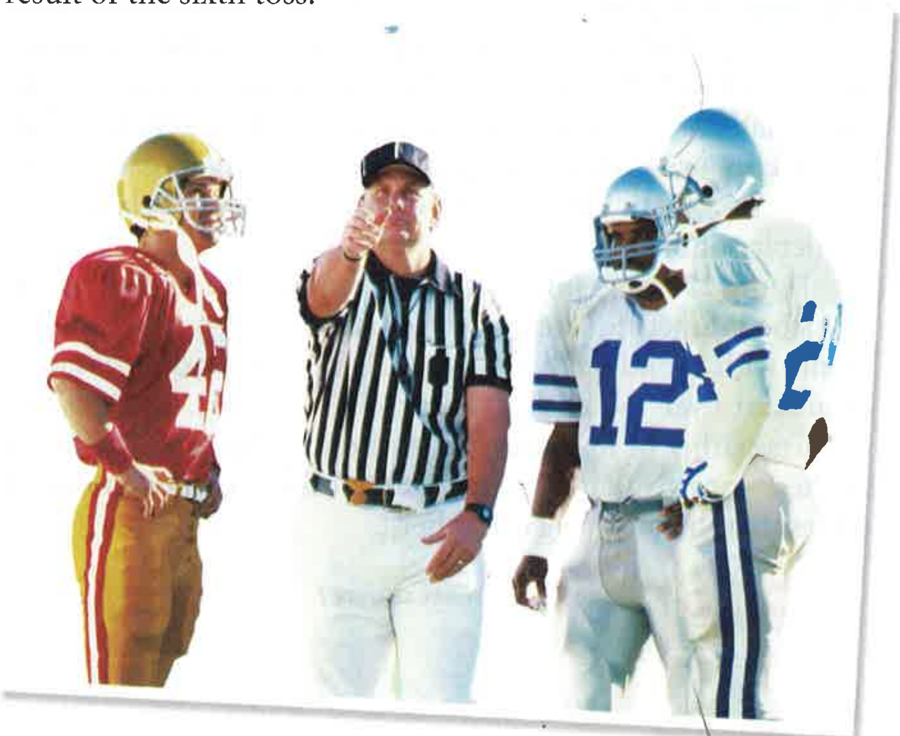
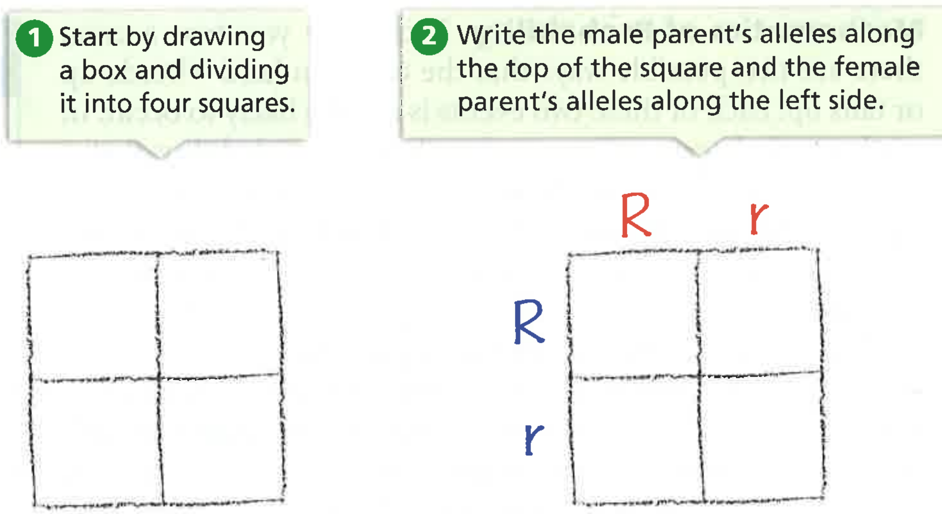


FIGURE 21
A Coin Toss
The result of a coin toss can be explained by probability.

FIGURE 22

How to Make a Punnett Square

The diagrams show how to make a Punnett square. In this cross, both parents are heterozygous for the trait of seed shape. *R* represents the dominant round allele, and *r* represents the recessive wrinkled allele.



Probability and Genetics

How is probability related to genetics? To answer this question, think back to Mendel's experiments with peas. Remember that Mendel carefully counted the offspring from every cross that he carried out. When Mendel crossed two plants that were hybrid for stem height (*Tt*), three fourths of the F_1 plants had tall stems. One fourth of the plants had short stems.

Each time Mendel repeated the cross, he obtained similar results. Mendel realized that the mathematical principles of probability applied to his work. He could say that the probability of such a cross producing a tall plant was 3 in 4. The probability of producing a short plant was 1 in 4. Mendel was the first scientist to recognize that the principles of probability can be used to predict the results of genetic crosses.

Punnett Squares A tool that can help you understand how the laws of probability apply to genetics is called a Punnett square. A **Punnett square** is a chart that shows all the possible combinations of alleles that can result from a genetic cross. Geneticists use Punnett squares to show all the possible outcomes of a genetic cross, and to determine the probability of a particular outcome.

Figure 22 shows how to construct a Punnett square. In this case, the Punnett square shows a cross between two hybrid pea plants with round seeds (*Rr*). The allele for round seeds (*R*) is dominant over the allele for wrinkled seeds (*r*). Each parent can pass either of its alleles, *R* or *r*, to its offspring. The boxes in the Punnett square represent the possible combinations of alleles that the offspring can inherit.

Reading Checkpoint What is a Punnett square?

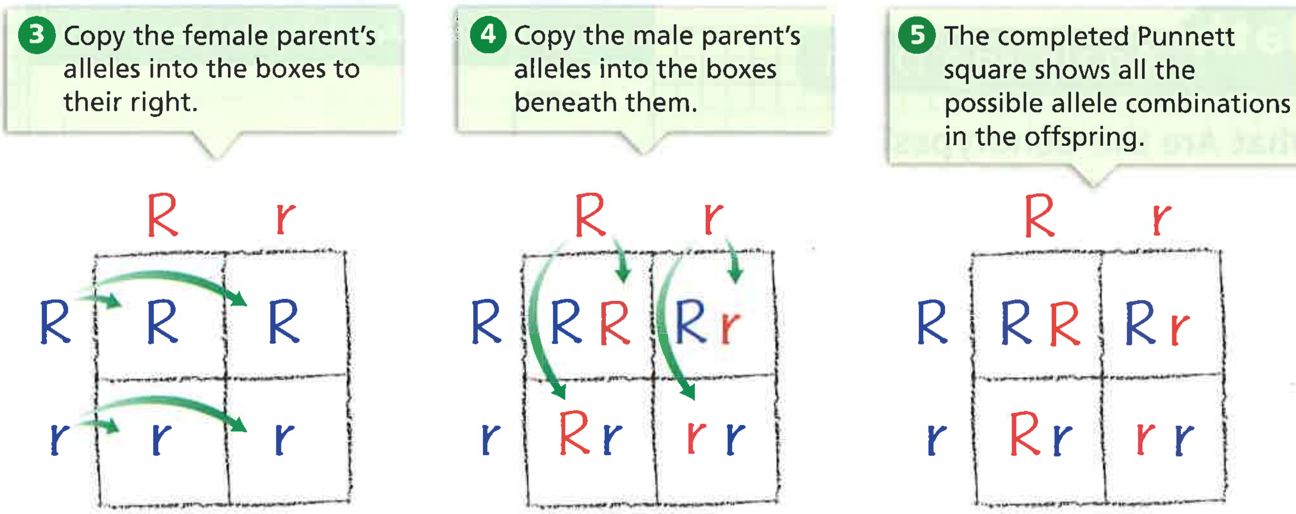
Lab zone Try This Activity

Coin Crosses

Here's how you can use coins to model Mendel's cross between two *Tt* pea plants.

1. Place a small piece of masking tape on each side of two coins.
2. Write a *T* (for tall) on one side of each coin and a *t* (for short) on the other.
3. Toss both coins together 20 times. Record the letter combinations that you obtain from each toss.

Interpreting Data How many of the offspring would be tall plants? (*Hint:* What different letter combinations would result in a tall plant?) How many would be short? Convert your results to percentages. Then compare your results to Mendel's.

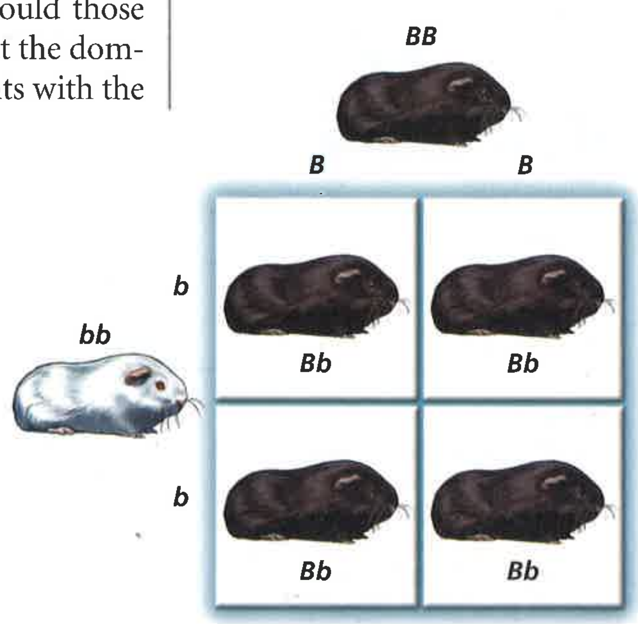


Using a Punnett Square You can use a Punnett square to calculate the probability that offspring with a certain combination of alleles will result. **In a genetic cross, the allele that each parent will pass on to its offspring is based on probability.** The completed Punnett square in Figure 22 shows four possible combinations of alleles. The probability that an offspring will be *RR* is 1 in 4, or 25 percent. The probability that an offspring will be *rr* is also 1 in 4, or 25 percent. Notice, however, that the *Rr* allele combination appears in two boxes in the Punnett square. This is because there are two possible ways in which this combination can occur. So the probability that an offspring will be *Rr* is 2 in 4, or 50 percent.

When Mendel crossed hybrid plants with round seeds, he discovered that about three fourths of the plants (75 percent) had round seeds. The remaining one fourth of the plants (25 percent) produced wrinkled seeds. Plants with the *RR* allele combination would produce round seeds. So too would those plants with the *Rr* allele combination. Remember that the dominant allele masks the recessive allele. Only those plants with the *rr* allele combination would have wrinkled seeds.

Predicting Probabilities You can use a Punnett square to predict probabilities. For example, Figure 8 shows a cross between a purebred black guinea pig and a purebred white guinea pig. The allele for black fur is dominant over the allele for white fur. Notice that only one allele combination is possible in the offspring—*Bb*. All of the offspring will inherit the dominant allele for black fur. Because of this, all of the offspring will have black fur. There is a 100 percent probability that the offspring will have black fur.

FIGURE 23
Guinea Pig Punnett Square
This Punnett square shows a cross between a black guinea pig (*BB*) and a white guinea pig (*bb*).
Calculating *What is the probability that an offspring will have white fur?*

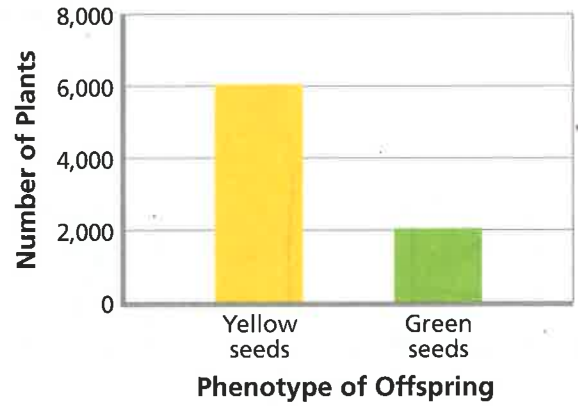


Math Analyzing Data

What Are the Genotypes?

Mendel allowed several F_1 pea plants with yellow seeds to self-pollinate. The graph shows the approximate numbers of the F_2 offspring with yellow seeds and with green seeds.

One of Mendel's Crosses



1. **Reading Graphs** How many F_2 offspring had yellow seeds? How many had green seeds?
2. **Calculating** Use the information in the graph to calculate the total number of offspring that resulted from this cross. Then calculate the percentage of the offspring with yellow peas, and the percentage with green peas.
3. **Inferring** Use the answers to Question 2 to infer the probable genotypes of the parent plants. (*Hint:* Construct Punnett squares with the possible genotypes of the parents.)

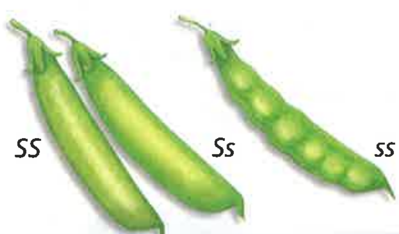
Phenotypes and Genotypes

Two useful terms that geneticists use are **phenotype** (FEE noh typ) and **genotype** (JEN uh typ). **An organism's phenotype is its physical appearance, or visible traits. An organism's genotype is its genetic makeup, or allele combinations.**

To understand the difference between phenotype and genotype, look at Figure 24. The allele for smooth pea pods (*S*) is dominant over the allele for pinched pea pods (*s*). All of the plants with at least one dominant allele have the same phenotype—they all produce smooth pods. However, the plants can have two different genotypes—*SS* or *Ss*. If you were to look at the plants with smooth pods, you would not be able to tell the difference between those with the *SS* genotype and those with the *Ss* genotype. The plants with pinched pods, on the other hand, would all have the same phenotype—pinched pods—as well as the same genotype—*ss*.

Geneticists use two additional terms to describe an organism's genotype. An organism that has two identical alleles for a trait is said to be **homozygous** (hoh moh ZY gus) for that trait. A smooth-pod plant that has the alleles *SS* and a pinched-pod plant with the alleles *ss* are both homozygous. An organism that has two different alleles for a trait is **heterozygous** (het ur oh ZY gus) for that trait. A smooth-pod plant with the alleles *Ss* is heterozygous. Mendel used the term *hybrid* to describe heterozygous pea plants.

Reading Checkpoint **If a pea plant's genotype is *Ss*, what is its phenotype?**



Phenotypes and Genotypes

Phenotype	Genotype
Smooth pods	*SS*
Smooth pods	*Ss*
Pinched pods	*ss*

FIGURE 24
The phenotype of an organism is its physical appearance. Its genotype is its genetic makeup.
Interpreting Tables *How many genotypes are there for the smooth-pod phenotype?*

Codominance

For all of the traits that Mendel studied, one allele was dominant while the other was recessive. This is not always the case. For some alleles, an inheritance pattern called **codominance** exists. **In codominance, the alleles are neither dominant nor recessive. As a result, both alleles are expressed in the offspring.**

Look at Figure 25. Mendel's principle of dominant and recessive alleles does not explain why the heterozygous chickens have both black and white feathers. The alleles for feather color are codominant—neither dominant nor recessive. As you can see, neither allele is masked in the heterozygous chickens. Notice also that the codominant alleles are written as capital letters with superscripts—F^B for black feathers and F^W for white feathers. As the Punnett square shows, heterozygous chickens have the F^BF^W allele combination.

Reading Checkpoint **How are the symbols for codominant alleles written?**

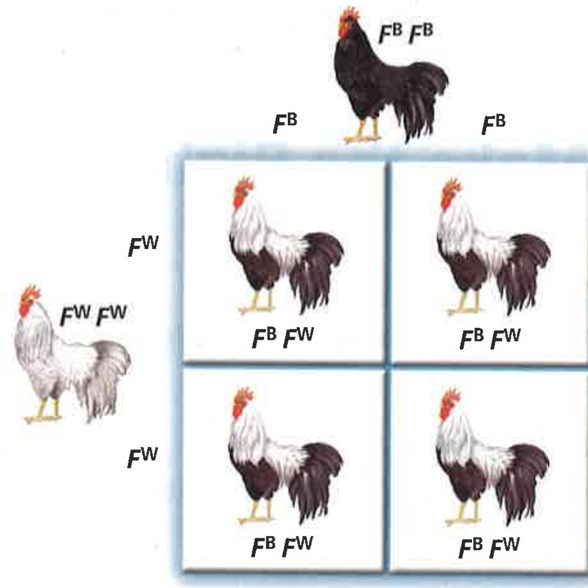


FIGURE 25
Codominance
The offspring of the cross in this Punnett square will have both black and white feathers.
Classifying *Will the offspring be heterozygous or homozygous? Explain your answer.*

Section 4 Assessment

Target Reading Skill **Building Vocabulary** Use your definitions to help you answer the questions.

Reviewing Key Concepts

1. a. **Reviewing** What is probability?
   b. **Explaining** If you know the parents' alleles for a trait, how can you use a Punnett square to predict the probable genotypes of the offspring?
   c. **Predicting** A pea plant with round seeds has the genotype *Rr*. You cross this plant with a wrinkled-seed plant, genotype *rr*. What is the probability that the offspring will have wrinkled seeds? (Use a Punnett square to help with the prediction.)
2. a. **Defining** Define *genotype* and *phenotype*.
   b. **Relating Cause and Effect** Explain how two organisms can have the same phenotype but different genotypes. Give an example.
   c. **Applying Concepts** A pea plant has a tall stem. What are its possible genotypes?
3. a. **Explaining** What is codominance? Give an example of codominant alleles and explain why they are codominant.
   b. **Applying Concepts** What is the phenotype of a chicken with the genotype F^BF^W?

Math Practice

4. **Ratios** A scientist crossed a tall pea plant with a short pea plant. Of the offspring, 13 were tall and 12 were short. Write the ratio of each phenotype to the total number of offspring. Express the ratios as fractions.
5. **Percentage** Use the fractions to calculate the percentage of the offspring that were tall and the percentage that were short.

Lab zone **Skills Lab**

Make the Right Call!

Problem

How can you predict the possible results of genetic crosses?

Skills Focus

making models, interpreting data

Materials

- 2 small paper bags
- marking pen
- 3 blue marbles
- 3 white marbles

Procedure

1. Label one bag "Bag 1, Female Parent." Label the other bag "Bag 2, Male Parent." Then read over Part 1, Part 2, and Part 3 of this lab. Write a prediction about the kinds of offspring you expect from each cross.

PART 1 Crossing Two Homozygous Parents

2. Copy the data table and label it *Data Table 1*. Then place two blue marbles in Bag 1. This pair of marbles represents the female parent's alleles. Use the letter *B* to represent the dominant allele for blue color.
3. Place two white marbles in Bag 2. Use the letter *b* to represent the recessive allele for white color.
4. For Trial 1, remove one marble from Bag 1 without looking in the bag. Record the result in your data table. Return the marble to the bag. Again, without looking in the bag, remove one marble from Bag 2. Record the result in your data table. Return the marble to the bag.
5. In the column labeled Offspring's Alleles, write *BB* if you removed two blue marbles, *bb* if you removed two white marbles, or *Bb* if you removed one blue marble and one white marble.
6. Repeat Steps 4 and 5 nine more times.

PART 2 Crossing Homozygous and Heterozygous Parents

7. Place two blue marbles in Bag 1. Place one white marble and one blue marble in Bag 2. Copy the data table again, and label it *Data Table 2*.
8. Repeat Steps 4 and 5 ten times.

Data Table

Number ________

Trial	Allele From Bag 1 (Female Parent)	Allele From Bag 2 (Male Parent)	Offspring's Alleles
1			
2			
3			
4			
5			
6			