Mr. Pierro

Section 1 Mendel's Work

Discover

What Does the Father Look Like?

1. Observe the colors of each kitten in the photo. Record each kitten's coat colors and patterns. 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 kittens' father might look like. Identify the evidence on which you based your inference.

Guide for Reading

- What factors control the inheritance of traits in organisms?

Reading Tip Before you read, preview the section and make a list of the boldfaced terms. As you read, write a definition for each term in your own words.

Gregor Mendel in the monastery garden ▼

The year was 1851. Gregor Mendel, a young priest from a monastery in Central Europe, entered the University of Vienna to study mathematics and science. Two years later, Mendel returned to the monastery and began teaching at a nearby high school.

Mendel also cared for the monastery's garden, where he grew hundreds of pea plants. He became curious about why some of the plants had different physical characteristics, or **traits.** Some pea plants grew tall while others were short. Some plants produced green seeds, while others had yellow seeds.

Mendel observed that the pea plants' traits were often similar to those of their parents. Sometimes, however, the pea plants had different traits than their parents. The passing of traits from parents to offspring is called **heredity.** For more than ten years, Mendel experimented with thousands of pea plants to understand the process of heredity. Mendel's work formed the foundation of **genetics,** the scientific study of heredity.

Mendel's Peas

Mendel made a wise decision when he chose to study peas rather than other plants in the monastery garden. Pea plants are easy to study because they have many traits that exist in only two forms. For example, pea plant stems are either tall or short, but not medium height. Also, garden peas produce a large number of offspring in one generation. Thus, it is easy to collect large amounts of data to analyze.

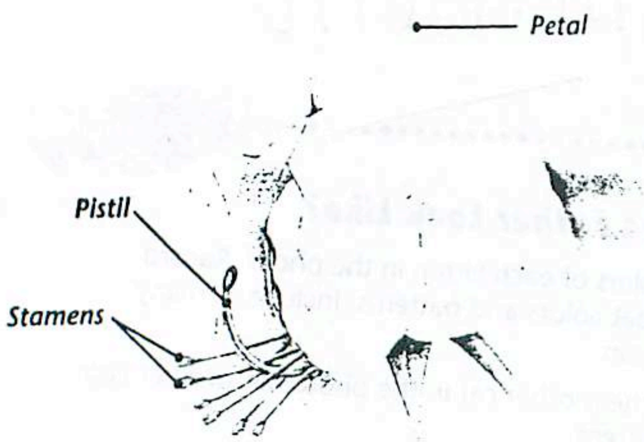


Figure 1 Garden peas usually reproduce by self-pollination. Pollen from a flower's stamens lands on the pistil of the same flower. Plants that result from self-pollination inherit all of their characteristics from the single parent plant. ***Relating Cause and Effect*** *Why was it important for Mendel to prevent his pea plants from self-pollinating?*

Figure 1 shows a flowering pea plant. Notice that the flower's etals surround the pistil and the stamens. The pistil produces emale sex cells, or eggs, while the stamens produce pollen, which ontains the male sex cells.

In nature, pea plants are usually self-pollinating. This means at pollen from one flower lands on the pistil of the same flower. Iendel developed a method by which he could cross-pollinate, or "cross," pea plants. To cross two plants, he removed pollen from a flower on one plant and brushed it onto a flower on a second plant. To prevent the pea plants from self-pollinating, he carefully removed the stamens from the flowers on the second plant.

Mendel's Experiments

Suppose you had a garden full of pea plants, and you wanted to study the inheritance of traits. What would you do? Mendel decided to cross plants with opposite forms of a trait, for example, tall plants and short plants. He started his experiments with purebred plants. A **purebred** plant is one that always produces offspring with the same form of a trait as the parent. For example, purebred short pea plants always produce short offspring. Purebred tall pea plants always produce tall offspring. To produce purebred plants, Mendel allowed peas with one particular trait to self-pollinate for many generations. By using purebred plants, Mendel knew that the offspring's trait would always be identical to that of the parents.

In his first experiment, Mendel crossed purebred tall plants with purebred short plants. He called these parent plants the parental generation, or P generation. He called the offspring from this cross the first filial (FIL ee ul) generation, or the F_1 generation. The word *filial* means "son" in Latin.

Language Arts CONNECTION

Gregor Mendel presented a detailed description of his observations in a scientific paper in 1866. In the excerpt that follows, notice how clearly he describes his observations of the two different seed shapes in peas.

"These are either round or roundish, the depressions, if any, occur on the surface, being always only shallow; or they are irregularly angular and deeply wrinkled."

In Your Journal

Choose an everyday object, such as a piece of fruit or a pen. Make a list of the object's features. Then write a short paragraph describing the object. Use clear, precise language in your description.

You can see the results of Mendel's first cross in Figure 2. To Mendel's surprise, all of the offspring in the F_1 generation were tall. Despite the fact that one of the parent plants was short, none of the offspring were short. The shortness trait had disappeared!

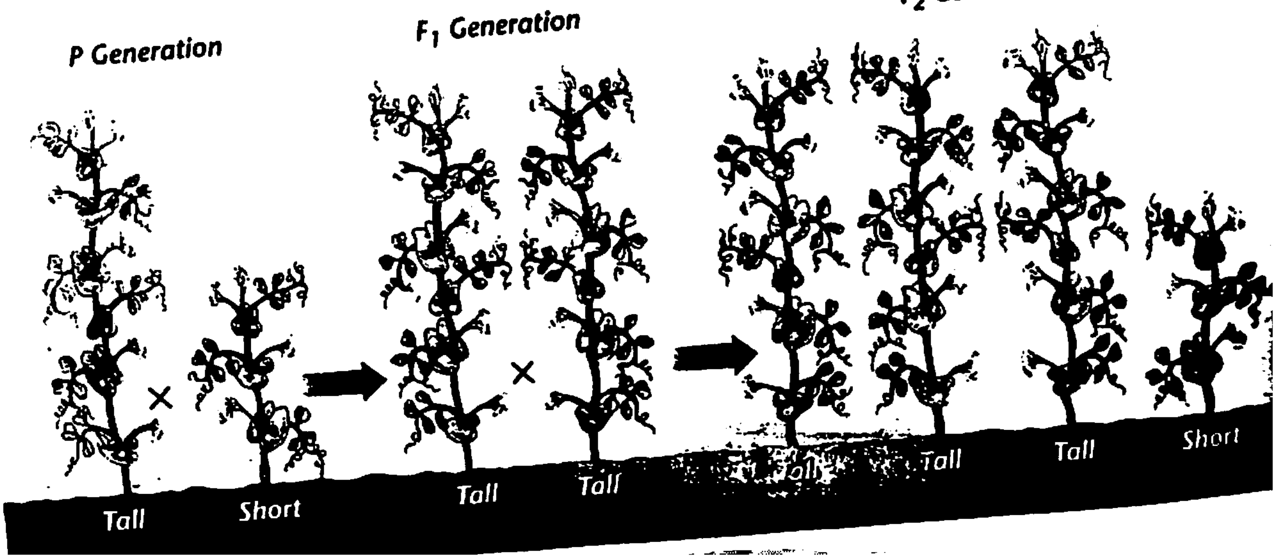
Mendel let the plants in the F_1 generation grow and allowed them to self-pollinate. The results of this experiment also surprised Mendel. The plants in the F_2 (second filial) generation were a mix of tall and short plants. This occurred even though none of the F_1 parent plants were short. The shortness trait had reappeared. Mendel counted the number of tall and short plants in the F_2 generation. He found that about three fourths of the plants were tall, while one fourth of the plants were short.

☑ ***Checkpoint*** *What is a purebred plant?*

Other Traits

In addition to stem height, Mendel studied six other traits in garden peas: seed shape, seed color, seed coat color, pod shape, pod color, and flower position. Compare the two forms of each trait in Figure 3. Mendel crossed plants with these traits in the same manner as he did for stem height. The results in each experiment were similar to those that he observed with stem height. 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.

Figure 2 When Mendel crossed purebred tall and short pea plants, all the offspring in the F_1 generation were tall. In the F_2 generation, three fourths of the plants were tall, while one fourth were short.



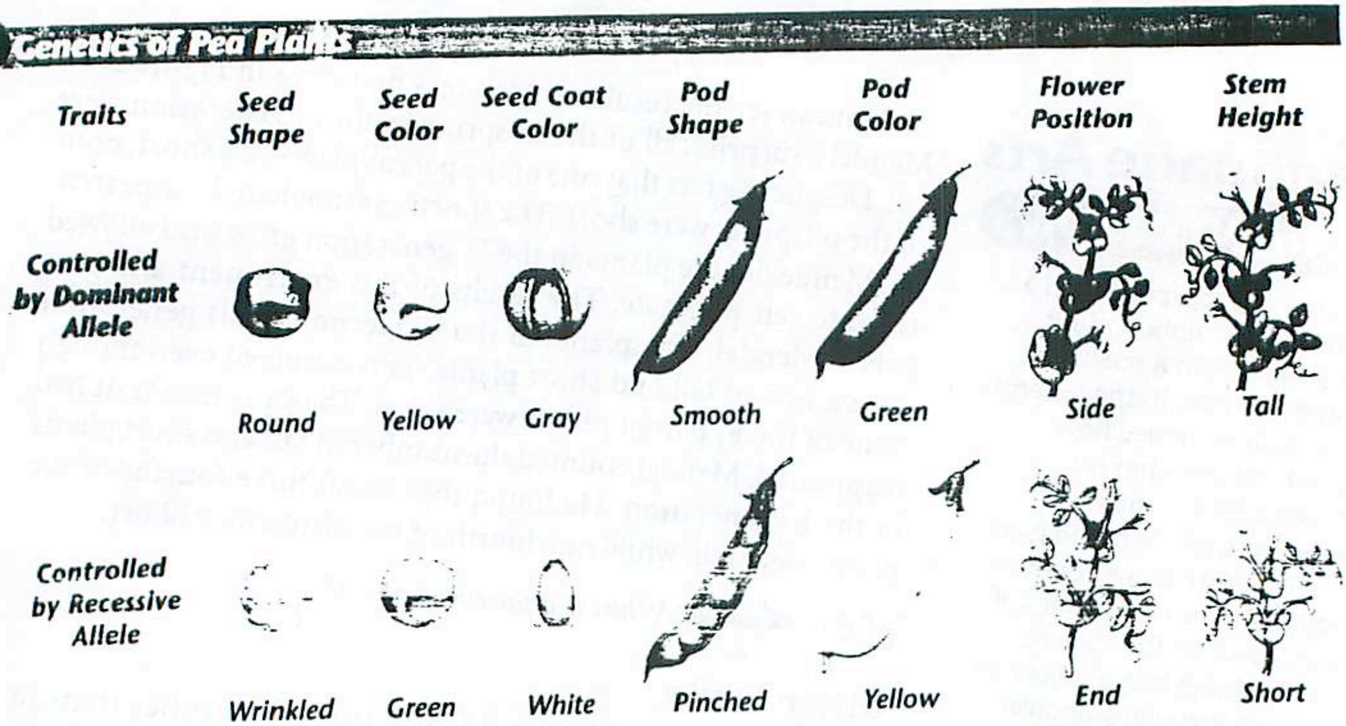


Figure 3 Mendel studied seven different traits in pea plants. Each trait has two different forms. *Interpreting Diagrams Is yellow seed color controlled by a dominant allele or a recessive allele? What type of allele controls pinched pod shape?*

Dominant and Recessive Alleles

From his results, Mendel reasoned that individual factors 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.

Mendel went on to reason that one factor in a pair can mask, or hide, the other factor. The tallness factor, for example, masked the shortness factor in the F_1 generation.

Today, scientists call the factors that control traits **genes.** They call the different forms of a gene **alleles** (uh LEELZ). 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 a combination of two alleles from its parents—either two alleles for tall stems, two alleles for short stems, or one of each.

Individual alleles control the inheritance of traits. 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 masked, or covered up, 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.

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.

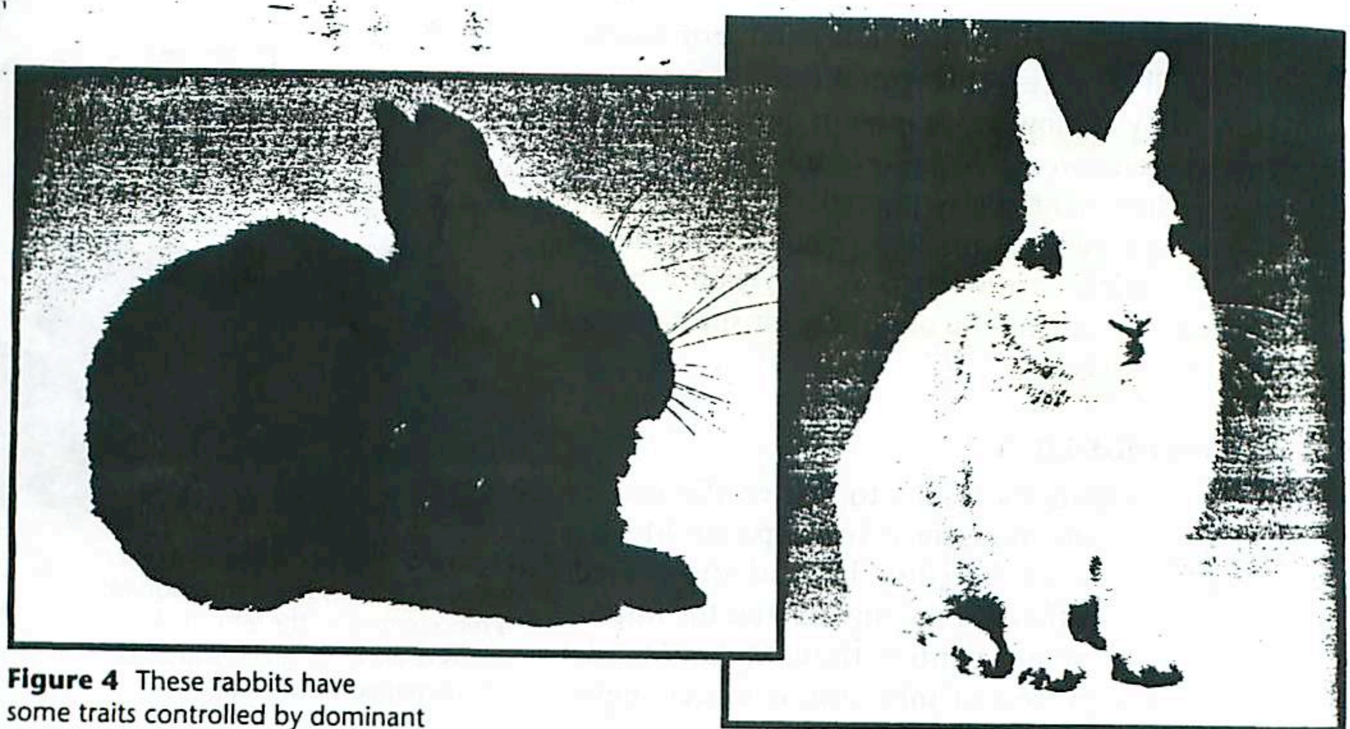


Figure 4 These rabbits have some traits controlled by dominant alleles and other traits controlled by recessive alleles. For example, the allele for black fur is dominant over the allele for white fur. ***Inferring*** *What combination of alleles must the white rabbit have?*

Understanding Mendel's Crosses

You can understand Mendel's results by tracing the inheritance of alleles in his experiments. The purebred plants in the P generation had two identical alleles for stem height. The purebred tall plants had two alleles for tall stems. The purebred short plants had two alleles for short stems. In the F_1 generation, all of the plants received one allele for tall stems from the tall parent. They received one allele for short stems from the short parent. The F_1 plants are called **hybrids** (HY bridz) because they have two different alleles for the 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 hybrid plants in the F_1 generation, some of the plants inherited two dominant alleles for tall stems. These plants were tall. Other plants inherited one dominant allele for tall stems and one recessive allele for short stems. These plants were also tall. Other plants inherited two recessive alleles for short stems. These plants were short.

☑ *Checkpoint* ***If a pea plant has a tall stem, what possible combinations of alleles could it have?***

Using Symbols in Genetics

Geneticists today use a standard shorthand method to write about alleles in genetic crosses. Instead of using words such as "tall stems" to represent alleles, they simply use letters. 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.*

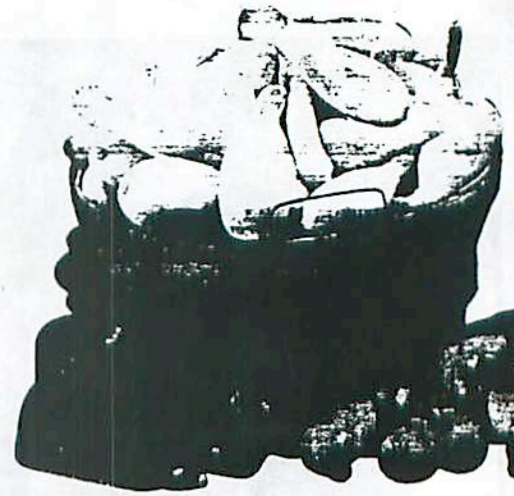


Figure 5 The dominant allele for yellow skin color in summer squash is represented by the letter *Y*. The recessive allele for green skin color is represented by the letter *y*.

Mendel's Contribution

In 1866, Mendel presented his results to a scientific society that met regularly near the monastery. In his paper, Mendel described the principles of heredity he had discovered. Unfortunately, other scientists did not understand the importance of Mendel's work. Some scientists thought that Mendel had oversimplified the process of inheritance. Others never read his paper, or even heard about his work. Remember, at that time there were no telephones or other types of electronic communication. So scientists in different parts of the world were isolated from each other. Mendel was especially isolated because he wasn't at a university.

Mendel's work was forgotten for 34 years. In 1900, three different scientists rediscovered Mendel's work. They had made many of the same observations as Mendel had. The scientists quickly recognized the importance of Mendel's work. Many of the genetic principles that Mendel discovered still stand to this day. Because of his work, Mendel is often called the Father of Genetics.

Section 1 Review

1. Explain how the inheritance of traits is controlled in organisms. Use the terms *genes* and *alleles* in your explanation.
2. What is a dominant allele? What is a recessive allele? Give an example of each.
3. The allele for round seeds is represented by *R*. Suppose that a pea plant inherited two recessive alleles for wrinkled seeds. How would you write the symbols for its alleles?
4. ***Thinking Critically*** **Applying Concepts** Can a short pea plant ever be a hybrid? Why or why not?

Check Your Progress

By now you should have constructed your paper pet. On the back, write what alleles your pet has for each trait. Use XX for a female, and XY for a male. The dominant alleles for the other four traits are: *B* (blue skin), *R* (round eyes), *T* (triangular nose), and *P* (pointed teeth). (*Hint:* If your pet has a trait controlled by a dominant allele, you can choose which of the possible combinations of alleles your pet has.)

Developing Hypotheses

Skills Lab

Take a Class Survey

In this lab, you'll explore how greatly traits can vary in a group of people—your classmates.

Problem

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

Materials

mirror (optional) PTC paper

Procedure

Part 1 Dominant and Recessive Alleles

1. Write a hypothesis reflecting your ideas about the problem question. Then copy the data table.
2. For traits A, B, C, D, and E, work with a partner to determine which trait you have. Circle that trait in your data table.
3. For trait F, wash and dry your hands. Taste the PTC paper your teacher gives you. Circle either "can taste PTC" or "cannot taste PTC" in your data table. **CAUTION:** *Never taste any substance in the lab unless directed to by your teacher.*
4. Count the number of students who have each trait. Record that number in your data table. Also record the total number of students.

DATA TABLE

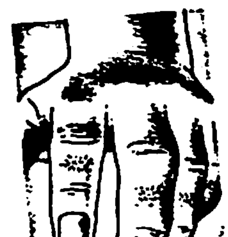
Total Number ______

	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	Can taste PTC*		Cannot taste PTC*	

*PTC stands for phenylthiocarbamide.


Free ear lobe

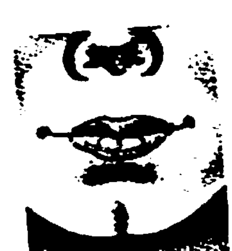

Attached ear lobe


Hair on fingers


No hair on fingers


Widow's peak


No widow's peak


Cleft chin


No cleft chin

rt 2 Are Your Traits Unique?

Look at the circle of traits below. 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.

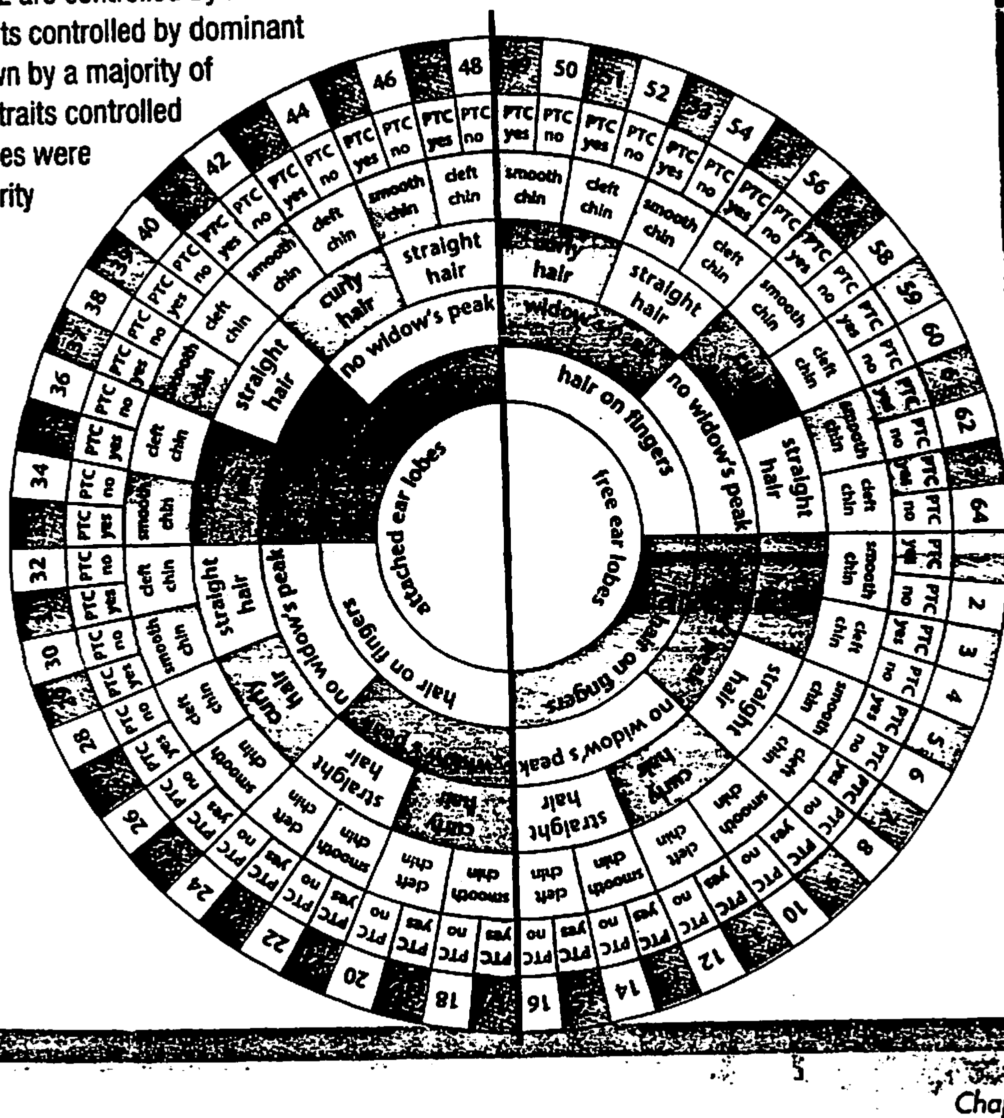
Look at the two traits touching the space your eraser is on. Move your eraser to the next description that applies to you. Continue using your eraser to trace your traits until you reach a number on the outside rim of the circle. Share that number with your classmates.

Analyze and Conclude

1. 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?
2. 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. **Think About It** Do your data support the hypothesis you proposed in Step 1? Explain your 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.



INTEGRATING MATHEMATICS

SECTION 2 Probability and Genetics

DISCOVER — ACTIVITY

What's the Chance?

1. Suppose you were to toss a coin 20 times. Predict how many times the coin would land "heads up" and how many times it would land "tails up."
2. Now test your prediction by tossing a coin 20 times. Record the number of times the coin lands heads up and the number of times it lands 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?

GUIDE FOR READING

- **How do the principles of probability help explain Mendel's results?**
- **How do geneticists use Punnett squares?**

Reading Tip **Before you read, rewrite the headings in the section as questions that begin with *how, what,* or *why.* As you read, look for answers to these questions.**

The city of Portland, Oregon, was founded in the mid-1800s. Two men, Asa L. Lovejoy and Francis W. Pettygrove, owned the land on which the new city was built. Lovejoy, who was from Massachusetts, wanted to name the new town Boston. Pettygrove, however, thought the town should be named after his hometown, Portland, Maine. To settle the dispute, they decided to toss a coin. Pettygrove won, and the new town was named Portland.

What was the chance that Pettygrove would win the coin toss? To answer this question, you need to understand the principles of probability. **Probability** is the likelihood that a particular event will occur.

rinciples of Probability

u did the Discover activity, you used the principles of prob-bility to predict the results of a particular event. Each time you oss a coin, there are two possible ways that the coin can land—eads up or tails up. Each of these two events is equally likely to occur. In mathematical terms, you can say that the probability hat a tossed coin will land heads up is 1 in 2. There is also a 1 in 2 probability that the coin will land tails up. A 1 in 2 prob-ability can also be expressed as the fraction $\frac{1}{2}$ or as a percent—50 percent.

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

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 heads up each time. What is the probability that it will nd 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 results of the sixth toss.

Checkpoint *Why is there a 1 in 2 probability that a tossed coin will land heads up?*

Math Toolbox

Calculating Probability

When the probability of an event is 1, the event is *certain* to happen. When the probability of an event is 0, the event is *impossible*. Events with probabilities between 0 and 1 are *possible*.

Suppose that 6 out of 10 marbles in a bag are red. Here's how you can calculate the probability of pulling out a red marble from the bag.

1. There are 10 marbles in the bag, and 6 of them are red.
2. Write this comparison as a fraction.

$$\frac{\text{6 red marbles}}{\text{10 marbles total}} = \frac{6}{10} = \frac{3}{5}$$

The probability of choosing a red marble is $\frac{3}{5}$, or 3 out of 5.

If the other 4 marbles in the bag are blue, what is the probability of pulling out a blue marble? What is the probability of pulling out a green marble?

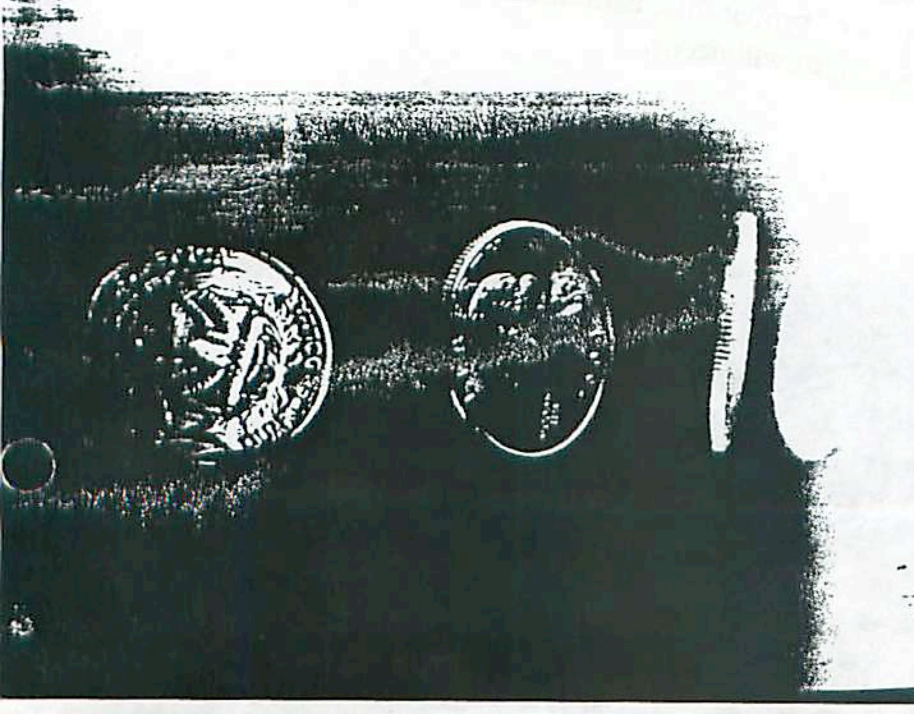


Figure 6 According to the laws of probability, there is a 50 percent probability that the coin will land heads up. ***Calculating*** *What is the probability that the coin will land tails up?*

Mendel and Probability

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.**

The Punnett square in Figure 7 shows a cross between two hybrid tall pea plants (*Tt*). Each parent can pass either of its alleles, *T* or *t*, to its offspring. The possible alleles that one parent can pass on are written across the top of the Punnett square. The possible alleles that the other parent can pass on are written down the left side of the Punnett square. The boxes in the Punnett square represent the possible combinations of alleles that the offspring can inherit. The boxes are filled in like a multiplication problem, with one allele contributed by each parent.

Using a Punnett Square You can use a Punnett square to calculate the probability that offspring will have a certain combination of alleles. The allele that each parent will pass on is based on chance, just like the toss of a coin. Thus, there are four possible combinations of alleles. The probability that an offspring will

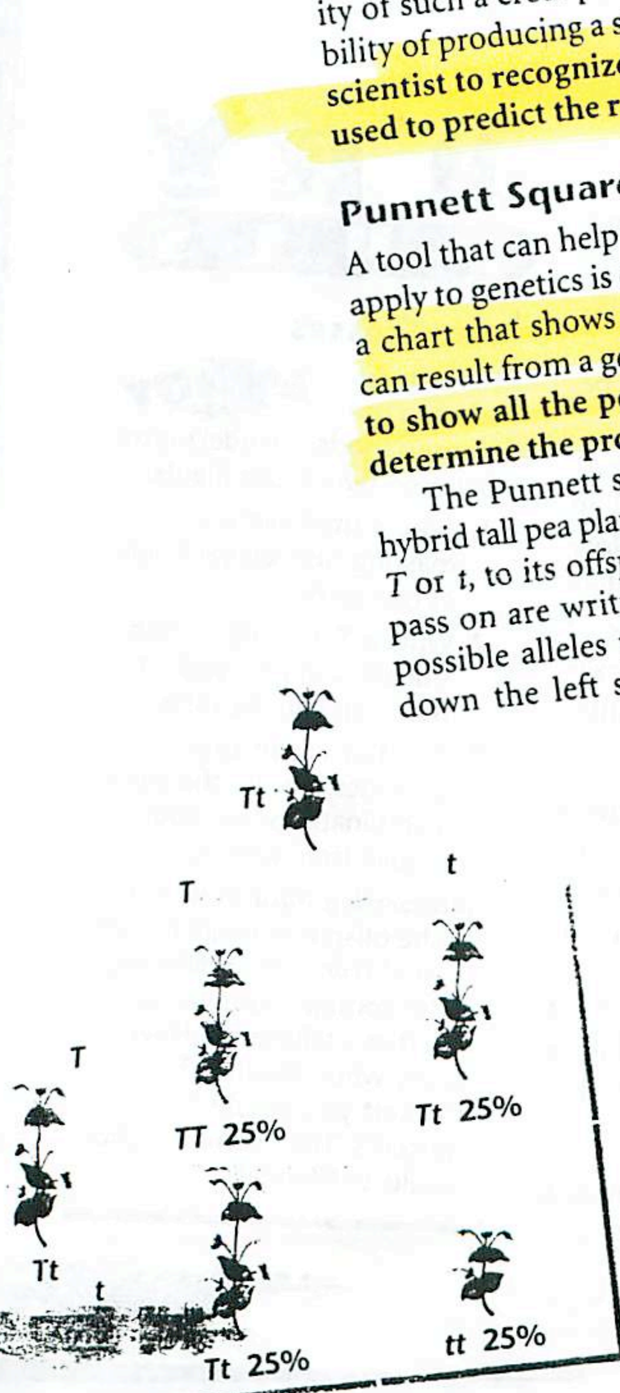


Figure 7 This Punnett square shows a cross between two hybrid tall pea plants. ***Interpreting Charts*** *Which allele combinations will result in tall offspring?*

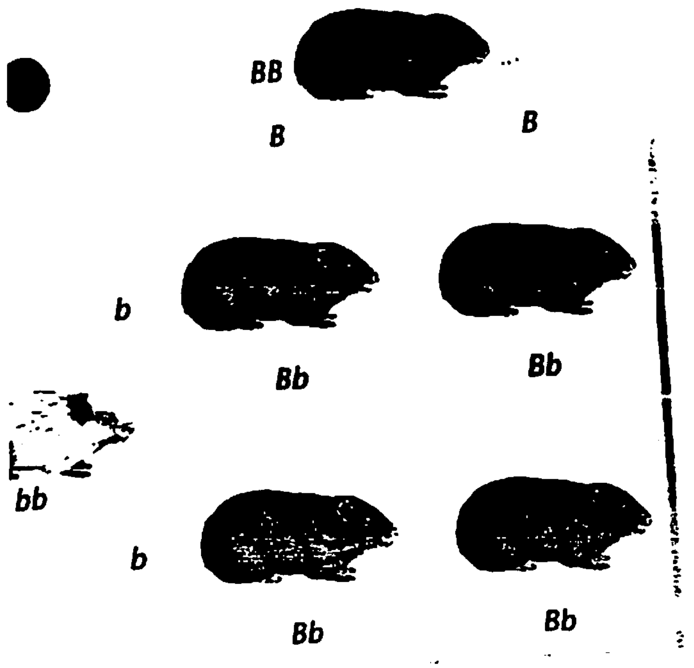


Figure 8 This Punnett square shows a cross between a black guinea pig (*BB*) and a white guinea pig (*bb*). *Calculating What is the probability that an offspring will have white fur?*

T is 1 in 4, or 25 percent. The probability that an offspring be tt is also 1 in 4, or 25 percent. Notice, however, that the Tt mbination appears in two boxes in the Punnett square. is because there are two possible ways in which this combi- on can occur. The probability, then, that an offspring will be s 2 in 4, or 50 percent.

Recall that when Mendel performed this cross, he discovered t about three fourths of the plants (75%) had tall stems. The aining one fourth of the plants (25%) had short stems. Now can understand why that was true. Plants with the *TT* allele mbination would be tall. So too would those plants with the *Tt* ele combination. Remember that the dominant allele masks e recessive allele. Only those plants with the *tt* allele combina- on would be short.

redicting Probabilities You can also use a Punnett square predict probabilities. For example, Figure 8 shows a cross etween a purebred black guinea pig and a purebred white uinea pig. The allele for black fur is dominant over the allele for hite fur. Notice that only one allele combination is possible in he offspring—*Bh*. All of the offspring will inherit the dominant llele for black fur. Because of this, all of the offspring will have lack fur. You can predict that there is a 100% probability that ffspring will have black fur.

***Checkpoint** If two guinea pigs with the alleles* Bb *are crossed, hat is the probability that an offspring will have white fur?*

TRY THIS

Coin Crosses

Activity

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 percents. Then compare your results to Mendel's.

Phenotypes and Genotypes	
Phenotype	**Genotype**
Tall	*TT*
Tall	*Tt*
Short	*tt*

Figure 9 The phenotype of an organism is its physical appearance. Its genotype is its genetic makeup.

Phenotypes and Genotypes

Two useful terms that geneticists use to describe organisms are phenotype and genotype. An organism's **phenotype** (FEE noh typ) is its physical appearance, or its visible traits. For example, pea plants can have one of two different phenotypes for stem height—short or tall.

An organism's **genotype** (JEN uh typ) is its genetic makeup, or allele combinations. To understand the difference between phenotype and genotype, look at the table in Figure 9. Although all of the tall plants have the same phenotype (they are all tall), they can have two different genotypes—*TT* or *Tt*. If you were to look at the tall plants, you would not be able to tell the difference between those with the *TT* genotype and those with the *Tt* genotype. The short pea plants, on the other hand, would all have the same phenotype—short stems—as well as the same genotype—*tt*.

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 tall pea plant that has the alleles *TT* and a short pea plant with the alleles *tt* are both homozygous. An organism that has two different alleles for a trait is said to be **heterozygous** (het ur oh ZY gus) for that trait. A tall pea plant with the alleles *Tt* is heterozygous. Mendel used the term *hybrid* to describe heterozygous pea plants.

☑ ***Checkpoint*** *If a pea plant's genotype is* Tt, *what is its 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, neither allele is masked in the offspring.

Look at the Punnett square in Figure 11. Mendel's principle of dominant and reces sive alleles does not explain why the het erozygous chickens have both black and whi feathers. The alleles for feather color

Figure 10 In Erminette chickens, the alleles for black feathers and white feathers are codominant.

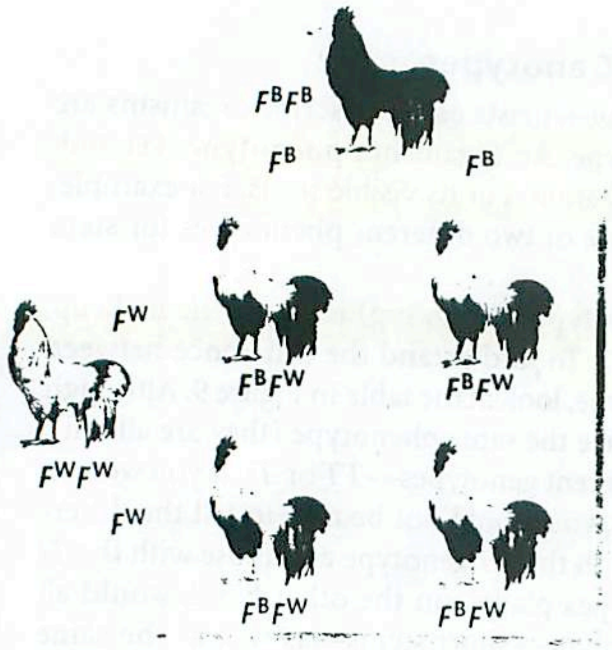


Figure 11 The offspring from the cross in this Punnett square will have both black and white feathers. *Classifying Will the offspring be heterozygous or homozygous? Explain your answer.*

›minant—neither dominant nor recessive. As you can see, ıer allele is masked in the heterozygous chickens. Notice also the codominant alleles are written as capital letters with ripts—F^B for black feathers and F^W for white feathers. ıe Punnett square shows, heterozygous chickens have the ᴺ allele combination.

ınother example of codominance can be found in cattle. Red and white hair are codominant. Heterozygous cattle have ; with both white hairs and red hairs. From a distance, het- ›gous cattle look pinkish brown, a color called roan.

Section 2 Review

ɦat is meant by the term *probability*? How is probability ated to genetics?

ɯ are Punnett squares useful to geneticists?

ɦat is the difference between a phenotype and a notype? Give an example of each.

white cow is crossed with a red bull. The calf is neither ite nor red, but roan. Explain how this happens.

inking Critically Problem Solving In pea plants, llele for round seeds (*R*) is dominant over the allele for ed seeds (*r*). Construct a Punnett square that shows a s between a heterozygous plant with round seeds (*Rr*) d a homozygous plant with wrinkled seeds (*rr*). What is probability that an offspring will have wrinkled seeds?

Science at Home

The Guessing Game Have a family member think of a number between 1 and 5. Then try to guess the number. Discuss the probability of guessing the correct number. Then repeat the guessing activity four more times. How did your success rate compare to the probability of guessing correctly? How can you account for any difference between your success rate and the results predicted by probability?

Skills Lab

Making Models

MAKE THE RIGHT CALL!

You know that making predictions is an important part of science. An accurate prediction can be a sign that you understand the event you are studying. In this lab, you will make predictions as you model the events involved in genetic crosses.

Problem

How can you predict the possible results of genetic crosses?

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.

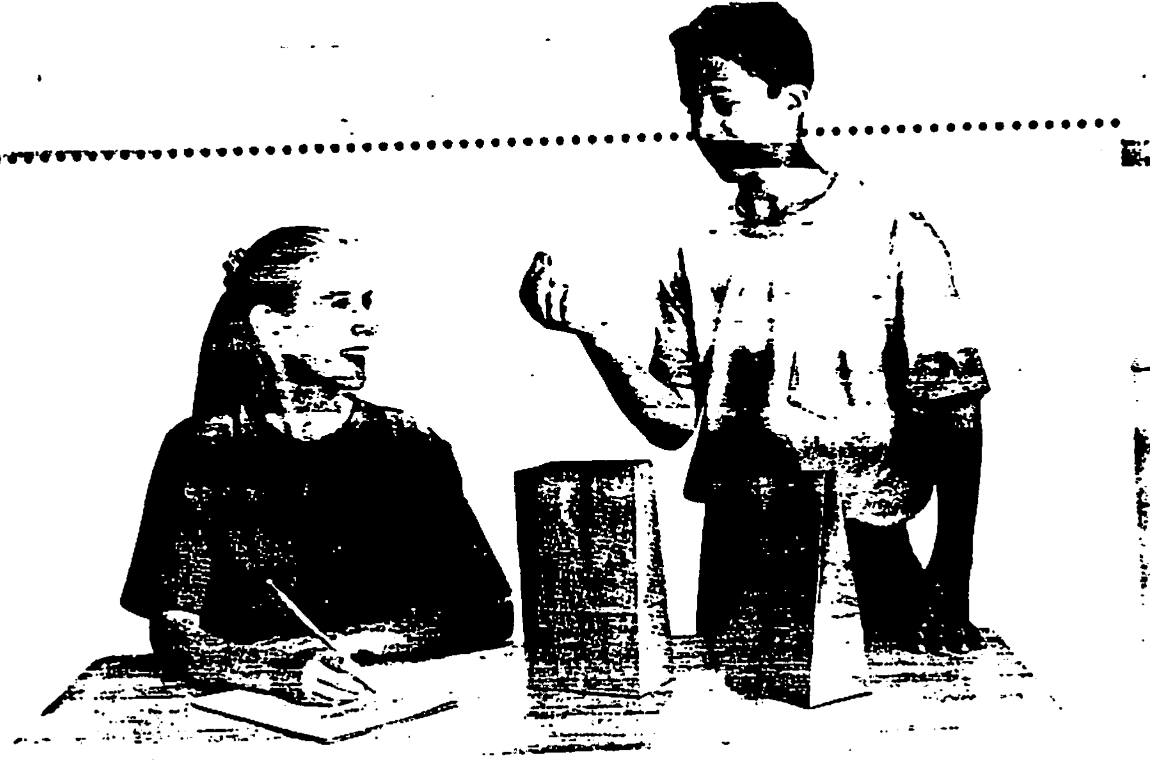
Part 1 Crossing Two Homozygous Parents

2. Copy the data table and label it *Data Table Number 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.

DATA TABLE

Number ______

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



Part 2 Crossing a Homozygous Parent With a Heterozygous Parent

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 Number 2.*
8. Repeat Steps 4 and 5 ten times.

Part 3 Crossing Two Heterozygous Parents

9. Place one blue marble and one white marble in Bag 1. Place one blue marble and one white marble in Bag 2. Copy the data table again and label it *Data Table Number 3.*
10. Repeat Steps 4 and 5 ten times.

Analyze and Conclude

1. Make a Punnett square for each of the crosses you modeled in Part 1, Part 2, and Part 3.
2. According to your results in Part 1, how many different kinds of offspring are possible when the homozygous parents (*BB* and *bb*) are crossed? Do the results you obtained using the marble model agree with the results shown by a Punnett square?
3. According to your results in Part 2, what percent of offspring are likely to be homozygous when a homozygous parent (*BB*) and a heterozygous parent (*Bb*) are crossed? What percent of offspring are likely to be heterozygous? Does the model agree with the results shown by a Punnett square?
4. According to your results in Part 3, what different kinds of offspring are possible when two heterozygous parents ($Bb \times Bb$) are crossed? What percent of each type of offspring are likely to be produced? Does the model agree with the results of a Punnett square?
5. For Part 3, if you did 100 trials instead of 10 trials, would your results be closer to the results shown in a Punnett square? Explain.
6. **Think About It** How does the marble model compare with a Punnett square? How are the two methods alike? How are they different?

Design an Experiment

In peas, the allele for yellow seeds (*Y*) is dominant over the allele for green seeds (*y*). What possible crosses do you think could produce a heterozygous plant with yellow seeds (*Yy*)? Use the marble model and Punnett squares to test your hypothesis.

SECTION 3

The Cell and Inheritance

DISCOVER — ACTIVITY

Which Chromosome Is Which?

Mendel did not know that chromosomes play a role in genetics. Today we know that genes are located on chromosomes.

1. Label two craft sticks with the letter *A*. The craft sticks represent a pair of chromosomes in the female parent. Turn the sticks face down on a piece of paper.
2. Label two more craft sticks with the letter *a*. These represent a pair of chromosomes in the male parent. Turn the sticks face down on another piece of paper.
3. Turn over one craft stick "chromosome" from each piece of paper. Move both sticks to a third piece of paper. These represent a pair of chromosomes in the offspring. Note the allele combination that the offspring received.

Inferring Use this model to explain how chromosomes are involved in the inheritance of alleles.

GUIDE FOR READING

- What role do chromosomes play in inheritance?
- What events occur during meiosis?

Reading Tip As you read, write a sentence that states the main idea of each paragraph.

When Mendel's results were rediscovered in 1900, scientists became excited about his principles of inheritance. They were eager to identify the structures that carried Mendel's hereditary factors, or genes.

In 1903, Walter Sutton, an American geneticist, added an important piece of information to the understanding of genetics. Sutton was studying the cells of grasshoppers. He was trying to understand how sex cells—sperm and egg—form. A **sperm** is the male sex cell. An **egg** is the female sex cell. During his studies, Sutton examined sex cells in many different stages of formation. He became particularly interested in the movement of chromosomes during the formation of sex cells. Sutton hypothesized that chromosomes were the key to understanding how offspring come to have traits similar to those of their parents.

Sperm cells ▼

◄ Egg cell

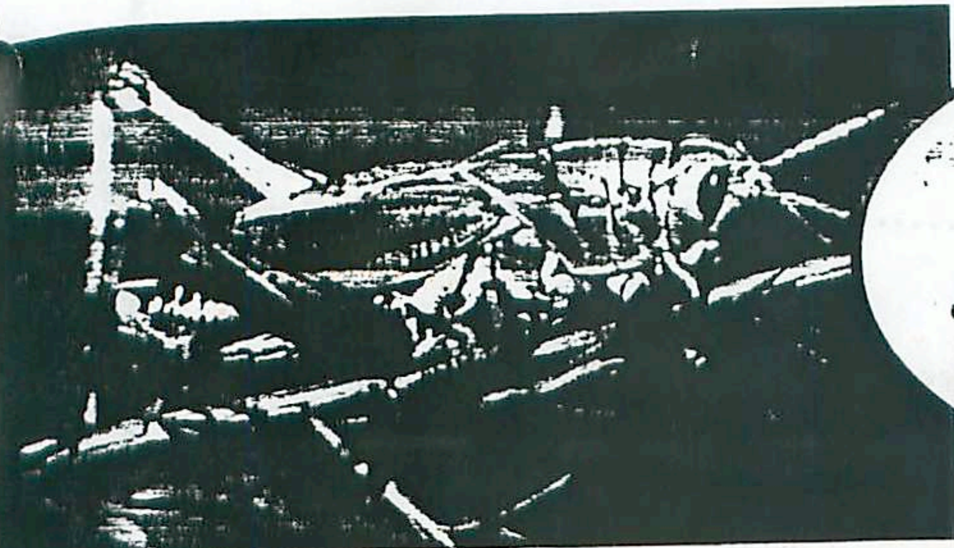


Figure 12 Grasshoppers have 24 chromosomes in each of their body cells. ***Applying Concepts*** *How many chromosomes did Sutton observe in the sperm cells and egg cells of grasshoppers?*

Chromosomes and Inheritance

Sutton knew that structures inside cells must be responsible for the inheritance of genes. He needed evidence to support his hypothesis that chromosomes were those structures. Sutton compared the number of chromosomes in a grasshopper's sex cells with the number of chromosomes in the other cells in the grasshopper's body. As you can see in Figure 12, the body cells of grasshoppers have 24 chromosomes. To his surprise, Sutton found that the grasshopper's sex cells have only 12 chromosomes. In other words, a grasshopper's sex cells have exactly half the number of chromosomes found in its body cells.

Sutton knew that he had discovered something important. He observed what happened when a sperm cell (with 12 chromosomes) and an egg cell (with 12 chromosomes) joined. The fertilized egg that formed had 24 chromosomes—the original number. As a result, the grasshopper offspring had exactly the same number of chromosomes in its cells as did each of its parents. The 24 chromosomes existed in 12 pairs. One chromosome in each pair came from the male parent, while the other chromosome came from the female parent.

Sutton concluded that the chromosomes carried Mendel's hereditary factors, or genes, from one generation to the next. In other words, genes are located on chromosomes. Sutton's idea came to be known as the chromosome theory of inheritance. **According to the chromosome theory of inheritance, genes are carried from parents to their offspring on chromosomes.**

Checkpoint *How does the number of chromosomes in a grasshopper's sex cells compare to the number in its body cells?*

Meiosis

How do sex cells end up with half the number of chromosomes as body cells? To answer this question, you need to understand the events that occur during meiosis. **Meiosis** (my OH sis) **is the process by which the number of chromosomes is reduced by half to form sex cells—sperm and eggs.**

You can trace the events of meiosis in *Exploring Meiosis.* In this example, each parent cell has four chromosomes arranged in two pairs. **During meiosis, the chromosome pairs separate and are distributed to two different cells. The resulting sex cells have only half as many chromosomes as the other cells in the organism.** In *Exploring Meiosis,* notice that the sex cells end up with only two chromosomes each—half the number found in the parent cell. Only one chromosome from each chromosome pair ends up in each sex cell.

When sex cells combine to produce offspring, each sex cell will contribute half the normal number of chromosomes. Thus, the offspring gets the normal number of chromosomes—half from each parent.

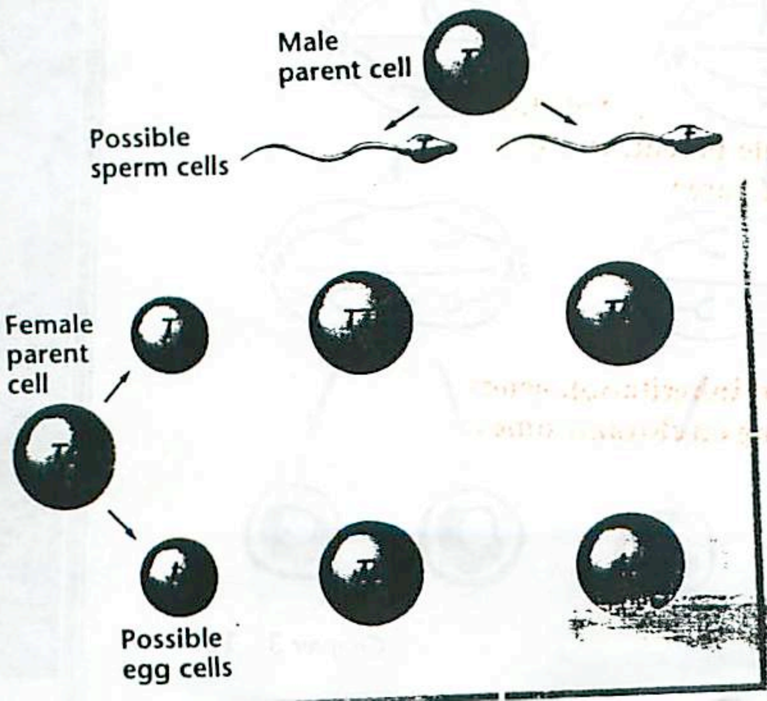
☑ ***Checkpoint*** *What types of cells form by meiosis?*

Meiosis and Punnett Squares

The Punnett squares that you learned about earlier in this chapter are actually a shorthand way to show the events that occur at meiosis. When the chromosome pairs separate into two different sex cells, so do the alleles carried on each chromosome. One allele from each pair goes to each sex cell. In Figure 13, you can see how the Punnett square accounts for the separation of alleles during meiosis.

As shown across the top of the Punnett square, half of the sperm cells from the male parent will receive the chromosome with the *T* allele. The other half of the sperm cells will receive the chromosome with the *t* allele. In this example, the same is true for the egg cells from the female parent, as shown down the left side of the Punnett square. Depending on which sperm cell combines with which egg cell, one of the allele combinations shown in the boxes will result.

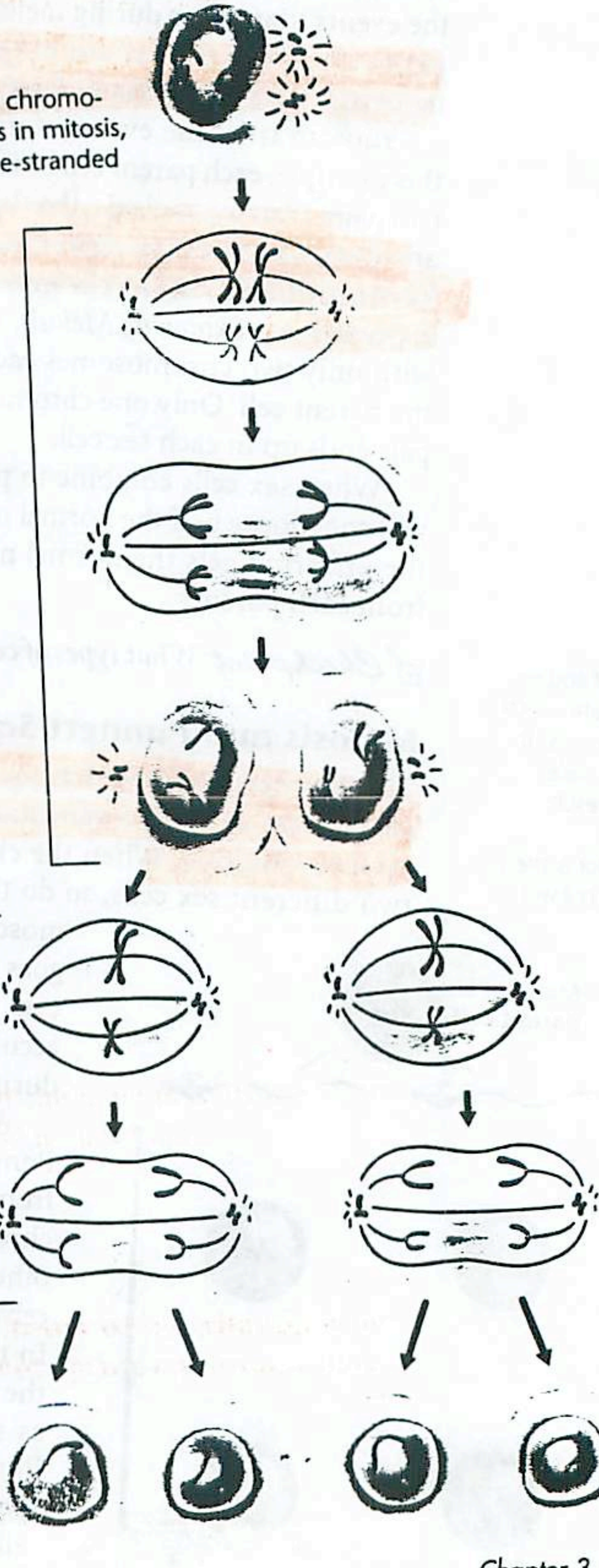
Figure 13 This Punnett square shows how alleles separate when sex cells form during meiosis. It also shows the possible allele combinations that can result after fertilization occurs. *Interpreting Charts What is the probability that a sperm cell will contain a T allele?*



[Ex]PLORING *Meiosis*

[Durin]g meiosis, a cell undergoes two divisions to [pro]duce sex cells that have half the number of [chromo]somes.

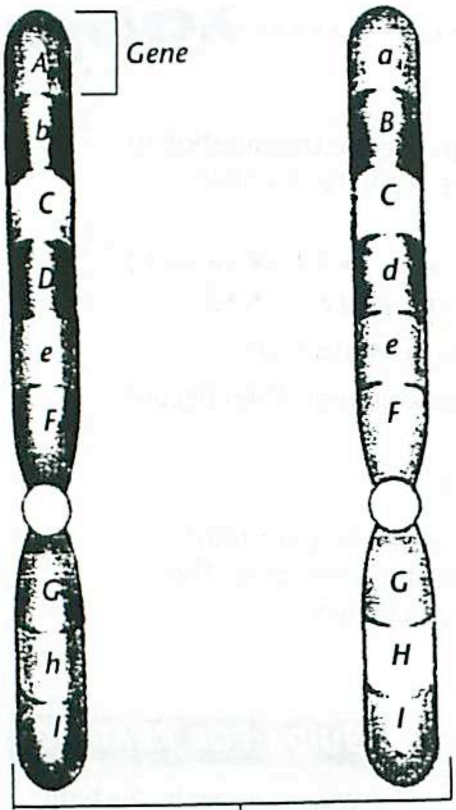
Beginning of Meiosis
Before meiosis begins, every chromosome in the cell is copied. As in mitosis, centromeres hold the double-stranded chromosomes together.



Meiosis I
The chromosome pairs line up next to each other in the center of the cell. The pairs then separate from each other and move to opposite ends of the cell. Two cells form, each with half the number of chromosomes. Each chromosome is still double-stranded.

Meiosis II
The double-stranded chromosomes move to the center of the cell. The centromeres split and the two strands of each chromosome separate. The two strands move to opposite ends of the cell.

End of Meiosis
Four sex cells have been produced. Each cell has only half the number of chromosomes that the parent cell had at the beginning of meiosis. Each cell has only one chromosome from each original pair.



A chromosome pair

Figure 14 Genes are located on chromosomes. The chromosomes in a pair may have different alleles for some genes and the same alleles for others. ***Classifying*** *For which genes is this organism homozygous? For which genes is it heterozygous?*

Chromosomes

Since Sutton's time, scientists have studied the chromosomes of many different organisms. The body cells of humans, for example, contain 23 pairs, or 46 chromosomes. The body cells of dogs have 78 chromosomes, while the body cells of silkworms have 56 chromosomes. As you can see, larger organisms don't always have more chromosomes.

Chromosomes are made up of many genes joined together like beads on a string. Sutton reasoned that chromosomes must contain a large number of genes because organisms have so many traits. Although you have only 23 pairs of chromosomes, your body cells contain more than 60,000 genes. Each of the genes controls a particular trait.

Look at the pair of chromosomes in Figure 14. One chromosome in the pair came from the female parent. The other chromosome came from the male parent. Notice that each chromosome in the pair has the same genes. The genes are lined up in the same order from one end of the chromosome to the other. However, the alleles for some of the genes might be different. For example, the organism has the *A* allele on one chromosome and the *a* allele on the other. As you can see, this organism is heterozygous for some traits and homozygous for others.

Section 3 Review

1. Explain the role that chromosomes play in inheritance.
2. Briefly describe what happens to chromosomes during meiosis.
3. On what structures in a cell are genes located?
4. How is a Punnett square a model for what happens during meiosis?
5. **Thinking Critically Inferring** The body cells of hamsters have 44 chromosomes. How many chromosomes would the sex cells of a hamster have?

Check Your Progress

At this point, you should find a classmate with a paper pet of the opposite sex. Suppose the two pets were crossed and produced six offspring. For each trait, use coin tosses to determine which allele the offspring will inherit from each parent. Construct a paper pet for each offspring, showing the traits each one has inherited. Write the genotype for each trait on their backs.

SECTION 4 The DNA Connection

DISCOVER ACTIVITY

A •–	N –•
B –•••	O –––
C –•–•	P •––•
D –••	Q ––•–
E •	R •–•
F ••–•	S •••
G ––•	T –
H ••••	U ••–
I ••	V •••–
J •–––	W •––
K –•–	X –••–
L •–••	Y –•––
M ––	Z ––••

Can You Crack the Code?

1. Use the Morse code in the chart to decode the question in the message below. The letters are separated by slash marks.

   •––/••••/•/•–•/•/•–/•–•/•/––•/•/–•/
   •/•••/•–••/–––/–•–•/•–/–/•/–••/

2. Write your answer to the question in Morse code.
3. Exchange your coded answer with a partner. Then decode your partner's answer.

Think It Over

Forming Operational Definitions Based on your results from this activity, write a definition of the word *code*. Then compare your definition to one in a dictionary.

A white buffalo calf was born on Childs Place Farm near Hanover, Michigan, in 1998. White buffaloes are extremely rare, occurring only once in every 10 million births. Why was this calf born with such an uncommon phenotype? To answer this question, you need to know how the genes on a chromosome control an organism's traits.

GUIDE FOR READING

- What is meant by the term "genetic code"?
- How does a cell produce proteins?
- How do mutations affect an organism?

Reading Tip As you read, create a flowchart that shows how a cell produces proteins.

The Genetic Code

Today scientists know that the main function of genes is to control the production of proteins in the organism's cells. Proteins help to determine the size, shape, and many other traits of an organism.

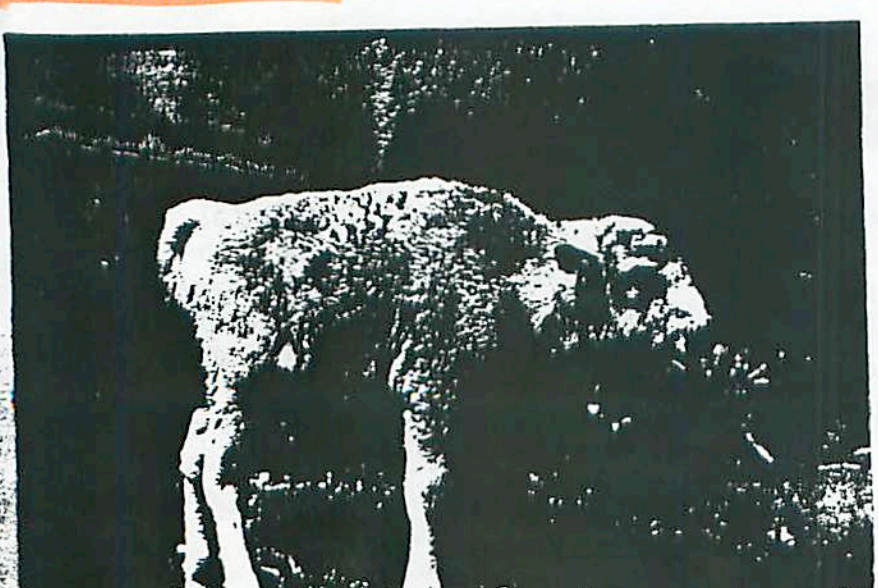


Figure 15 The white color of this buffalo calf is very unusual. Both of the calf's parents had brown coats.

Recall from Chapter 2 that DNA is a major component of chromosomes. In Figure 16, you can see the relationship between chromosomes and DNA. Notice that a DNA molecule is made up of four different nitrogen bases—adenine (A), thymine (T), guanine (G), and cytosine (C). These bases form the rungs of the DNA "ladder." A single gene on a chromosome may contain anywhere from several hundred to a million or more of these bases. The bases are arranged in a specific order—for example, ATGACGTAC.

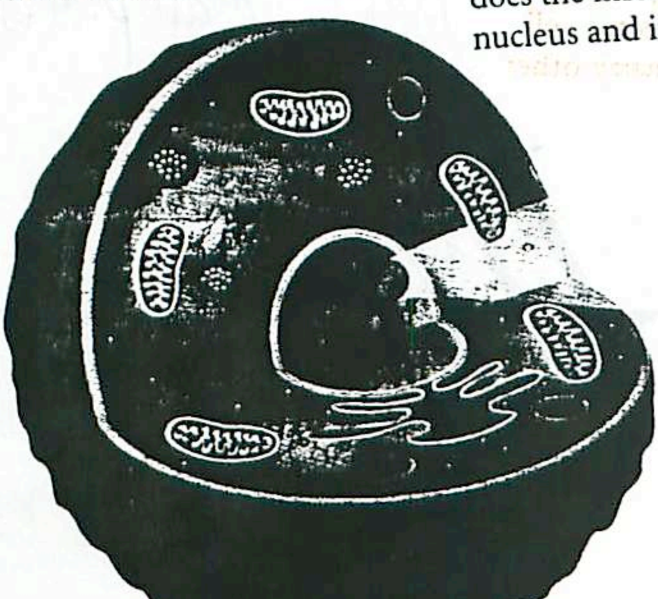
The order of the nitrogen bases along a gene forms a genetic code that specifies what type of protein will be produced. In the genetic code, a group of three bases codes for the attachment of a specific amino acid. Amino acids are the building blocks of proteins. The order of the bases determines the order in which amino acids are put together to form a protein. You can think of the bases as three-letter code words. The code words tell the cell which amino acid to add to the growing protein chain.

☑ *Checkpoint* *What is the main function of genes?*

How Cells Make Proteins

The production of proteins is called protein synthesis. **During protein synthesis, the cell uses information from a gene on a chromosome to produce a specific protein.** Protein synthesis takes place on the ribosomes in the cytoplasm of the cell. As you know, the cytoplasm is outside the nucleus. The chromosomes, however, are found inside the nucleus. How, then, does the information needed to produce proteins get out of the nucleus and into the cytoplasm?

Figure 16 A chromosome contains thousands of genes along its length. The sequence of bases along a gene forms a code that tells the cell what protein to produce. ***Interpreting Diagrams*** *Where in the cell are the chromosomes located?*



Cell

Chromosome

The Role of RNA Before protein synthesis can take place, a "messenger" must first carry the genetic code from the DNA inside the nucleus into the cytoplasm. This genetic messenger is called ribonucleic acid, or RNA.

Although RNA is similar to DNA, the two molecules differ in some important ways. Unlike DNA, which looks like a twisted ladder, an RNA molecule almost always looks like only one side, or strand, of the ladder. RNA also contains a different sugar molecule from the sugar found in DNA. Another difference between DNA and RNA is in their nitrogen bases. Like DNA, RNA contains adenine, guanine, and cytosine. However, instead of thymine, RNA contains uracil (YOOR uh sil).

There are several types of RNA involved in protein synthesis. **Messenger RNA** copies the coded message from the DNA in the nucleus, and carries the message into the cytoplasm. Another type of RNA, called **transfer RNA,** carries amino acids and adds them to the growing protein.

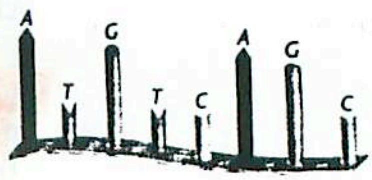
Translating the Code The process of protein synthesis is shown in *Exploring Protein Synthesis* on the next page. The first step is for a DNA molecule to "unzip" between its base pairs. Then one of the strands of DNA directs the production of a strand of messenger RNA. To form the RNA strand, RNA bases pair up with the DNA bases. Instead of thymine, however, uracil pairs with adenine. The messenger RNA then leaves the nucleus and attaches to a ribosome in the cytoplasm. There, molecules of transfer RNA pick up the amino acids specified by each three-letter code word. Each transfer RNA molecule puts the amino acid it is carrying in the correct order along the growing protein chain.

Checkpoint *What is the function of transfer RNA?*

Sharpen your Skills

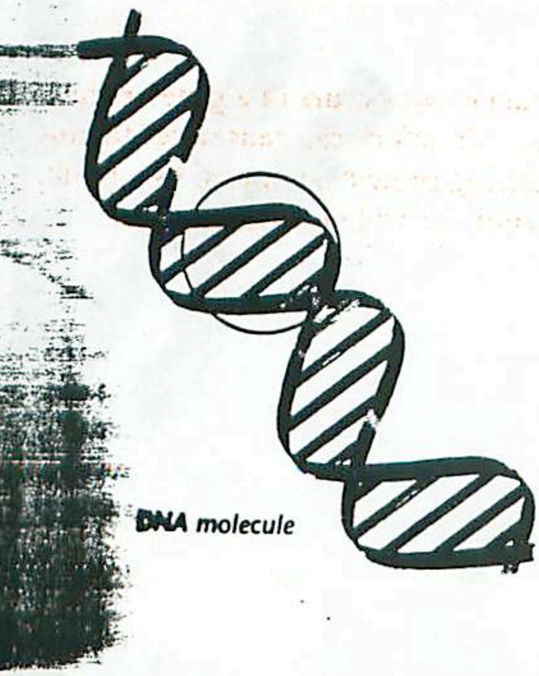
Predicting ACTIVITY

The following is a sequence of nitrogen bases on a DNA molecule.

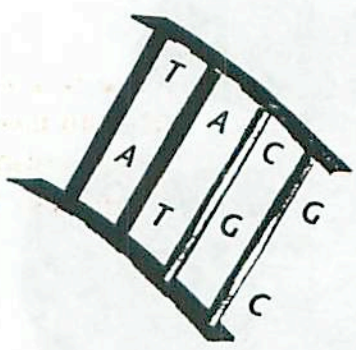


Write out the sequence of RNA bases that would pair up with the DNA bases.

There are 20 amino acids which make up all proteins



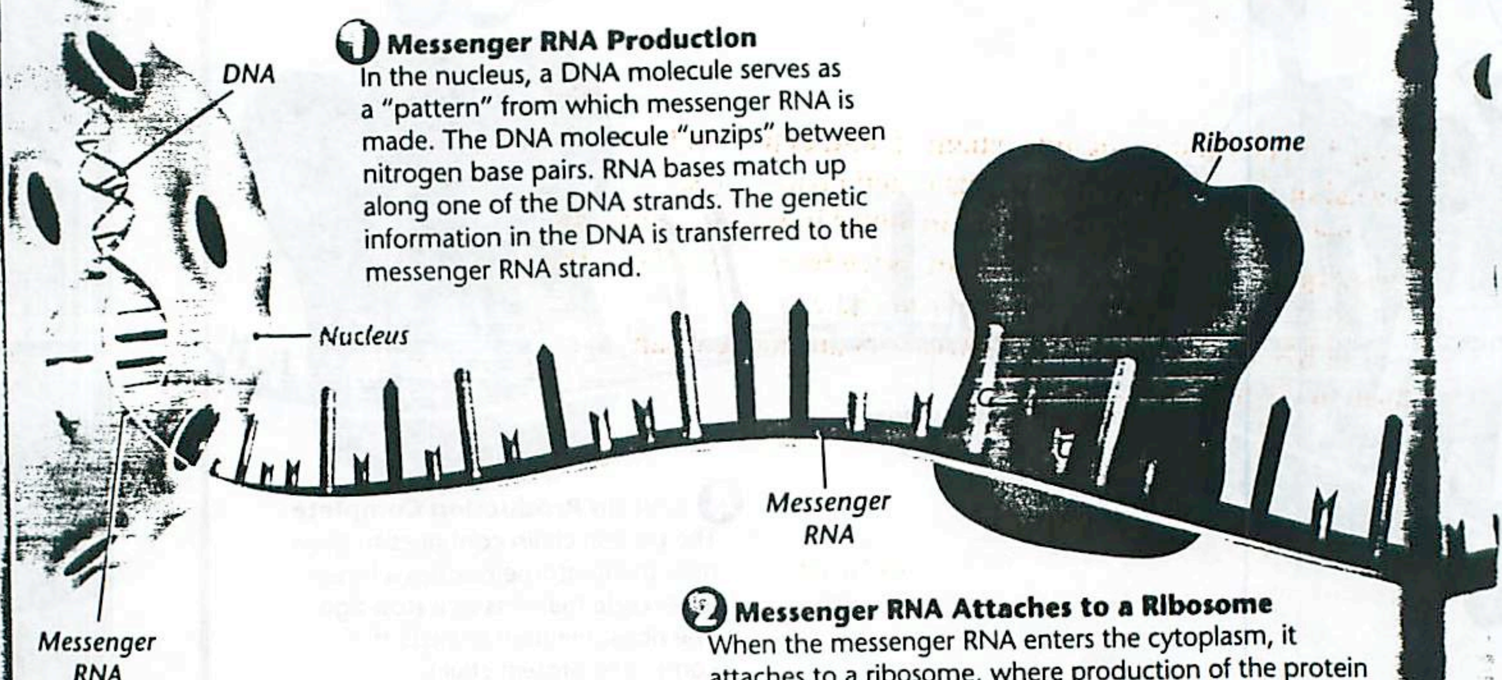
DNA molecule



Nitrogen bases

EXPLORING Protein Synthesis

To make proteins, messenger RNA copies information from DNA in the nucleus. Transfer RNA then uses this information to produce proteins in the ribosomes.



1 Messenger RNA Production
In the nucleus, a DNA molecule serves as a "pattern" from which messenger RNA is made. The DNA molecule "unzips" between nitrogen base pairs. RNA bases match up along one of the DNA strands. The genetic information in the DNA is transferred to the messenger RNA strand.

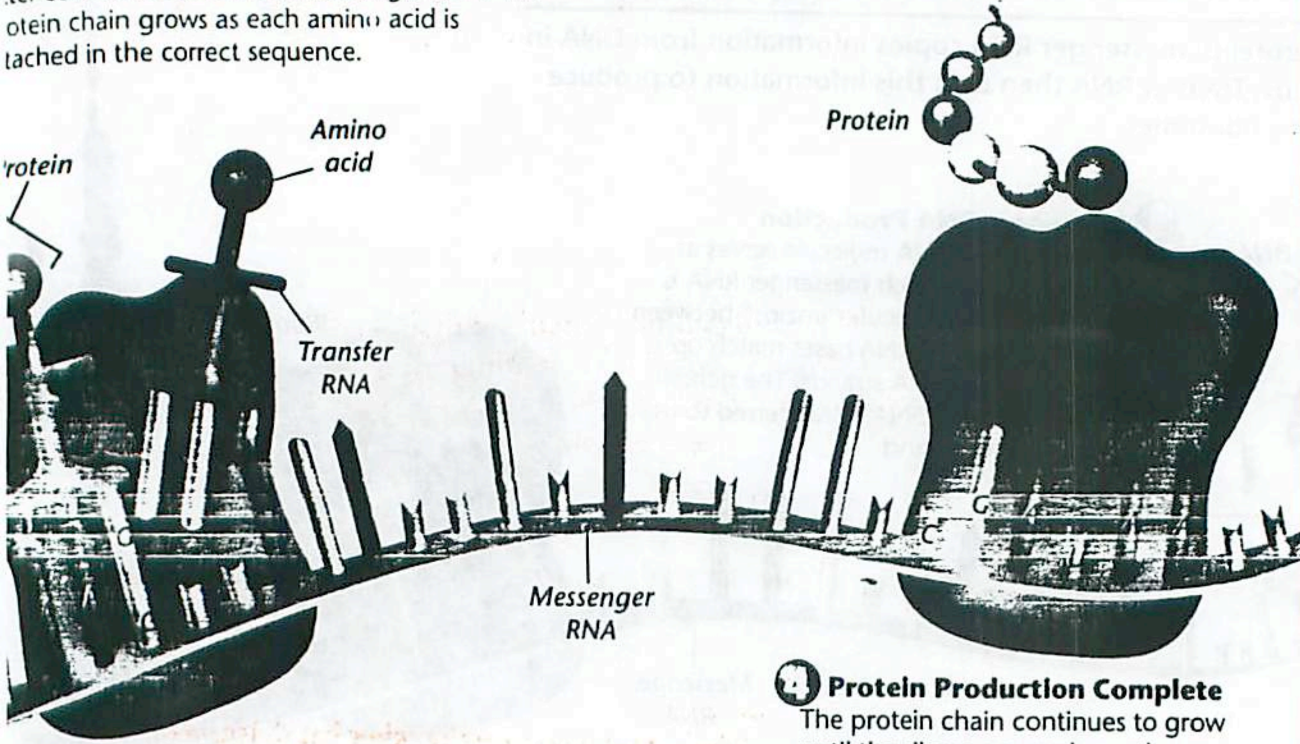
2 Messenger RNA Attaches to a Ribosome
When the messenger RNA enters the cytoplasm, it attaches to a ribosome, where production of the protein chain begins. The ribosome moves along the messenger RNA strand and "reads" each three-letter code of bases.

Mutations

Suppose that a mistake occurred in one gene of a chromosome. Instead of the base A, for example, the DNA molecule might have the base G. This is one type of mistake that can occur in a cell's hereditary material. Any change that occurs in a gene or chromosome is called a **mutation.** Mutations can cause a cell to produce an incorrect protein during protein synthesis. As a result, the organism's traits, or phenotype, will be different from what it normally would have been. In fact, the term *mutation* comes from a Latin word that means "change."

Types of Mutations Some mutations are the result of small changes in an organism's hereditary material, such as the substitution of a single base for another. This type of mutation can occur during the DNA replication process. The white coat on the

Transfer RNA Attaches to Messenger RNA
ansfer RNA molecules carry specific amino acids
ribosome. There they match up with three-
codes of bases on the messenger RNA. The
otein chain grows as each amino acid is
tached in the correct sequence.



4 Protein Production Complete
The protein chain continues to grow until the ribosome reaches a three-letter code that acts as a stop sign. The ribosome then releases the completed protein chain.

falo calf you read about at the start of this section might have ılted from this type of mutation. Other mutations may occur en chromosomes don't separate correctly during meiosis. en this type of mutation occurs, a cell can end up with too ny or too few chromosomes.

If a mutation occurs in a body cell, such as a skin cell, the tation will affect only the cell that carries it. If, however, a tation occurs in a sex cell, the mutation can be passed on to offspring and affect the offspring's phenotype.

e.Effects of Mutations Because mutations can introduce nges in an organism, they can be a source of genetic variety. ne of the changes brought about by mutations are harmful organism. Other mutations, however, are helpful, and thers are neither harmful nor helpful. A mutation is harmful to an organism if it reduces the organism's chance for survival and reproduction.

Whether a mutation is harmful or not depends partly on the organism's environment. The mutation that led to the production of a white buffalo calf would probably be harmful to an organism in the wild. Its white color would make it more visible, and thus easier for predators to find. However, a white buffalo calf raised on a farm has the same chance for survival as a brown buffalo. On the farm, the mutation is neutral—it neither helps nor harms the buffalo.

INTEGRATING HEALTH Some diseases in humans are caused by harmful mutations. For example, some forms of cancer are caused by mutations in an organism's body cells. Overexposure to the ultraviolet radiation in sunlight, for example, may lead to mutations that could cause skin cancer. In Chapter 4, you will learn more about other diseases that result from harmful mutations.

Helpful mutations, on the other hand, improve an organism's chances for survival and reproduction. For example, a gene mutation in potatoes led to the production of a new variety of potato called the Katahdin potato. This potato is resistant to some diseases that attack other varieties of potatoes. As a bonus for humans, it also looks and tastes better than other types of potatoes.

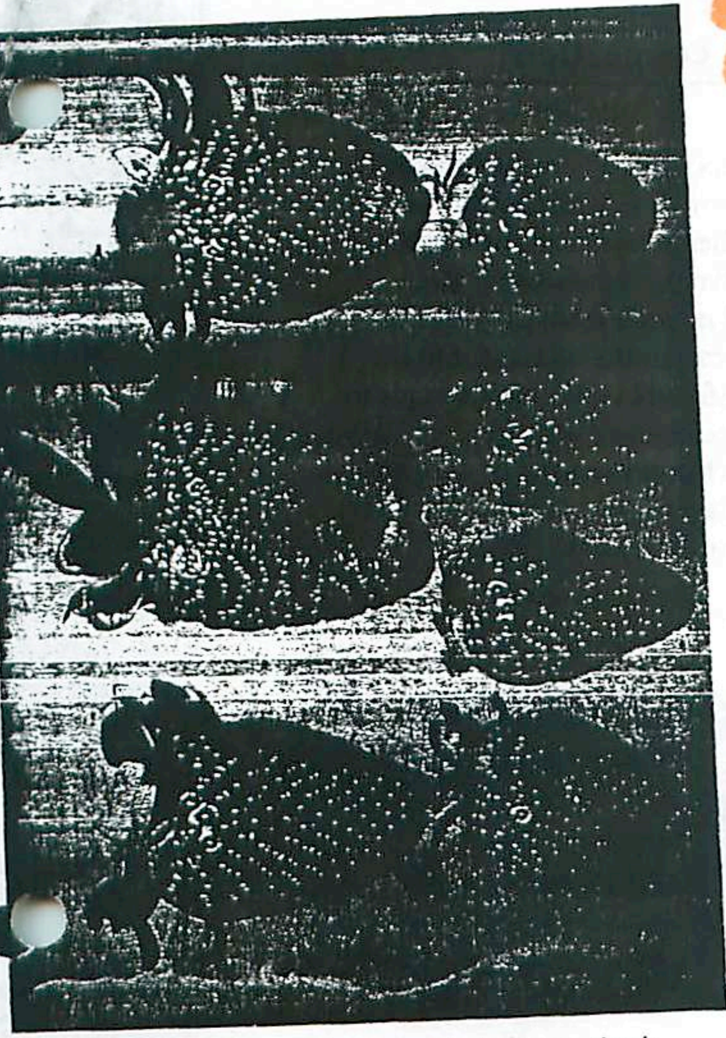


Figure 17 Mutations can affect an organism's traits, or phenotype. The unusually large strawberries on the left are the result of a mutation. The cells of these strawberries have extra sets of chromosomes.

Section 4 Review

1. How do the nitrogen bases along a gene serve as a genetic code?
2. Briefly describe the process by which a cell produces proteins.
3. What possible effects can a mutation have on an organism?
4. Where in a cell does protein synthesis take place?
5. **Thinking Critically Relating Cause and Effect** Why are mutations that occur in an organism's body cells not passed on to its offspring?

Check Your Progress

With your partner, plan a display of your pet's family. Label the parents the P generation. Label the offspring the F_1 generation. Construct a Punnett square for each trait to help explain the inheritance pattern in your pet's family. *(Hint: Attach your pets to the display in a way that lets viewers turn the pets over to read their genotypes.)*

CHAPTER 3 STUDY GUIDE

Mendel's Work

eas

or Mendel's work was the foundation for rstanding why offspring have traits similar ose of their parents.

s are controlled by alleles of genes.

nisms inherit one allele from each parent.

e alleles are dominant and some alleles are sive.

rms

y	purebred	dominant allele
s	gene	recessive allele
	allele	hybrid

Probability and Genetics

INTEGRATING MATHEMATICS

leas

bability is the likelihood that a particular t will happen.

del was the first scientist to interpret his using the principles of probability.

eticists use Punnett squares to show all the sible outcomes of a genetic cross.

erms

bility	homozygous
ett square	heterozygous
otype	codominance
ype	

The Cell and Inheritance

deas

cording to the chromosome theory of heritance, genes are carried from parents to eir offspring on chromosomes.

ring meiosis, chromosome pairs separate to m sex cells. Only one chromosome from h pair ends up in each sex cell. The sex cells ve half the number of chromosomes as the dy cells.

erm

n egg meiosis

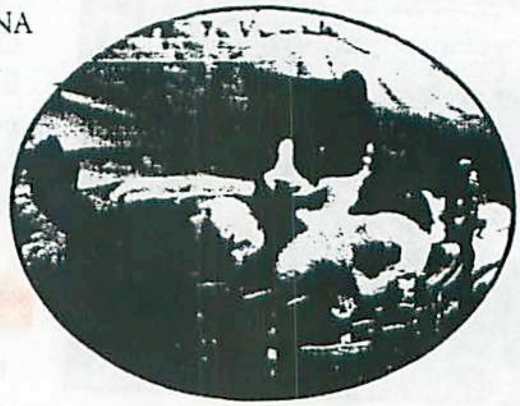
SECTION 4 The DNA Connection

Key Ideas

- The nitrogen bases along a gene form a code that specifies the order in which amino acids will be put together to produce a protein.
- During protein synthesis, messenger RNA copies the coded message from the DNA in the nucleus and carries the message into the cytoplasm. Transfer RNA adds amino acids to the growing protein.
- A mutation is a change in a gene or chromosome. Some mutations are harmful, some are helpful, and some are neutral.

Key Terms

messenger RNA
transfer RNA
mutation



Organizing Information

Compare/Contrast Table Copy the table comparing DNA and messenger RNA onto a separate sheet of paper. Then complete the table. (For more about compare/contrast tables, see the Skills Handbook.)

Characteristic	DNA	Messenger RNA
Nitrogen bases	a. __?__, b. __?__, c. __?__, d. __?__	Adenine, uracil, guanine, cytosine
Structure	Twisted ladder	e. __?__
Function	Forms a genetic code that specifies what type of protein will be produced	f. __?__

Reviewing Content

[illegible] CD-ROM

Multiple Choice

Choose the letter of the best answer.

1. The different forms of a gene are called
   a. alleles.
   b. chromosomes.
   c. phenotypes.
   d. genotypes.
2. In a coin toss, the probability of the coin landing heads up is
   a. 100 percent.
   b. 75 percent.
   c. 50 percent.
   d. 25 percent.
3. An organism with two identical alleles for a trait is
   a. heterozygous.
   b. homozygous.
   c. recessive.
   d. dominant.
4. If the body cells of an organism have 10 chromosomes, then its sex cells would have
   a. 5 chromosomes.
   b. 10 chromosomes.
   c. 15 chromosomes.
   d. 20 chromosomes.
5. During protein synthesis, messenger RNA
   a. "reads" each three-letter code of bases.
   b. releases the completed protein chain.
   c. copies information from DNA in the nucleus.
   d. carries amino acids to the ribosome.

True or False

If the statement is true, write true. If it is false, change the underlined word or words to make the statement true.

6. The scientific study of heredity is called genetics.
7. An organism's physical appearance is its genotype.
8. In codominance, neither of the alleles is dominant or recessive.
9. Heredity is the process by which sex cells form.
10. Proteins are made in the nucleus of the cell.

Checking Concepts

11. Describe what happened when Mendel crossed purebred tall pea plants with purebred short pea plants.
12. You toss a coin five times and it lands heads up each time. What is the probability that it will land heads up on the sixth toss? Explain your answer.
13. In guinea pigs, the allele for black fur (*B*) is dominant over the allele for white fur (*b*). In a cross between a heterozygous black guinea pig (*Bb*) and a homozygous white guinea pig (*bb*), what is the probability that an offspring will have white fur? Use a Punnett square to answer the question.
14. In your own words, describe the sequence of steps in the process of meiosis.
15. Describe the role of transfer RNA in protein synthesis.
16. **Writing to Learn** Imagine that you are a student in the 1860s visiting Gregor Mendel in his garden. Write a letter to a friend describing Mendel's experiments.

Thinking Critically

17. **Applying Concepts** In rabbits, the allele for a spotted coat is dominant over the allele for a solid-colored coat. A spotted rabbit was crossed with a solid-colored rabbit. The offspring all had spotted coats. What were the genotypes of the parents? Explain.
18. **Problem Solving** Suppose you are growing purebred green-skinned watermelons. One day you find a mutant striped watermelon. You cross the striped watermelon with a purebred green watermelon. Fifty percent of the offspring are striped, while fifty percent are green. Is the allele for the striped trait dominant or recessive? Explain.
19. **Predicting** A new mutation in mice causes the coat to be twice as thick as normal. In what environments would this mutation be helpful?

ying Skills

s, the allele for green pods (G) is dominant ie allele for yellow pods (g). The table shows enotypes of the offspring produced from a f two plants with green pods. Use the data wer Questions 20–22.

henotype	Number of Offspring
;reen pods	9
'ellow pods	3

Calculating Calculate what percent of the offspring have green pods. Calculate what percent have yellow pods.

Inferring What is the genotype of the offspring with yellow pods? What are the possible genotypes of the offspring with green pods?

22. **Drawing Conclusions** What are the genotypes of the parents? How do you know?

Performance CHAPTER PROJECT **Assessment**

Present Your Project Finalize your display of your pet's family. Be prepared to discuss the inheritance patterns in your pet's family. Examine your classmates' exhibits, and see which offspring look most like, and least like, their parents. Can you find any offspring that "break the laws" of inheritance?

Reflect and Record How did your paper pets help you learn about genetics? How do the inheritance patterns in your pet's family resemble real-life patterns? How could you use paper pets to help you understand other topics in genetics?

est Preparation

Use these questions to prepare for standardized tests.

e the information to answer Questions 23–26.

et store's customers prefer pet mice with ck fur over mice with white fur. With this in nd, the owner crossed a female with black fur d a male with black fur. When the mice were rn, she was surprised that three of the ten spring had white fur. She did not know that e parents were heterozygous for fur color.

. Which letters represent the genotype of the female parent?
a. BB b. Bb
c. B d. bb

. Which letters represent the genotype of the male parent?
a. BB b. Bb
c. B d. bb

25. How could the pet store owner breed a litter of only white mice?
a. by making sure that either the mother or the father has white fur
b. by making sure that both the mother and the father have white fur
c. by making sure that at least one of the grandparents has white fur
d. She could not breed a litter of only white mice.

26. If the pet store owner were to cross one homozygous black mouse with a heterozygous black mouse, what percentage of the mice would you expect to have white fur?
a. 0% b. 25%
c. 50% d. 75%