Section 1

Human Inheritance

Reading Preview

Key Concepts

- What are some patterns of inheritance in humans?
- What are the functions of the sex chromosomes?
- What is the relationship between genes and the environment?

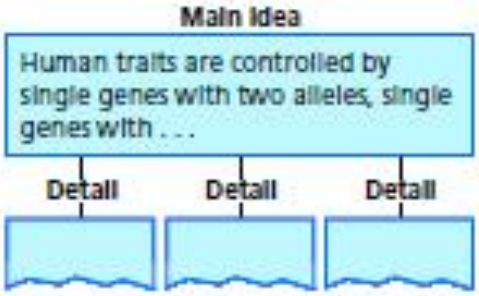
Key Terms

- multiple alleles
- sex chromosomes
- sex-linked gene
- carrier

Target Reading Skill

Identifying Main Ideas

As you read the Patterns of Human Inheritance section, write the main idea—the biggest or most important idea—in a graphic organizer like the one below. Then write three supporting details that further explain the main idea.



Lab zone

Discover Activity

How Tall Is Tall?

1. Choose a partner. Measure each other's height to the nearest 5 centimeters. Record your measurements on the chalkboard.
2. Create a bar graph showing the number of students at each height. Plot the heights on the horizontal axis and the number of students on the vertical axis.

Think It Over

Inferring Do you think height in humans is controlled by a single gene, as it is in peas? Explain your answer.

The arrival of a baby is a happy event. Eagerly, the parents and grandparents gather around to admire the newborn baby. "Don't you think she looks like her father?" "Yes, but she has her mother's eyes."

When a baby is born, the parents, their families, and their friends try to determine whom the baby resembles. Chances are good that the baby will look a little bit like both parents. That is because both parents pass alleles for traits on to their offspring.

FIGURE 1
Family Resemblance
Because children inherit alleles for traits from their mother and father, children often look like their parents.

Patterns of Human Inheritance

Take a few seconds to look at the other students in your classroom. Some people have curly hair; others have straight hair. Some people are tall, some are short, and many others are in between. You'll probably see eyes of many different colors, ranging from pale blue to dark brown. The different traits you see are determined by a variety of inheritance patterns. **Some human traits are controlled by single genes with two alleles, and others by single genes with multiple alleles. Still other traits are controlled by many genes that act together.**

Single Genes With Two Alleles A number of human traits are controlled by a single gene with one dominant allele and one recessive allele. These human traits have two distinctly different phenotypes, or physical appearances.

For example, a widow's peak is a hairline that comes to a point in the middle of the forehead. The allele for a widow's peak is dominant over the allele for a straight hairline. The Punnett square in Figure 2 illustrates a cross between two parents who are heterozygous for a widow's peak. Trace the possible combinations of alleles that a child may inherit. Notice that each child has a 3 in 4, or 75 percent, probability of having a widow's peak. There is only a 1 in 4, or 25 percent, probability that a child will have a straight hairline. When Mendel crossed peas that were heterozygous for a trait, he obtained similar percentages in the offspring.

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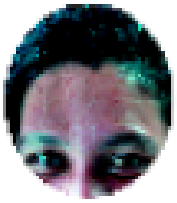

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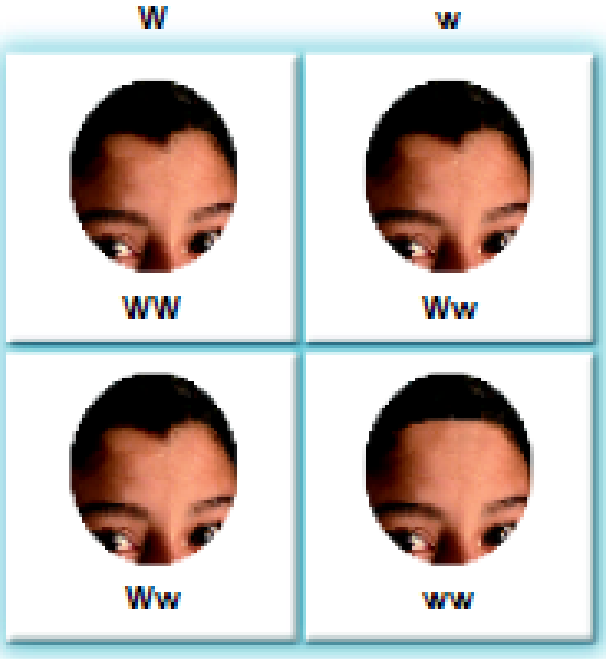

Figure 2
Widow's Peak Punnett Square
This Punnett square shows a cross between two parents with widow's peaks.
Interpreting Diagrams *What are the possible genotypes of the offspring? What percentage of the offspring will have each genotype?*

FIGURE 3
Inheritance of Blood Type
Blood type is determined by a single gene with three alleles. This chart shows which combinations of alleles result in each blood type.

Alleles of Blood Types	
Blood Type	**Combination of Alleles**
A	I^AI^A or I^Ai
B	I^BI^B or I^Bi
AB	I^AI^B
O	ii

Single Genes With Multiple Alleles

Some human traits are controlled by a single gene that has more than two alleles. Such a gene is said to have **multiple alleles**—three or more forms of a gene that code for a single trait. Even though a gene may have multiple alleles, a person can carry only two of those alleles. This is because chromosomes exist in pairs. Each chromosome in a pair carries only one allele for each gene.

Human blood type is controlled by a gene with multiple alleles. There are four main blood types—A, B, AB, and O. Three alleles control the inheritance of blood types. The allele for blood type A and the allele for blood type B are codominant. The allele for blood type A is written as I^A. The allele for blood type B is written I^B. The allele for blood type O—written i—is recessive. Recall that when two codominant alleles are inherited, neither allele is masked. A person who inherits an I^A allele from one parent and an I^B allele from the other parent will have type AB blood. Figure 3 shows the allele combinations that result in each blood type. Notice that only people who inherit two i alleles have type O blood.

Traits Controlled by Many Genes

If you completed the Discover activity, you saw that height in humans has more than two distinct phenotypes. In fact, there is an enormous variety of phenotypes for height. Some human traits show a large number of phenotypes because the traits are controlled by many genes. The genes act together as a group to produce a single trait. At least four genes control height in humans, so there are many possible combinations of genes and alleles. Skin color is another human trait that is controlled by many genes.

Reading Checkpoint **Why do some traits exhibit a large number of phenotypes?**

FIGURE 4
Many Phenotypes
Skin color in humans is determined by three or more genes. Different combinations of alleles for each of the genes result in a wide range of possible skin colors.

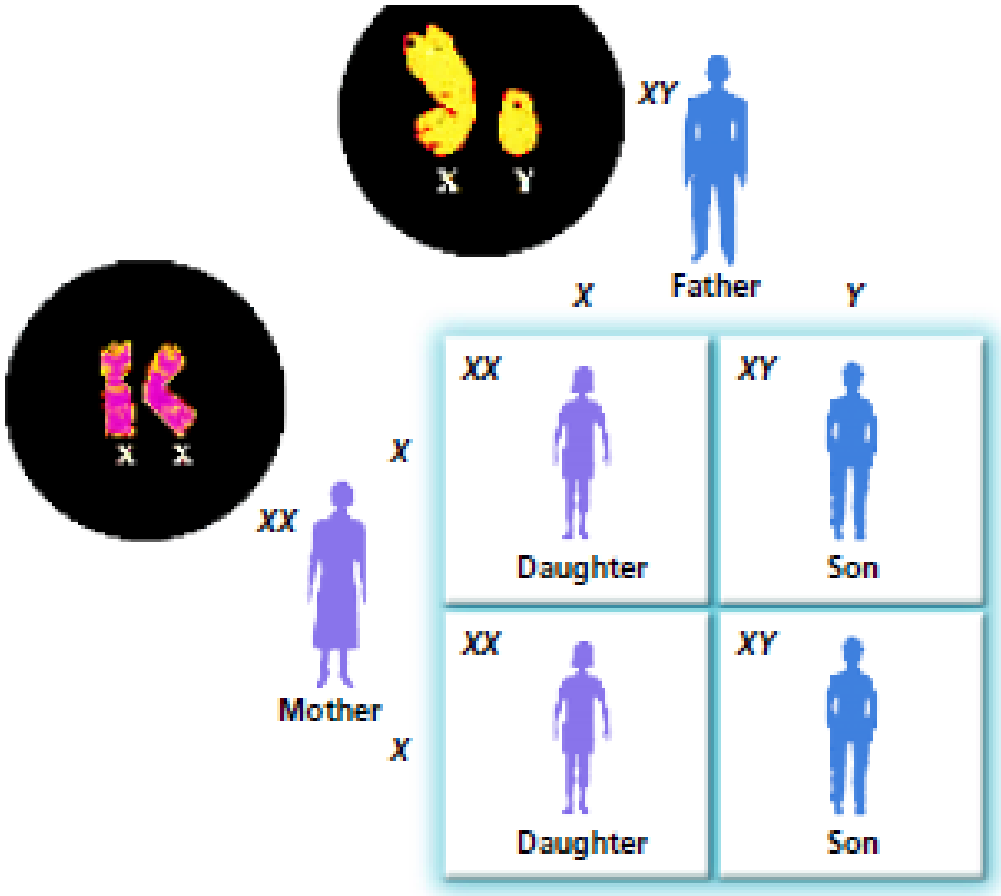

Figure 5
Male or Female?
As this Punnett square shows, there is a 50 percent probability that a child will be a girl and a 50 percent probability that a child will be a boy.
Interpreting Diagrams *What sex will the child be if a sperm with a Y chromosome fertilizes an egg?*

The Sex Chromosomes

The **sex chromosomes** are one of the 23 pairs of chromosomes in each body cell. **The sex chromosomes carry genes that determine whether a person is male or female. They also carry genes that determine other traits.**

Girl or Boy? The sex chromosomes are the only chromosome pair that do not always match. If you are a girl, your two sex chromosomes match. The two chromosomes are called X chromosomes. If you are a boy, your sex chromosomes do not match. One of them is an X chromosome, and the other is a Y chromosome. The Y chromosome is much smaller than the X chromosome.

Sex Chromosomes and Fertilization What happens to the sex chromosomes when egg and sperm cells form? Since both of a female's sex chromosomes are X chromosomes, all eggs carry one X chromosome. Males, however, have two different sex chromosomes. Therefore, half of a male's sperm cells carry an X chromosome, while half carry a Y chromosome.

When a sperm cell with an X chromosome fertilizes an egg, the egg has two X chromosomes. The fertilized egg will develop into a girl. When a sperm with a Y chromosome fertilizes an egg, the egg has one X chromosome and one Y chromosome. The fertilized egg will develop into a boy.

Lab zone **Try This Activity**

The Eyes Have It

One inherited trait is eye dominance—the tendency to use one eye more than the other. Here's how you can test yourself for this trait.

1. Hold your hand out in front of you at arm's length. Point your finger at an object across the room.
2. Close your right eye. With only your left eye open, observe how far your finger appears to move.
3. Repeat Step 2 with the right eye open. With which eye did your finger seem to remain closer to the object? That eye is dominant.

Designing Experiments
Is eye dominance related to hand dominance—whether a person is right-handed or left-handed? Design an experiment to find out. *Obtain your teacher's permission before carrying out your experiment.*

Sex-Linked Genes The genes for some human traits are carried on the sex chromosomes. Genes on the X and Y chromosomes are often called **sex-linked genes** because their alleles are passed from parent to child on a sex chromosome. Traits controlled by sex-linked genes are called sex-linked traits. One sex-linked trait is red-green colorblindness. A person with this trait cannot distinguish between red and green.

Recall that females have two X chromosomes, whereas males have one X chromosome and one Y chromosome. Unlike most chromosome pairs, the X and Y chromosomes have different genes. Most of the genes on the X chromosome are not on the Y chromosome. Therefore, an allele on an X chromosome may have no corresponding allele on a Y chromosome.

Like other genes, sex-linked genes can have dominant and recessive alleles. In females, a dominant allele on one X chromosome will mask a recessive allele on the other X chromosome. But in males, there is usually no matching allele on the Y chromosome to mask the allele on the X chromosome. As a result, any allele on the X chromosome—even a recessive allele—will produce the trait in a male who inherits it. Because males have only one X chromosome, males are more likely than females to have a sex-linked trait that is controlled by a recessive allele.

FIGURE 6
Colorblindness
The lower photo shows how a red barn and green fields look to a person with red-green colorblindness.

Inheritance of Colorblindness Colorblindness is a trait controlled by a recessive allele on the X chromosome. Many more males than females have red-green colorblindness. You can understand why this is the case by examining the Punnett square in Figure 7. Both parents in this example have normal color vision. Notice, however, that the mother is a carrier of colorblindness. A **carrier** is a person who has one recessive allele for a trait and one dominant allele. A carrier of a trait controlled by a recessive allele does not have the trait. However, the carrier can pass the recessive allele on to his or her offspring. In the case of sex-linked traits, only females can be carriers.

As you can see in Figure 7, there is a 25 percent probability that this couple will have a colorblind child. Notice that none of the couple's daughters will be colorblind. On the other hand, the sons have a 50 percent probability of being colorblind. For a female to be colorblind, she must inherit two recessive alleles for colorblindness, one from each parent. A male needs to inherit only one recessive allele. This is because there is no gene for color vision on the Y chromosome. Thus, there is no allele that could mask the recessive allele on the X chromosome.

Reading Checkpoint **What is the sex of a person who is a carrier for colorblindness?**

Go Online
SCILINKS
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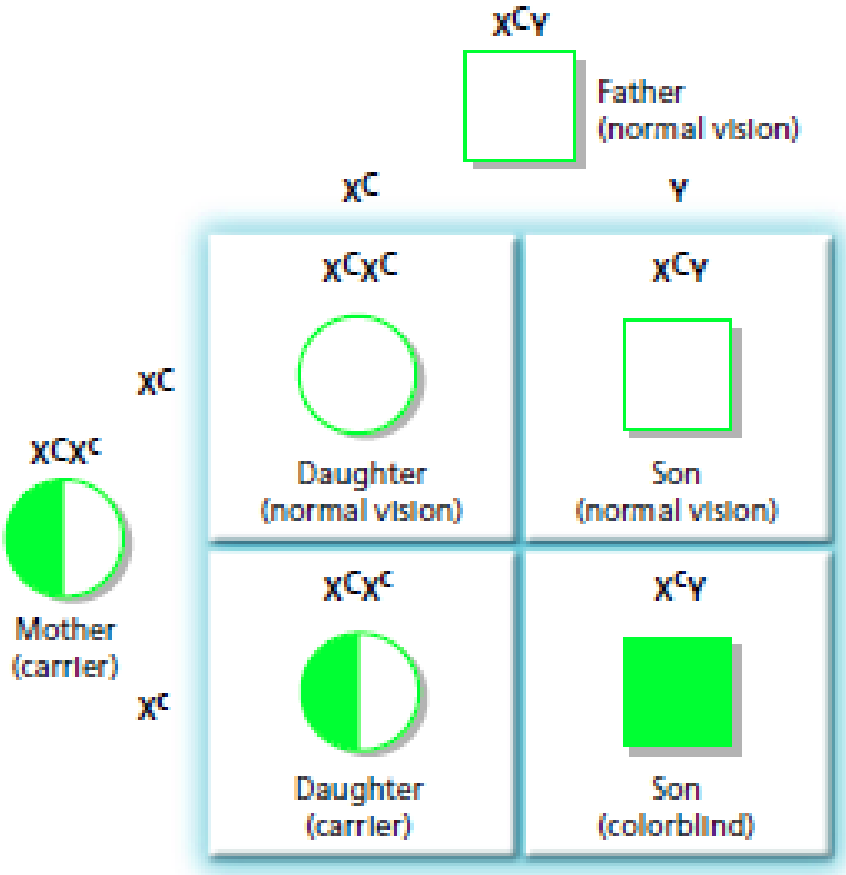

Figure 7
Colorblindness Punnett Square
Red-green colorblindness is a sex-linked trait. A girl who receives only one recessive allele (written X^c) for red-green colorblindness will not have the trait. However, a boy who receives one recessive allele will be colorblind.
Applying Concepts *What allele combination would a daughter need to inherit to be colorblind?*

FIGURE 8
Heredity and Environment
When a person plays a violin, genetically determined traits such as muscle coordination interact with environmental factors such as time spent in practice.

The Effect of Environment

In humans and other organisms, the effects of genes are often influenced by the environment—an organism's surroundings. **Many of a person's characteristics are determined by an interaction between genes and the environment.**

You have learned that several genes work together to help determine human height. However, people's heights are also influenced by their environments. People's diets can affect their height. A diet lacking in protein, certain minerals, or certain vitamins can prevent a person from growing as tall as might be possible.

Environmental factors can also affect human skills, such as playing a musical instrument. For example, physical traits such as muscle coordination and a good sense of hearing will help a musician play well. But the musician also needs instruction on how to play the instrument. Musical instruction is an environmental factor.

Reading Checkpoint **How can environmental factors affect a person's height?**

Section 1 Assessment

Target Reading Skill Identifying Main Ideas
Use your graphic organizer to help you answer Question 1 below.

Reviewing Key Concepts

1. a. Identifying Identify three patterns of inheritance in humans. Give an example of a trait that follows each pattern.
   b. Summarizing How many human blood types are there? Summarize how blood type is inherited.
   c. Drawing Conclusions Aaron has blood type O. Can either of his parents have blood type AB? Explain your answer.
2. a. Reviewing What are the functions of the sex chromosomes?
   b. Comparing and Contrasting Contrast the sex chromosomes found in human females and human males.
   c. Relating Cause and Effect Explain how red-green colorblindness is inherited. Why is the condition more common in males than in females?
3. a. Reviewing Are a person's characteristics determined only by genes? Explain.
   b. Applying Concepts Explain what factors might work together to enable a great soccer player to kick a ball a long distance.

Writing in Science

Heredity and Environment Think of an ability you admire, such as painting, dancing, snowboarding, or playing games skillfully. Write a paragraph explaining how genes and the environment might work together to enable a person to develop this ability.