Modern Genetics

The children in this family have some traits like their mother's and some traits like their father's.

A Family Portrait

A pedigree, or family tree, is a branched drawing that shows many generations of a family. In some cases, a pedigree may show centuries of a family's history.

In genetics, pedigrees are used to show how inherited characteristics are passed from one generation to the next. In this project, you will create a genetic pedigree for an imaginary family. Although the family will be imaginary, your pedigree must show how real human traits are passed from parents to children.

Your Goal To create a pedigree for an imaginary family that shows the transfer of genetic traits from one generation to the next.

To complete the project you will

- choose two different genetic traits, and identify all the possible genotypes and phenotypes

Human Inheritance

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 If Gregor Mendel had graphed the heights of his pea plants, the graph would have had two bars—one for tall stems and one for short stems. Do you think height in humans is controlled by a single gene, as it is in peas? Explain your answer.

GUIDE FOR READING

- Why do some human traits show a large variety of phenotypes?
- How does the environment affect an organism's characteristics?
- Why are some sex-linked traits more common in males than in females?

Reading Tip Before you read, rewrite the headings in this section as *how*, *why*, or *what* questions. As you read, write answers to the questions.

Key Terms • multiple alleles • sex-linked gene • carrier • pedigree

Have you ever heard someone say "He's the spitting image of his dad" or "She has her mother's eyes"? Children often resemble their parents. The reason for this is that alleles for eye color, hair color, and thousands of other traits are passed from parents to their children. People inherit some alleles from their mother and some from their father. This is why most people look a little like their mother and a little like their father.

- create pedigrees that trace each trait through three generations of your imaginary family
- prepare a family "photo" album to show what each family member looks like

Get Started With a partner, review the human traits described in Chapter 16. List what you already know about human inheritance. For example, which human traits are controlled by dominant alleles? Which are controlled by recessive alleles? Then preview Section 1 of this chapter, and list the traits you'll be studying. Choose two traits that you would like to focus on in your project.

Check Your Progress You'll be working on this project as you study this chapter. To keep your project on track, look for Check Your Progress boxes at the following points.

- Section 1 Review: Create a pedigree for the first trait you chose.
- Section 2 Review: Create the second pedigree, and begin your family album.

Present Your Project At the end of the chapter, you will present your family's pedigrees and "photo" album to the class.

In addition to process TEKS, this chapter addresses these concept TEKS as they relate to the chapter's topics.

(8.11) The student knows that traits of species can change through generations and that the instructions for traits are contained in the genetic material of the organisms. The student is expected to:
(B) distinguish between inherited traits and other characteristics that result from interactions with the environment;
(C) make predictions about possible outcomes of various genetic combinations of inherited characteristics.

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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. You can think of multiple alleles as being like flavors of pudding. Pudding usually comes in more flavors than just chocolate and vanilla!

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.

One human trait that is controlled by a gene with multiple alleles is blood type. 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 codominant alleles are written as capital letters with superscripts—I^A for blood type A and I^B for blood type 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. The table below shows the allele combinations that result in each blood type. Notice that only people who inherit two *i* alleles have type O blood.

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

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

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SECTION 1

Traits Controlled by Many Genes

There is an enormous variety of phenotypes for height in humans. What causes this wide range of phenotypes? **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.

Like height, skin color is determined by many genes. Human skin color ranges from almost white to nearly black, with many shades in between. Skin color is controlled by at least three genes. Each gene, in turn, has at least two possible alleles. Various combinations of alleles at each of the genes determine the amount of pigment that a person's skin cells produce. Thus, a wide variety of skin colors is possible.

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The Effect of Environment

The effects of genes are often altered by the environment—the organism's surroundings. **Many of an organism's characteristics are determined by an interaction between genes and the environment.** For example, people's diets can affect their height. A diet lacking in protein, minerals, and vitamins can prevent a person from growing to his or her potential maximum height. Since the late 1800s, the average height of adults in the United States has increased by almost 10 centimeters. During that time, American diets have become more healthful.

Height is determined by both genes and the environment. **In contrast, some characteristics of organisms are not determined by genes at all. Instead, these characteristics result entirely from interactions with the environment.** For example, suppose a person becomes blind as the result of an accident. The blindness was caused by the environment, not by alleles that the person inherited from his or her parents.

SECTION 1

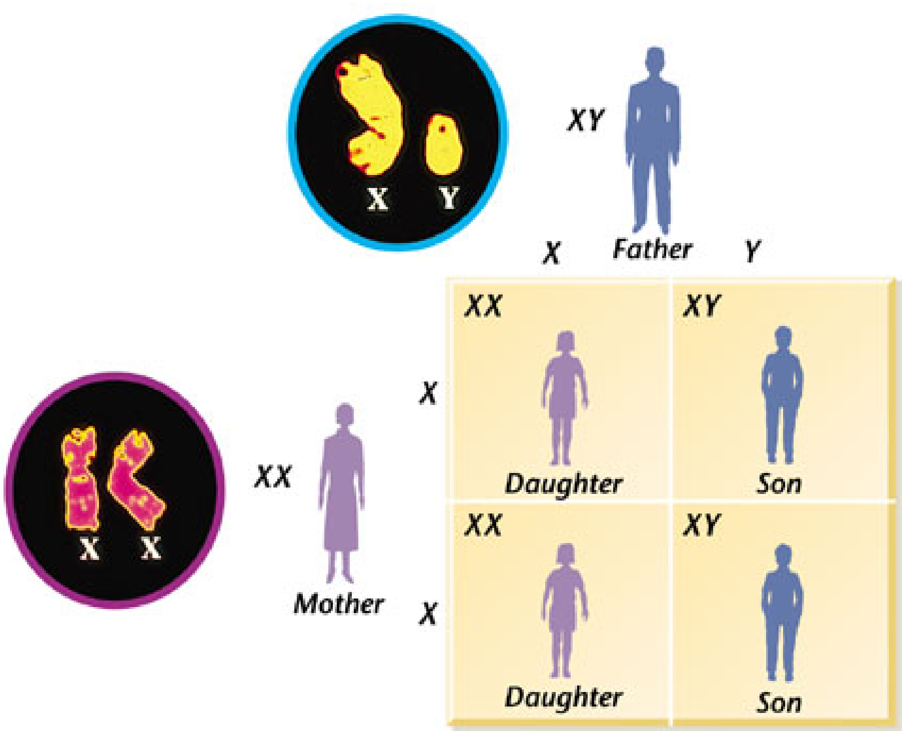
Male or Female?

What determines whether a baby is a boy or a girl? As with other traits, the sex of a baby is determined by genes on chromosomes. Among the 23 pairs of chromosomes in each body cell is a single pair of chromosomes called the sex chromosomes. The sex chromosomes determine whether a person is male or female.

The sex chromosomes are the only pair of chromosomes that do not always match. If you are female, your two sex chromosomes match. The two chromosomes are called X chromosomes. If you are male, your sex chromosomes do not match. One of your sex chromosomes is an X chromosome. The other sex chromosome is a Y chromosome. The Y chromosome is much smaller than the X chromosome.

What happens to the sex chromosomes when egg and sperm cells form? As you know, each egg and sperm cell has only one chromosome from each pair. Since both of a female's sex chromosomes are X chromosomes, all eggs carry one X chromosome. Males, however, have two different sex chromosomes. This means that 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. Thus it is the sperm that determines the sex of the child, as you can see in the Punnett square below.



Gender 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*** Predict the sex of the child if a sperm with a Y chromosome fertilizes an egg.

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Girl or Boy?

You can model how the sex of an offspring is determined.

1. Label one paper bag “female.” Label another paper bag “male.”
2. Place two red marbles in the bag labeled “female.” The red marbles represent X chromosomes.
3. Place one red marble and one white marble in the bag labeled “male.” The white marble represents a Y chromosome.
4. Without looking, pick one marble from each bag. Two red marbles represent a female offspring. One red marble and one white marble represent a male offspring. Record the sex of the “offspring.”
5. Put the marbles back in the correct bags. Repeat Step 4 nine more times.

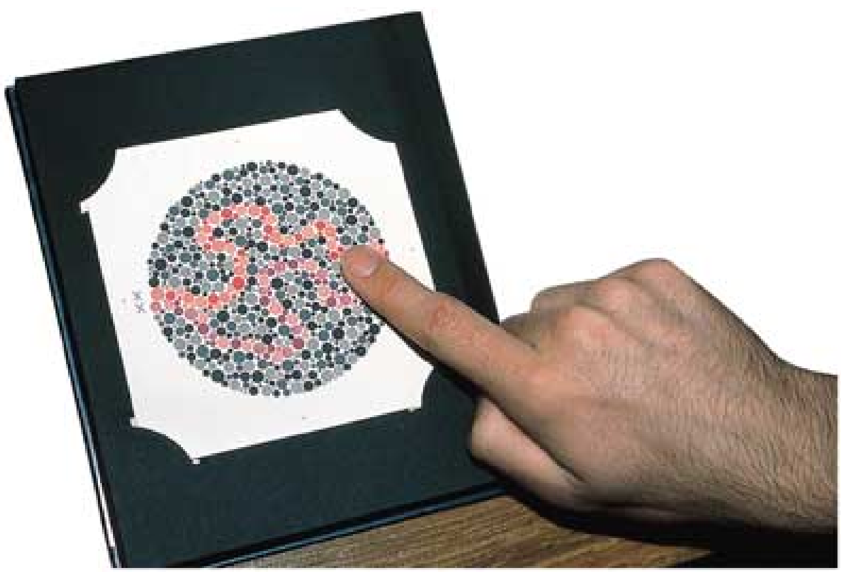
Making Models How many males were produced? How many females? How close were your results to the expected probabilities for male and female offspring?

Sex-Linked Genes

Some human traits occur more often in one sex than the other. The genes for these traits are often 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.

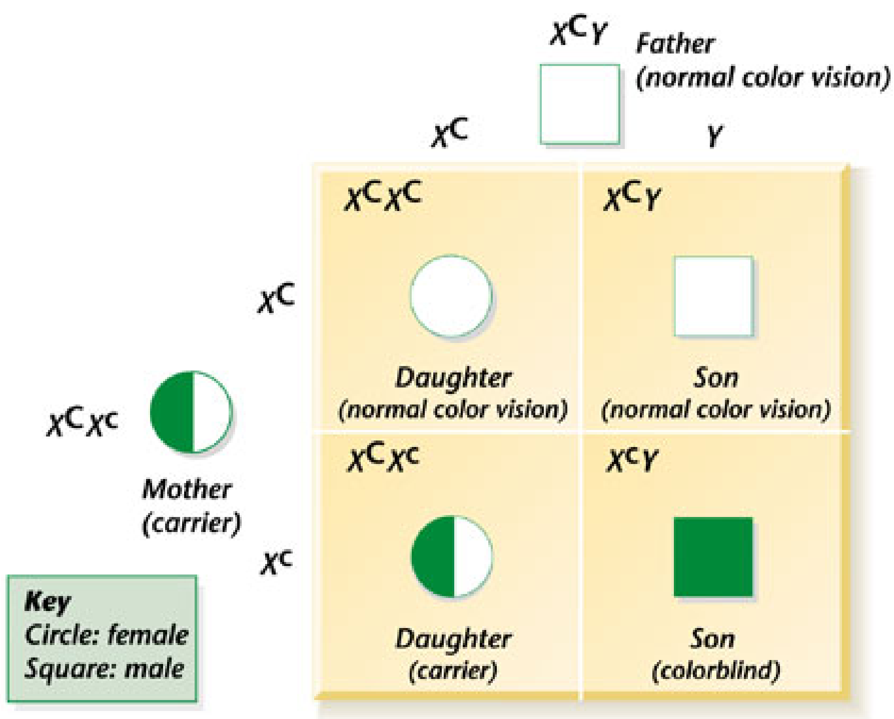
Like other genes, sex-linked genes can have dominant and recessive alleles. Recall that females have two X chromosomes, whereas males have one X chromosome and one Y chromosome. In females, a dominant allele on one X chromosome will mask a recessive allele on the other X chromosome. The situation is not the same in males, however. In males, there is no matching allele on the Y chromosome to cover up 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.**

One example of a sex-linked trait that is controlled by a recessive allele is red-green colorblindness. A person with red-green colorblindness cannot distinguish between red and green.



Testing for Colorblindness A person with red-green colorblindness cannot see the loop of red and pink dots in this test chart.

Many more males than females have red-green colorblindness. You can understand why this is the case by examining the Punnett square below. 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. Although a carrier does not have the trait, 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.



Genetics of Colorblindness Red-green color-blindness 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?

As you can see in the Punnett squares, 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 cover up the recessive allele on the X chromosome.

Pedigrees

Imagine that you are a geneticist studying inheritance patterns in humans. What would you do? You can't set up crosses with people as Mendel did with peas. Instead, you would need to trace the inheritance of traits through many generations in a number of families.

One tool that geneticists use to trace the inheritance of traits in humans is a pedigree. A **pedigree** is a chart or "family tree" that tracks which members of a family have a particular trait. The trait recorded in a pedigree can be an ordinary trait such as the widow's peak, or it could be a sex-linked trait such as colorblindness. In *Exploring a Pedigree*, you can trace the inheritance of colorblindness through three generations of a family.

Exploring a Pedigree

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