

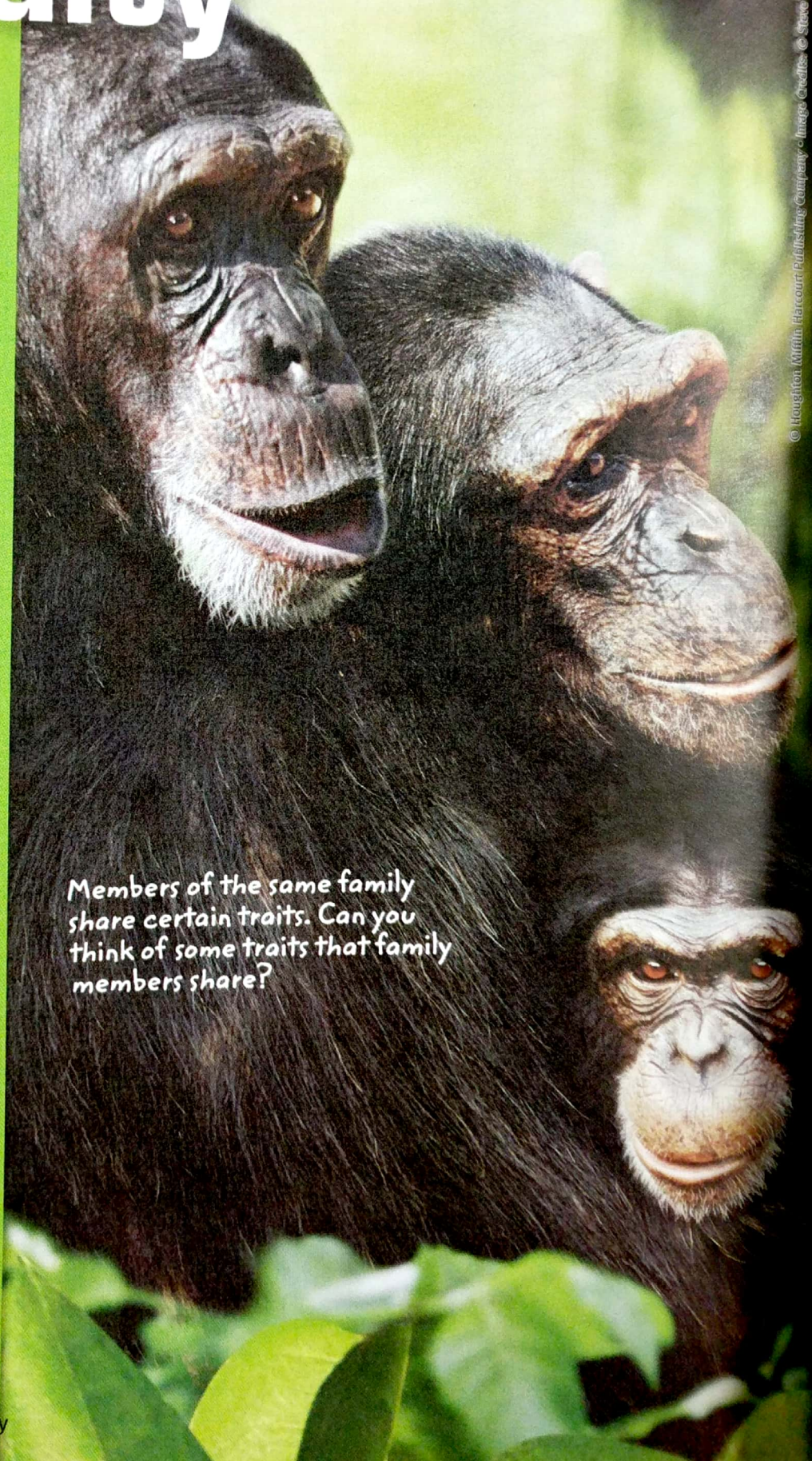
Heredity

ESSENTIAL QUESTION

How are traits inherited?

By the end of this lesson, you should be able to analyze the inheritance of traits in individuals.

Members of the same family share certain traits. Can you think of some traits that family members share?



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Lesson Labs

Quick Labs

- Dominant Alleles
- What's the Difference between a Dominant Trait and a Recessive Trait?



Engage Your Brain

1 Predict Check T or F to show whether you think each statement is true or false.

- | | | |
|--------------------------|--------------------------|--|
| T | F | |
| <input type="checkbox"/> | <input type="checkbox"/> | Siblings look similar because they each have some traits of their parents. |
| <input type="checkbox"/> | <input type="checkbox"/> | Siblings always have the same hair color. |
| <input type="checkbox"/> | <input type="checkbox"/> | Siblings have identical DNA. |

2 Describe Do you know any identical twins? How are they similar? How are they different?



Active Reading

3 Infer Use context clues to write your own definition for the words *exhibit* and *investigate*.

Example sentence

A person with brown hair may also exhibit the trait of brown eye color.

exhibit:

Example sentence

Gregor Mendel began to investigate the characteristics of pea plants.

investigate:

Vocabulary Terms

- | | |
|-------------|------------------------|
| • heredity | • dominant |
| • gene | • recessive |
| • allele | • incomplete dominance |
| • genotype | • codominance |
| • phenotype | |

4 Identify This list contains the key terms you'll learn in this lesson. As you read, circle the definition of each term.

Give Peas a Chance









What is heredity?

Imagine a puppy. The puppy has long floppy ears like his mother has, and the puppy has dark brown fur like his father has. How did the puppy get these traits? The traits are a result of information stored in the puppy's genetic material. The passing of genetic material from parents to offspring is called **heredity**.

What did Gregor Mendel discover about heredity?

The first major experiments investigating heredity were performed by a monk named Gregor Mendel. Mendel lived in Austria in the 1800s. Before Mendel became a monk, he attended a university and studied science and mathematics. This training served him well when he began to study the inheritance of traits among the pea plants in the monastery's garden. Mendel studied seven different characteristics of pea plants: plant height, flower and pod position, seed shape, seed color, pod shape, pod color, and flower color. A *characteristic* is a feature that has different forms in a population. Mendel studied each pea plant characteristic separately, always starting with plants that were true-breeding for that characteristic. A true-breeding plant is one that will always produce offspring with a certain trait when allowed to self-pollinate. Each of the characteristics that Mendel studied had two different forms. For example, the color of a pea could be green or yellow. These different forms are called *traits*.

Characteristics of Pea Plants

Characteristic	Traits	
Seed color		
Seed shape		
Pod color		
Flower position		

5 Apply Is flower color a characteristic or a trait?



Traits Depend on Inherited Factors

In his experiments with seed pod color, Mendel took two sets of plants, one true-breeding for plants that produce yellow seed pods and the other true-breeding for plants that produce green seed pods. Instead of letting the plants self-pollinate as they do naturally, he paired one plant from each set. He did this by fertilizing one plant with the pollen of another plant. Mendel called the plants that resulted from this cross the first generation. All of the plants from this first generation produced green seed pods. Mendel called this trait the *dominant* trait. Because the yellow trait seemed to recede, or fade away, he called it the *recessive* trait.

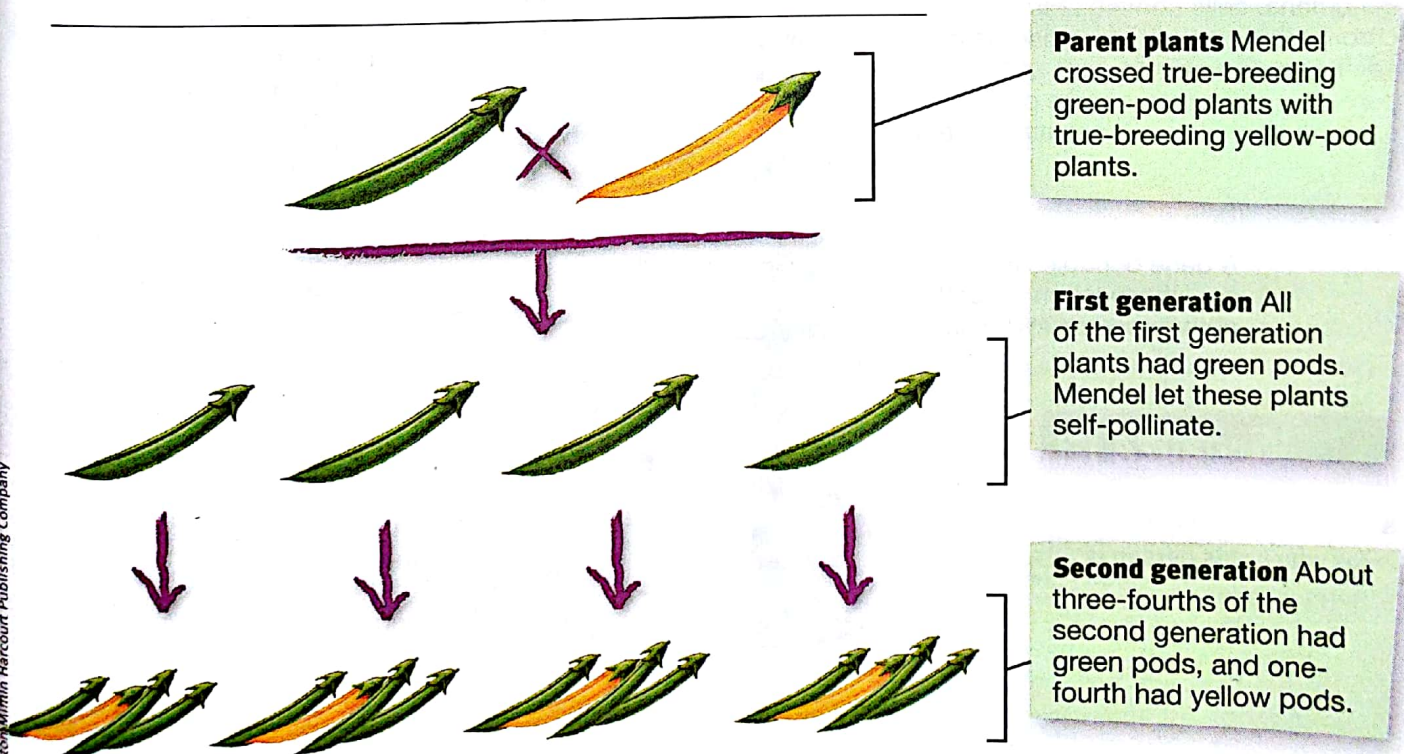
Then Mendel let the first-generation plants self-pollinate. He called the offspring that resulted from this self-pollination the second generation. About three-fourths of the second-generation plants had green seed pods, but about one-fourth had yellow pods. So the trait that seemed to disappear in the first generation reappeared in the second generation. Mendel hypothesized that each plant must have two heritable “factors” for each trait, one from each parent. Some traits, such as yellow seed pod color, could only be observed if a plant received two factors—one from each parent—for yellow pod color. A plant with one yellow factor and one green factor would produce green pods because producing green pods is a dominant trait. However, this plant could still pass on the yellow factor to the next generation of plants.

Active Reading

6 Identify As you read, underline Mendel’s hypothesis about how traits are passed from parents to offspring.

Visualize It!

7 Apply Which pod color is recessive?



It's in your genes!

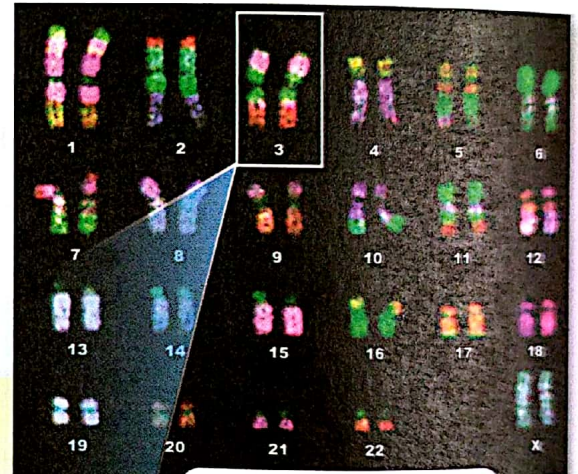
Genes are made up of DNA.

How are traits inherited?

Mendel's experiments and conclusions have been the basis for much of the scientific thought about heredity. His ideas can be further explained by our modern understanding of the genetic material DNA. What Mendel called "factors" are actually segments of DNA known as genes!

Genes Are Passed from Parents to Offspring

Genes are segments of DNA found in chromosomes that give instructions for producing a certain characteristic. Humans, like many other organisms, inherit their genes from their parents. Each parent gives one set of genes to the offspring. The offspring then has two versions, or forms, of the same gene for every characteristic—one version from each parent. The different versions of a gene are known as **alleles** (uh•LEELZ). Genes are often represented by letter symbols. Dominant alleles are shown with a capital letter, and recessive alleles are shown with a lowercase version of the same letter. An organism with two dominant or two recessive alleles is said to be *homozygous* for that gene. An organism that has one dominant and one recessive allele is *heterozygous*.



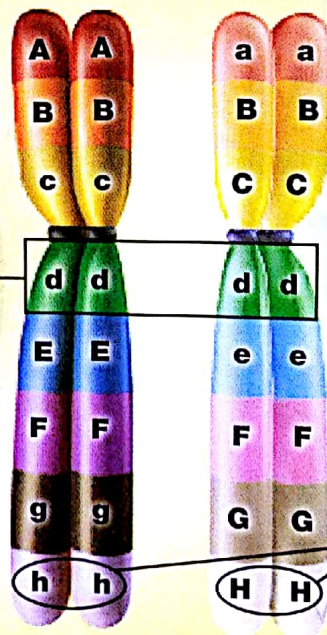
Humans have 23 pairs of chromosomes.

In humans, cells contain pairs of chromosomes. One chromosome of each pair comes from each of two parents. Each chromosome contains sites where specific genes are located.

A gene occupies a specific location on both chromosomes in a pair.

Visualize It!

8 Apply Circle a gene pair for which this person is heterozygous.



Alleles are alternate forms of the same gene.

9 Apply The girls in this photograph have different types of hair. Is hair type a genotype or a phenotype?



This girl does not have dimples.

Genes Influence Traits

The alternate forms of genes, called alleles, determine the traits of all living organisms. The combination of alleles that you inherited from your parents is your **genotype** (JEEN•uh•typ). Your observable traits make up your **phenotype** (FEEN•uh•typ). The phenotypes of some traits follow patterns similar to the ones that Mendel discovered in pea plants. That is, some traits are dominant over others. For example, consider the gene responsible for producing dimples, or creases in the cheeks. This gene comes in two alleles: one for dimples and one for no dimples. If you have even one copy of the allele for dimples, you will have dimples. This happens because the allele for producing dimples is dominant. The **dominant** allele contributes to the phenotype if one or two copies are present in the genotype. The no-dimples allele is recessive. The **recessive** allele contributes to the phenotype only when two copies of it are present. If one chromosome in the pair contains a dominant allele and the other contains a recessive allele, the phenotype will be determined by the dominant allele. If you do not have dimples, it is because you inherited two no-dimples alleles—one from each parent. This characteristic shows *complete dominance*, because one trait is completely dominant over another. However, not all characteristics follow this pattern.

Active Reading

11 Identify What is the phenotype of an individual with one allele for dimples and one allele for no dimples?

Think Outside the Book **Inquiry**

10 Imagine Write a short story about a world in which you could change your DNA and your traits. What would be the advantages? What would be the disadvantages?

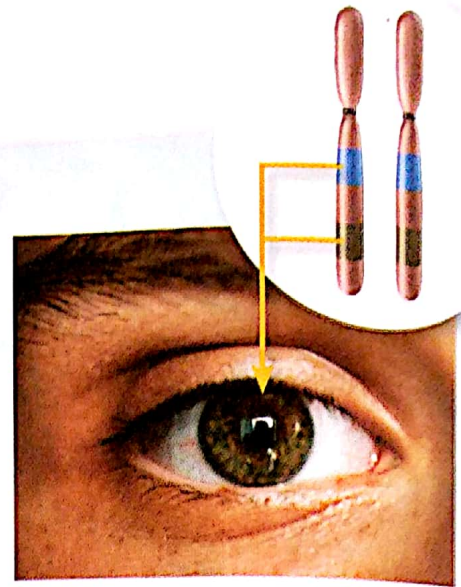
Many Genes Can Influence a Single Trait

Some characteristics, such as the color of your skin, hair, and eyes, are the result of several genes acting together. Different combinations of alleles can result in different shades of eye color. Because there is not always a one-to-one relationship between a trait and a gene, many traits do not have simple patterns of inheritance.

A Single Gene Can Influence Many Traits

Sometimes, one gene influences more than one trait. For example, a single gene causes the tiger shown below to have white fur. If you look closely, you will see that the tiger also has blue eyes. The gene that affects fur color also influences eye color.

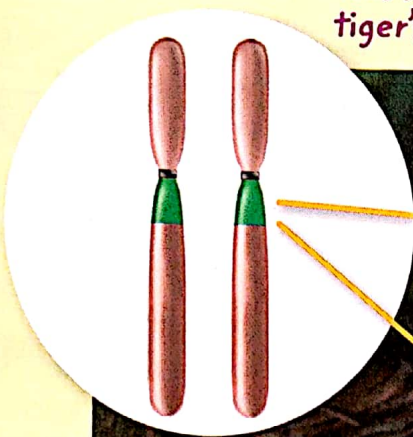
Many genetic disorders in humans are linked to a single gene but affect many traits. For example, the genetic disorder sickle cell anemia occurs in individuals who have two recessive alleles for a certain gene. This gene carries instructions for producing a protein in red blood cells. When a person has sickle cell anemia alleles, the body makes a different protein. This protein causes red blood cells to be sickle or crescent shaped when oxygen levels are low. Sickle-shaped blood cells can stick in blood vessels, sometimes blocking the flow of blood. These blood cells are also more likely to damage the spleen. With fewer healthy red blood cells, the body may not be able to deliver oxygen to the body's organs. All of the traits associated with sickle cell anemia are due to a single gene.



Visualize It!

12 Identify How many genes are responsible for eye color in this example?

This single gene affects the tiger's fur color and eye color.



The Environment Can Influence Traits

Sometimes, the environment influences an organism's phenotype. For example, the arctic fox has a gene that is responsible for coat color. This gene is affected by light. In the winter, there are fewer hours of daylight, and the hairs that make up the arctic fox's coat grow in white. In the summer, when there are more daylight hours, the hairs in the coat grow in brown. In this case, both genes and the environment contribute to the organism's phenotype. The environment can influence human characteristics as well. For example, your genes may make it possible for you to grow to be tall, but you need a healthy diet to reach your full height potential.

Traits that are learned in one's environment are not inherited. For example, your ability to read and write is an acquired trait—a skill you learned. You were not born knowing how to ride a bike, and if you have children, they will not be born knowing how to do it either. They will have to learn the skill just as you did.

Active Reading

13 Identify Give an example of an acquired trait.

In the winter, the arctic fox has a white coat.



In the summer, the arctic fox has a brown coat.



14 Predict What advantage does white fur give the arctic fox in winter?

Bending the Rules

What are the exceptions to complete dominance?

The characteristics that Mendel chose to study demonstrated complete dominance, meaning that heterozygous individuals show the dominant trait. Some human traits, such as freckles and dimples, follow the pattern of complete dominance, too. However, other traits do not. For traits that show incomplete dominance or codominance, one trait is not completely dominant over another.

Incomplete Dominance

In **incomplete dominance**, each allele in a heterozygous individual influences the phenotype. The result is a phenotype that is a blend of the phenotypes of the parents. One example of incomplete dominance is found in the snapdragon flower, shown below. When a true-breeding red snapdragon is crossed with a true-breeding white snapdragon, all the offspring are pink snapdragons. Both alleles of the gene have some influence. Hair texture is an example of incomplete dominance in humans. A person with one straight-hair allele and one curly-hair allele will have wavy hair.

Pink snapdragons are produced by a cross between a red snapdragon and a white snapdragon.



Active Reading

15 Identify As you read, underline examples of incomplete dominance and codominance.

Visualize It!

16 Analyze How can you tell that these snapdragons do not follow the pattern of complete dominance?

Codominance

For a trait that shows **codominance**, both of the alleles in a heterozygous individual contribute to the phenotype. Instead of having a blend of the two phenotypes, heterozygous individuals have both of the traits associated with their two alleles. An example of codominance is shown in the genes that determine human blood types. There are three alleles that play a role in determining a person's blood type: A, B, and O. The alleles are responsible for producing small particles on the surface of red blood cells called antigens. The A allele produces red blood cells coated with A antigens. The B allele produces red blood cells coated with B antigens. The O allele does not produce antigens. The A and B alleles are codominant. So, someone with one A allele and one B allele will have blood cells that are coated with A antigens and B antigens. This person would have type AB blood.

Think Outside the Book **Inquiry**

17 Research Blood type is an important factor when people give or receive blood. Research the meanings of the phrases "universal donor" and "universal recipient." What are the genotypes of each blood type?

Active Reading **18 Identify** What antigens coat the red blood cells of a person with type AB blood?

Visualize It!

19 Predict The color of these imaginary fish is controlled by a single gene. Sketch or describe their offspring if the phenotypes follow the pattern of complete dominance, incomplete dominance, or codominance.



Complete dominance
(Blue is dominant to yellow.)

Incomplete dominance

Codominance

How can a pedigree trace a trait through generations?

A pedigree is another tool used to study patterns of inheritance. A **pedigree** traces the occurrence of a trait through generations of a family. Pedigrees can be created to trace any inherited trait—even hair color!

Pedigrees can be useful in tracing a special class of inherited disorders known as *sex-linked disorders*. Sex-linked disorders are associated with an allele on a sex chromosome. Many sex-linked disorders, such as hemophilia and colorblindness, are caused by an allele on the X chromosome. Women have two X chromosomes, so a woman can have one allele for colorblindness without being colorblind. A woman who is heterozygous for this trait is called a *carrier*, because she can carry or pass on the trait to her offspring. Men have just one X chromosome. In men, this single chromosome determines if the trait is present.

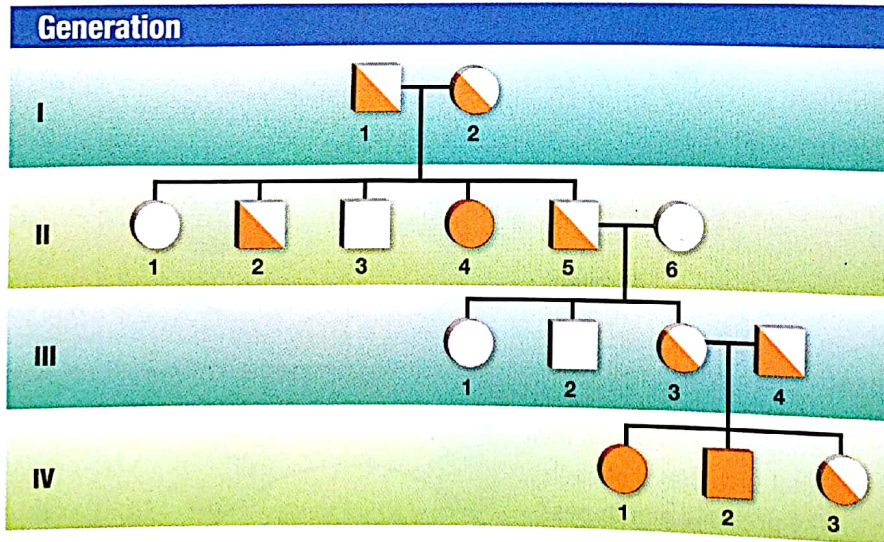
The pedigree below traces a disease called *cystic fibrosis*. Cystic fibrosis causes serious lung problems. Carriers of the disease have one recessive allele. They do not have cystic fibrosis, but they are able to pass the recessive allele on to their children. If a child receives a recessive allele from each parent, then the child will have cystic fibrosis. Other genetic conditions follow a similar pattern.

Think Outside the Book Inquiry

10 Design Create a pedigree chart that traces the occurrence of dimples in your family or in the family of a friend. Collect information for as many family members as you can.

Visualize It!

Pedigree for Cystic Fibrosis



□ Males ○ Females

Vertical lines connect children to their parents.

■ or ● A solid square or circle indicates that the person has a certain trait.

◻ or ◐ A half-filled square or circle indicates that the person is a carrier of the trait.

11 Analyze Does anyone in the third generation have cystic fibrosis? Explain.

12 Calculate What is the probability that the child of two carriers will have cystic fibrosis?

Visual Summary

To complete this summary, circle the correct word or phrase. Then use the key below to check your answers. You can use this page to review the main concepts of the lesson.

Heredity

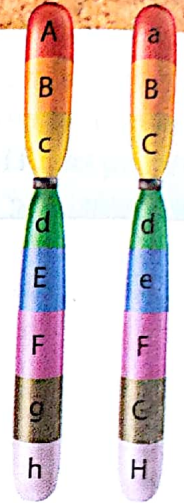
Gregor Mendel studied patterns of heredity in pea plants.



20 Traits that seemed to disappear in Mendel's first-generation crosses were dominant / recessive traits.

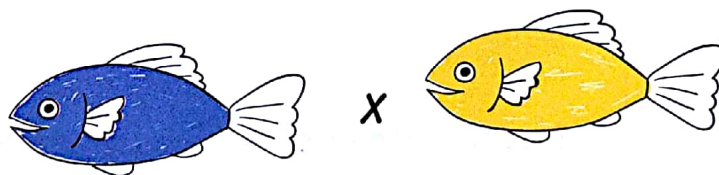
Inherited genes influence the traits of an individual.

21 An individual with the genotype BB is heterozygous / homozygous.



Phenotypes can follow complete dominance, incomplete dominance, or codominance.

22 When these imaginary fish cross, their offspring are all green. This is an example of codominance / incomplete dominance.



Answers: 20 recessive; 21 homozygous; 22 Incomplete dominance

23 **Apply** If a child has blonde hair and both of her parents have brown hair, what does that tell you about the allele for blonde hair?

Lesson Review

Vocabulary

Draw a line to connect the following terms to their definitions.

- 1 heredity **A** an organism's appearance or other detectable characteristic
- 2 gene **B** a section of DNA that contains instructions for a particular characteristic
- 3 phenotype **C** the passing of genetic material from parent to offspring

Key Concepts

4 Describe What did Mendel discover about genetic factors in pea plants?

5 Describe What is the role of DNA in determining an organism's traits?

6 Apply Imagine that a brown horse and a white horse cross to produce an offspring whose coat is made up of some brown hairs and some white hairs. Which pattern of dominance is this an example of?

7 Identify Give an example of a trait that is controlled by more than one gene.

Use this diagram to answer the following questions.



8 Identify What is the genotype at the Q gene?

9 Apply For which genes is this individual heterozygous?

Critical Thinking

10 Describe Marfan syndrome is a genetic disorder caused by a dominant allele. Describe how Marfan syndrome is inherited.

11 Describe Jenny, Jenny's mom, and Jenny's grandfather are all good basketball players. Give an example of an inherited trait and an acquired trait that could contribute to their skill at basketball.
