

4.1

KEY CONCEPT

Living things inherit traits in patterns.



BEFORE, you learned

- Life comes from life
- Cells contain chromosomes
- Some organisms reproduce with asexual reproduction



NOW, you will learn

- How genes for traits are passed from parent to offspring
- About discoveries made by Gregor Mendel
- About dominant and recessive alleles

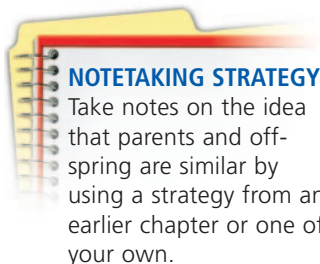
VOCABULARY

sexual reproduction
p. 102
gene p. 102
heredity p. 102
allele p. 103
phenotype p. 106
genotype p. 106
dominant p. 107
recessive p. 107

THINK ABOUT

What characteristics might be inherited?

Make a list of characteristics you can observe about the girl in the photograph to the right. Perhaps your list includes the fact that she has pale skin, or that she can read. Some of these characteristics are qualities or abilities learned or acquired from the environment around her. However, some of the characteristics were probably inherited from her parents. Of the characteristics on your list, which do you think were inherited and which do you think were acquired?



NOTETAKING STRATEGY

Take notes on the idea that parents and offspring are similar by using a strategy from an earlier chapter or one of your own.

Parents and offspring are similar.

You are an individual who has a unique combination of characteristics. These characteristics are also known as traits. Many of your traits may resemble those your parents have, including your hair color, eye color, and blood type. These characteristics are called inherited traits.

Some traits are acquired, not inherited. An acquired trait is developed during your life. Learned behaviors are one type of acquired trait. 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.

Some acquired traits are not learned but result from interaction with the environment. Skin color, for example, has both an inherited component and an environmental one. The skin color of many light-skinned people darkens when they are exposed to the Sun.



CHECK YOUR READING

How are inherited traits and acquired traits different? Give one example of each.



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Find out more about sexual reproduction.

In this chapter, you will learn about inheritance that happens through sexual reproduction. During **sexual reproduction** a cell containing genetic information from the mother and a cell containing genetic information from the father combine into a completely new cell, which becomes the offspring. You will learn more about the mechanics of sexual reproduction in Section 4.3.

Genes are on chromosome pairs.

Inherited traits are controlled by the structures, materials, and processes you learned about in Chapters 1 and 2. In turn, these structures, materials, and processes are coded for by genes. A **gene** is a unit of heredity that occupies a specific location on a chromosome and codes for a particular product. **Heredity** is the passing of genes from parents to offspring.

Individuals inherit their genes from their parents. The genes code for the expression of traits. It is important to understand that an

organism does not inherit the traits themselves from its parents. It inherits the genes that code for the traits it has. Most traits are not coded for by just one gene. Some characteristics are affected by many genes in complicated ways. We have much to learn about which genes might affect which characteristics.

In most eukaryotes, cells contain pairs of chromosomes, with one chromosome of each pair coming from each of two parents. The chromosomes in a pair are called homologs. They resemble each other, having the same size and shape, and carrying genetic information for particular traits.

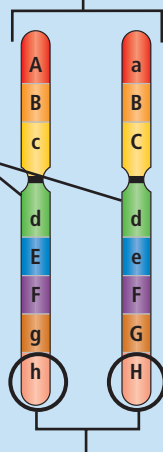
On each homolog are sites where specific genes are located. Let us say, for example, that the gene that determines

Chromosomes and Genes

The letters on the pair of chromosomes below represent alleles.

Chromosomes come in pairs. Each member in a pair is called a homolog.

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



Alleles are alternate forms of the same gene.

whether or not a plant is tall is located at place A on a pair of homologs. Though both homologs have the gene for height at site A, the genes may not be identical. They may be variations instead. The various forms of the same gene are called **alleles** (uh-LEELZ).

Thus, the homolog from one parent might have an allele for regular height at site A, while the gene from the other parent might have an allele for short height at site A. The alleles on a pair of homologs may or may not be different. Though any one plant can have only two alleles of a gene, there can be many alleles for a particular gene within a population.

CHECK YOUR READING

What are alleles?

READING TIP

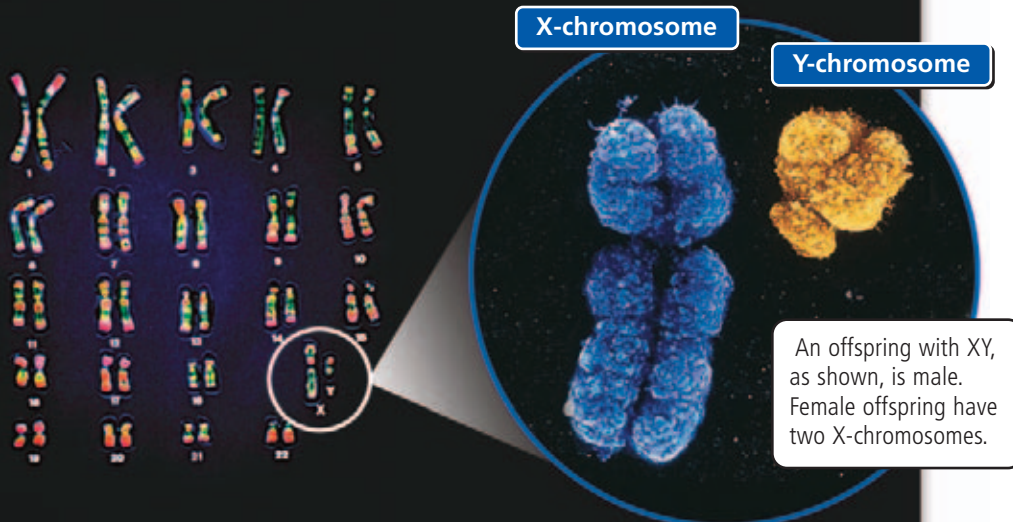
The word *homolog* comes from the Greek words *homos*, which means "same," and *logos*, which means "proportion."

Each species has a characteristic number of chromosomes. Chimpanzees have 24 pairs of chromosomes, for a total of 48 chromosomes. Fruit flies have 4 pairs of chromosomes, or 8 in all. Humans have 23 pairs, for a total of 46 chromosomes. Scientists refer to chromosomes by their number. Human chromosomes are numbered 1 through 22; the 23rd pair are the sex chromosomes.

In humans, the sex chromosomes are called the X-chromosome and the Y-chromosome. A human female has two X-chromosomes, while a human male has one X-chromosome and one Y-chromosome. In addition to determining the sex of an offspring, the X- and Y-chromosomes contain important genes, just as the other, numbered chromosomes do.

Human Chromosomes

Humans have 23 pairs of chromosomes, for a total of 46. One of these pairs, shown below, determines the sex of the offspring.



Gregor Mendel made some important discoveries about heredity.

The first major experiments investigating heredity were performed by a monk named Gregor Mendel, who lived in Austria during the mid-1800s. Before Mendel became a monk, he attended university and received training in science and mathematics. This training served him well when he began investigating the inheritance of traits among the pea plants in the monastery's garden.

READING TIP

The root of the word *trait* means to “draw out.” It was originally used in the sense of drawing out a line. This same idea works in heredity if you think of drawing a connection between parents and offspring.

Mendel took very detailed notes, carefully recording all the data from his many experiments. He worked with seven different traits: plant height, flower and pod position, seed shape, seed color, pod shape, pod color, and flower color. He studied each trait separately, always starting with plants that were true-breeding for that one particular trait. A true-breeding plant is one that will always produce offspring with a particular trait when allowed to self-pollinate.

One Example

In his experiments with plant height, Mendel took two sets of plants, one true-breeding for plants of regular height and the other true-breeding for plants of short or dwarf height.

- 1 Instead of letting the plants self-pollinate as they do naturally, he deliberately paired as parents one plant from each set. Mendel called the plants that resulted from this cross the first generation. All of the plants from this first generation were of regular height. The dwarf-height trait seemed to have disappeared entirely.
- 2 Mendel then 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 were of regular height, but about one fourth were of dwarf height. So the trait that seemed to disappear in the first generation reappeared in the second generation.

Mendel's experiments with other traits showed similar patterns.



Summarize the pattern shown in Mendel's experiments with plant height.

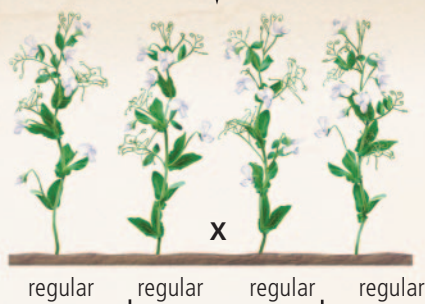
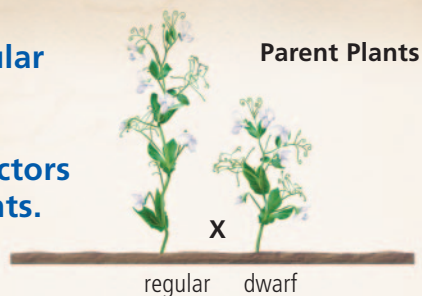
Mendel's Conclusions

Mendel drew upon his knowledge of mathematics while analyzing his data in order to suggest a hypothesis that would explain the patterns he observed. Mendel realized that each plant must have two “factors” for each possible trait, one factor from each parent. Some traits, such as dwarf height, could be masked—dwarf height could be seen in the

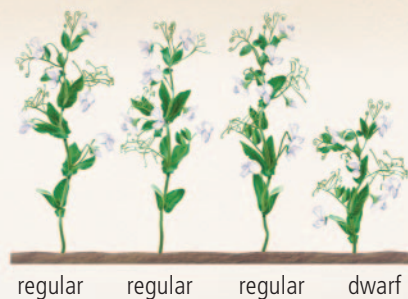
Mendel's Pea Plants

Mendel observed variation in the height of pea plants (regular or dwarf height). By crossing plants with specific traits, he deduced that offspring get factors for each trait from both parents.

- 1 First generation** Crossing a true-breeding regular pea plant with a true-breeding dwarf pea plant produces all regular pea plants in the first generation.



- 2 Second generation** Allowing the first generation pea plants to self-pollinate resulted in about three-fourths regular pea plants and one-fourth dwarf pea plants.



plant only if both of the plant's factors were for dwarf height. All of the plants in the first generation had one dwarf factor and one regular factor. A plant with one dwarf-height factor and one regular-height factor would be of regular height, because the regular-height factor masks the dwarf-height factor.

Later experiments allowed Mendel to draw a number of other conclusions about how these factors are distributed. Since the mid-1800s, Mendel's experiments and conclusions have been the basis for most of the scientific thought about heredity. Those things he called "factors" are what we now call genes and alleles.



How many factors or genes does each plant have for each possible trait?

Alleles interact to produce traits.

The pea-plant traits Gregor Mendel chose to study were all controlled by single genes, and each of the genes was on a different chromosome. As you learned earlier, most traits are not controlled by only one gene. However, simple examples such as Mendel's peas do help us better understand heredity.

READING TIP

The word *phenotype* and *phenomenon* have a similar root word meaning "to appear."

VOCABULARY

Make word magnet diagrams for the terms *phenotype* and *genotype*.



Phenotype and Genotype

What color eyes do you have? The eye color you see when you look in the mirror is your phenotype. An organism's **phenotype** describes the actual characteristics that can be observed. Your height, the size of your feet, the presence or absence of a fold in your eyelids—all are observable traits and are part of your phenotype.

By contrast, the genes that control the development of eyefolds are part of your genotype. **Genotype** is the name for the genes an organism has. Your genotype is not always obvious from your phenotype. If you have eyefolds, your genotype definitely contains at least one eyefold-producing allele. But it may also have one allele for no eyefolds. Sometimes your genes contain information that is not expressed in your phenotype.



Which term describes characteristics that can be observed?



COMPARE The photograph above shows **phenotypes** of the eyefold gene. A person with eyefolds is shown to the left, a person without eyefolds to the right.

Dominant and Recessive Alleles

The eyefold gene, which controls the development of folds in the eyelids, has two alleles: eyefolds and no-eyefolds. If you have even one copy of the allele for eyefolds, you will have eyefolds. This happens because the allele that codes for eyefolds is dominant. A **dominant** allele is one that is expressed in the phenotype even if only one copy is present in the genotype—that is, even if the other allele is an alternative form.

Suppose your genotype contains a no-eyefolds allele. The no-eyefolds allele is recessive. A **recessive** allele is one that is expressed in the phenotype only when two copies of it are present on the homologs. If one chromosome in the pair contains a dominant allele and the other contains a recessive allele, the dominant allele will be expressed in your phenotype. If you do not have eyefolds, it is because you got two no-eyefolds genes—one from each parent.

The interaction of dominant and recessive alleles means that it is possible for two brown-haired parents to have a blond child.

CHECK YOUR READING

Under what conditions is a recessive allele expressed in an offspring's phenotype?

Hair color is determined by multiple genes, can be affected by the environment, and sometimes changes over time. However, in some cases it has a dominant-recessive pattern similar to that of the eyefold gene. As in the family shown at right, parents who both have brown hair can have a blond child. The allele for brown hair is dominant, so if both parents have alleles for both brown hair and blond hair, the brown-hair allele is more likely to be expressed. Their child, however, could have two blond-hair alleles (one from each parent) and therefore have blond hair instead of brown.



4.1 Review

KEY CONCEPTS

1. Explain the difference between acquired and inherited traits.
2. Describe the conclusions that Mendel drew from his experiments with pea plants.
3. What type of alleles are expressed only if two identical copies exist on the homologs of the offspring?

CRITICAL THINKING

4. **Compare and Contrast** What is the difference between a genotype and a phenotype?
5. **Analyze** Explain why a person with an allele for a particular trait may not have a phenotype that shows the trait.

CHALLENGE

6. **Apply** In guinea pigs, the allele for black fur is dominant over the allele for brown fur. If you had two parent guinea pigs, each with brown fur, what color fur might the offspring have, and why?