6.4 Traits, Genes, and Alleles

KEY CONCEPT Genes encode proteins that produce a diverse range of traits.

MAIN IDEAS

- The same gene can have many versions.
- Genes influence the development of traits.

VOCABULARY

gene, p. 180
allele, p. 180
homozygous, p. 180
heterozygous, p. 180
genome, p. 181
genotype, p. 181
phenotype, p. 181
dominant, p. 181
recessive, p. 181

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Connect Most things come in many forms. Bread can be wheat, white, or rye. Cars can be two-door, four-door, hatchback, or convertible. Even the variety of potatoes cannot be counted on two hands. Genes, too, come in many forms.

MAIN IDEA

The same gene can have many versions.

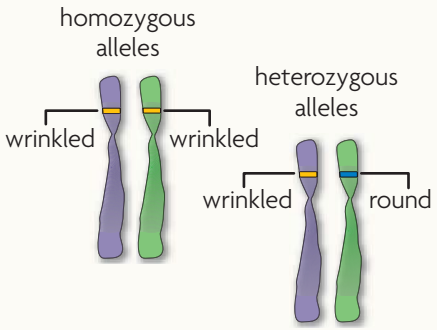
As you have learned, Mendel's discrete units of heredity are now called genes. But what are genes? You can think of a **gene** as a piece of DNA that provides a set of instructions to a cell to make a certain protein. This definition is not precise, but it gives you the main idea. Each gene has a locus, a specific position on a pair of homologous chromosomes. Just as a house is a physical structure and an address tells where that house is located, you can think of the locus as the "address" that tells where a gene is located on a chromosome.

Most genes exist in many forms. In Mendel's experiments, the effects of these different forms were easy to see: yellow or green, round or wrinkled. An **allele** (uh-LEEL) is any of the alternative forms of a gene that may occur at a specific locus. Your cells have two alleles for each gene, one on each of the homologous chromosomes on which the locus for that gene is found. Each parent gives one allele. The two alleles may be the same, or they may be different. The term **homozygous** (HOH-moh-ZY-guhs) describes two of the same alleles at a specific locus. For example, both might code for white flowers. The term **heterozygous** (HEHT-uhr-uh-ZY-guhs) describes two different alleles at a specific locus. Thus, one might code for white flowers, the other for purple flowers.

Compare and Contrast **Distinguish between the terms *locus* and *allele*.**

VISUAL VOCAB

Homozygous alleles are identical to each other.



Heterozygous alleles are different from each other.

A plant's genotype might be homozygous dominant (*TT*), heterozygous (*Tt*), or homozygous recessive (*tt*).

Animated BIOLOGY
Explore how genotype affects phenotype at ClassZone.com.

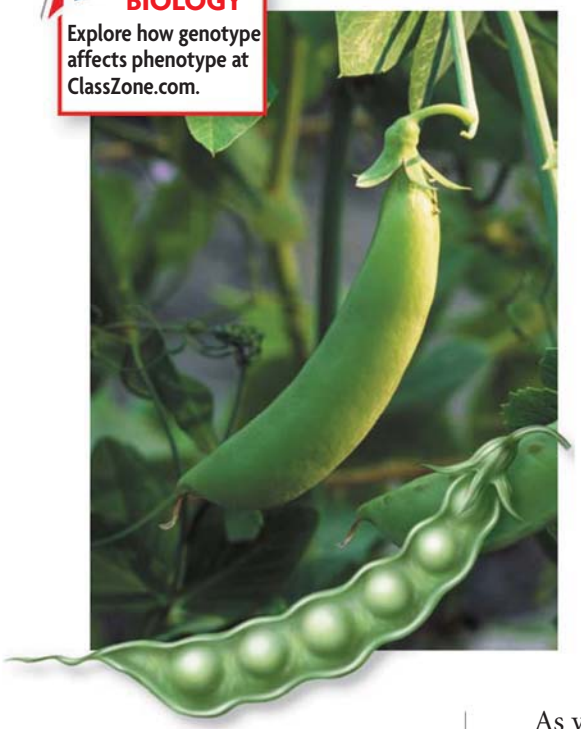


FIGURE 6.12 Both the homozygous dominant and heterozygous genotypes result in smooth, or inflated, pods (top). Only the homozygous recessive genotype results in constricted pods (inset).

Alleles and Phenotype

Because some alleles are dominant over others, two genotypes can produce the dominant phenotype. For example, smooth pods and constricted pods in pea plants, shown in **FIGURE 6.12**, are phenotypes. A plant with smooth pods could have a homozygous dominant (*SS*) or heterozygous (*Ss*) genotype. In contrast, a plant with constricted, or compressed, pods could only have a homozygous recessive (*ss*) genotype.

What actually makes one allele dominant over another? The answer is very complicated. It depends on the nature of the protein that is, or is not, made. Let's look at a fairly simple example. Pigment gives cells color. If *P* directs flower cells to make pigment, the flower may look purple. If *p* directs the cells not to make pigment, the flower looks white. So *P* codes for pigment to be present, but *p* codes for nothing, the absence of pigment. As a result, *P* has to be dominant. Even if the flower has only one *P* allele (*Pp*), that one allele tells its cells to make pigment, and the flower has color. Flower pigment is only one example. Many factors make one allele dominant over another.

As you know, most plants are not simply tall or short. Most flowers are not just white or purple. Most traits occur in a range. Other factors also affect traits. A lack of sunshine or vital nutrients could stunt a plant's growth. How does genetics account for these issues? Mendel studied traits that follow simple dominant-recessive patterns of inheritance, and each trait was the result of a single gene. In general, however, inheritance is much more complex. Most alleles are not simply dominant or recessive; some are codominant. Many traits are influenced by multiple genes. The environment also interacts with genes and affects their expression. These complexities are discussed in Chapter 7.

Contrast **Explain the difference between genotype and phenotype.**

6.4 ASSESSMENT

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REVIEWING MAIN IDEAS

1. How are the terms **gene,** locus, and **allele** related?
2. Explain why an organism's genotype may be **homozygous** dominant, homozygous recessive, or **heterozygous,** but never heterozygous recessive.

CRITICAL THINKING

3. **Apply** Suppose you are studying a fruit fly's DNA and you discover a gene for antenna length on chromosome 2. What word describes its location, and where would it be found in other fruit flies' DNA?
4. **Predict** If a **recessive** allele helps an organism reproduce, but the **dominant** allele hinders reproduction, which will be more common in a population?

Connecting CONCEPTS

5. **Human Biology** Cystic fibrosis is a recessive disease that causes the production of abnormally thick, life-threatening mucus secretions. What is the **genotype** of a person with cystic fibrosis: *CC*, *Cc*, or *cc*? Explain.

MAIN IDEA

Genes influence the development of traits.

You may have heard about the Human Genome Project. Its goal was to find out the sequence of the 3 billion nucleotide pairs that make up a human's genome. A **genome** is all of an organism's genetic material. Unless you have an identical twin, you have a unique genome that determines all of your traits. Some of your traits can be seen, such as the color of your eyes. Other traits cannot be seen, such as the exact chemical makeup of your eyeball.

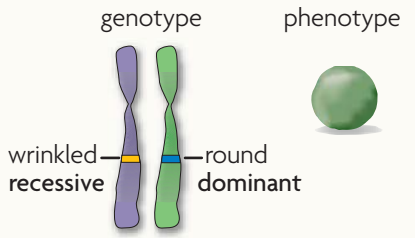
In genetics, we often focus on a single trait or set of traits. A genome is all of an organism's genes, but a **genotype** (JEHN-uh-TYP) typically refers to the genetic makeup of a specific set of genes. The genotype of a pea plant includes both of the genes that code for flower color, even if one of these genes is masked. In contrast, the physical characteristics, or traits, of an individual organism make up its **phenotype** (FEE-nuh-TYP). A pea plant with purple flowers has a phenotype for purple flowers. The plant might have a hidden gene for white flowers, but that does not matter to its phenotype.

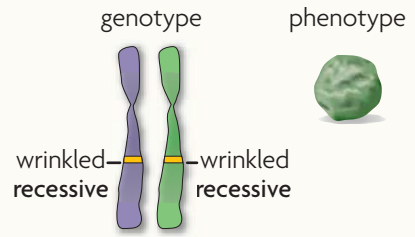
Dominant and Recessive Alleles

If an organism is heterozygous for a trait, which allele will be expressed? That is, if a plant has one allele for purple flowers and one for white flowers, what color will the flowers be? As Mendel learned, one allele may be dominant over another allele. A **dominant** allele is the allele that is expressed when two different alleles or two dominant alleles are present. A **recessive** allele is the allele that is only expressed when two copies are present. In Mendel's experiments, the allele for purple flowers was dominant to the allele for white flowers. All F_1 plants were purple even though they had only one allele for purple flowers.

VISUAL VOCAB

A **dominant** allele is expressed when two different alleles are present.





A **recessive** allele is expressed only when two copies are present.

FIGURE 6.11 Polydactyly is the condition of having more than the typical number of fingers or toes. The allele for polydactyly is dominant.

Sometimes the word *dominant* is misunderstood. A dominant allele is not necessarily better or stronger than a recessive allele. It does not necessarily occur most often in the population. An allele is dominant in a heterozygote simply because it is expressed and the other allele is not.

Alleles are often represented on paper with individual letters. An organism's genotype for a trait can be shown with two letters—one per allele. Uppercase letters are used for dominant alleles, and lowercase letters are used for recessive alleles. For example, the dominant allele for height in pea plants is written as *T*, for tall. The recessive allele for short plants is written as *t*.

Connecting CONCEPTS

Exceptions to Mendel's Laws Mendel's theory of inheritance cannot explain all patterns of inheritance. As you will learn in **Chapter 7,** incomplete dominance, codominance, polygenic traits, and environmental influences all provide exceptions.