

# Genetics

## Understanding Inheritance

### ..... Before You Read .....

#### Key Concepts

- What determines the expression of traits?
- How can inheritance be modeled?
- How do some patterns of inheritance differ from Mendel’s model?

**What do you think?** Read the two statements below and decide whether you agree or disagree with them. Place an A in the Before column if you agree with the statement or a D if you disagree. After you’ve read this lesson, reread the statements to see if you have changed your mind.

Before	Statement	After
	3. All inherited traits follow Mendel’s patterns of inheritance.	
	4. Scientists have tools to predict the form of a trait an offspring might inherit.	

### ..... Read to Learn .....


#### What controls traits?

Mendel concluded that two factors control each trait. One factor comes from the egg cell and one factor comes from the sperm cell. What are these factors? How are they passed from parents to offspring?

#### Chromosomes

Inside each cell is a nucleus that has threadlike structures called chromosomes. Chromosomes contain genetic information that controls traits. What Mendel called “factors” are parts of chromosomes. Each cell in an offspring contains chromosomes from both parents. These chromosomes exist in pairs—one chromosome from each parent.

#### Genes and Alleles

Each chromosome can have information about hundreds or thousands of traits. A **gene** (JEEN) is a section on a chromosome that has genetic information for one trait. For example, a gene of a pea plant might have information about flower color. An offspring inherits two genes (factors) for each trait, one from each parent. The genes can be the same or different, such as purple or white for pea flower color. The different forms of a gene are called **alleles** (uh LEELS). Pea plants can have two purple alleles, two white alleles, or one of each allele. 

#### Study Coach

**Build Vocabulary** Skim this lesson and circle any words you do not know. After you’ve read the lesson, review the circled words. Look up the definitions in the dictionary for any words you cannot define.

#### Reading Check

**1. Identify** How many alleles controlled flower color in Mendel’s experiments?


## Genotype and Phenotype

Geneticists call how a trait appears, or is expressed, the trait's **phenotype** (FEE nuh tipe). A person's eye color is an example of phenotype. The trait of eye color can be expressed as blue, brown, green, or other colors.

Mendel concluded that two alleles control the expression or phenotype of each trait. *The two alleles that control the phenotype of a trait are called the trait's **genotype** (JEE nuh tipe).* You cannot see an organism's genotype. But you can make guesses about a genotype based on its phenotype. For example, you have already learned that a pea plant with white flowers has two recessive alleles for that trait. These two alleles are its genotype. The white flower is its phenotype.

**Symbols for Genotype** Scientists use symbols to represent the alleles in a genotype. The table below shows the possible genotypes for both round and wrinkled seed phenotypes. Uppercase letters represent dominant alleles and lowercase letters represent recessive alleles. The dominant allele, if present, is written first.

The round pea seed can have either of these two genotypes— $RR$  or  $Rr$ . Both genotypes have a round phenotype.  $Rr$  results in round seeds because the round allele ( $R$ ) is dominant to the wrinkled allele ( $r$ ).

The wrinkled pea can have only one genotype— $rr$ . The wrinkled phenotype is possible only when two recessive alleles ( $rr$ ) are present in the genotype. 

**Homozygous and Heterozygous** *When the two alleles of a gene are the same, its genotype is **homozygous** (hoh muh ZI gus).* Both  $RR$  and  $rr$  are homozygous genotypes. The  $RR$  genotype has two dominant alleles. The  $rr$  genotype has two recessive alleles.

*If the two alleles of a gene are different, its genotype is **heterozygous** (he tuh roh ZI gus).*  $Rr$  is a heterozygous genotype. It has one dominant and one recessive allele.

Phenotype and Genotype	
Phenotype (observed traits)	Genotype (alleles of a gene)
Round	Homozygous dominant ( $RR$ )
	Heterozygous ( $Rr$ )
Wrinkled	Homozygous recessive ( $rr$ )



### Think it Over

**2. Draw Conclusions** In a pea plant, an allele for a tall stem is dominant to an allele for a short stem. You see a pea plant with a short stem. What can you conclude about the genotype of this plant?

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### Key Concept Check

**3. Explain** How do alleles determine the expression of traits?

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### Interpreting Tables

**4. Identify** the genotype of a plant that produces a wrinkled pea.

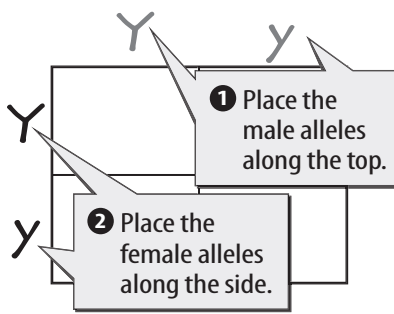
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## Visual Check

**5. Specify** What phenotypes are possible for pea offspring of this cross?

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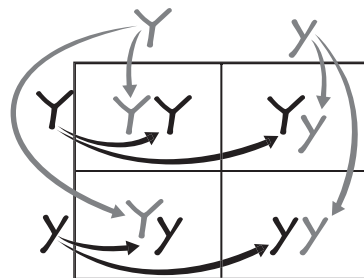


## Modeling Inheritance

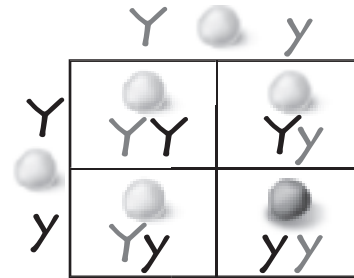
Plant breeders and animal breeders use two tools to help them predict how often traits will appear in offspring. These tools, Punnett squares and pedigrees, can be used to predict and identify traits among genetically related individuals.

### Punnett Squares

If the genotypes of the parents are known, then the different genotypes and phenotypes of the offspring can be predicted. A **Punnett square** is a model used to predict possible genotypes and phenotypes of offspring. Follow the steps shown below to learn how to make a Punnett square.



3 Copy female alleles across each row. Copy male alleles down each column.



**Analysis** The ratio of phenotypes is 3:1, yellow:green. The ratio of genotypes is 1:2:1, YY:Yy:yy.

## Think it Over

**6. Apply** If the cross shown in the figure produced 100 offspring, about how many offspring would have green peas?

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## Reading Check

**7. Interpret** What does the ratio 3:1 mean?

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### Analyzing a Punnett Square

The figure shows a cross between two pea plants that are heterozygous for seed color— $Yy$  and  $Yy$ . Yellow is the dominant allele— $Y$ . Green is the recessive allele— $y$ . The offspring can have one of three genotypes— $YY$ ,  $Yy$ , or  $yy$ . The ratio of genotypes is written as 1:2:1.

Because  $YY$  and  $Yy$  represent the same phenotype (yellow), the offspring can have one of only two phenotypes—yellow or green. The ratio of phenotypes is written 3:1. About 75 percent of the offspring of the cross between two heterozygous plants will produce yellow seeds. About 25 percent of the plants will produce green seeds.

### Using Ratios to Predict

A 3:1 ratio means that an offspring of heterozygous parents has a 3:1 chance of having yellow seeds. It does not mean that any group of four offspring will have three plants with yellow seeds and one with green seeds. This is because one offspring does not affect the phenotype of other offspring. But if you examine large numbers of offspring from a particular cross, as Mendel did, the overall ratio will be close to the ratio predicted by a Punnett square. ✓



## Multiple Alleles

Unlike the genes in Mendel's pea plants, some genes have more than two alleles, or multiple alleles. Human ABO blood type is an example of a trait that is determined by multiple alleles. There are three alleles for the ABO blood type— $I^A$ ,  $I^B$ , and  $i$ . The way the alleles combine results in one of four blood types—A, B, AB, or O. The  $I^A$  and  $I^B$  alleles are codominant to each other, but they both are dominant to the  $i$  allele. Even though there are multiple alleles, a person inherits only two of these alleles, one from each parent, as shown below.

Human ABO Blood Types	
Phenotype	Possible Genotypes
Type A	$I^A I^A$ or $I^A i$
Type B	$I^B I^B$ or $I^B i$
Type O	$ii$
Type AB	$I^A I^B$

### Interpreting Tables

**10. Identify** What are the possible genotypes for blood type B?

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### ACADEMIC VOCABULARY

#### conclude

(verb) to reach a logically necessary end by reasoning

### Key Concept Check

**11. Explain** How does polygenic inheritance differ from Mendel's model?

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## Polygenic Inheritance

Mendel concluded that only one gene determined each trait. We now know that more than one gene can affect a trait. **Polygenic inheritance** occurs when multiple genes determine the phenotype of a trait. Because several genes determine a trait, many alleles affect the phenotype even though each gene has only two alleles. Therefore, polygenic inheritance has many possible phenotypes. Eye color in humans is an example of polygenic inheritance. Polygenic inheritance also determines the human characteristics of height, weight, and skin color.

## Genes and the Environment

Recall that an organism's genotype determines its phenotype. However, genes are not the only factors that can affect phenotypes. An organism's environment can also affect its phenotype. For example, the flower color of one type of hydrangea is determined by the soil in which the hydrangea plant grows. Acidic soil produces blue flowers. Basic, or alkaline, soil produces pink flowers.

For humans, healthful choices can also affect phenotype. Many genes affect a person's chances of having heart disease. However, what a person eats and the amount of exercise he or she gets can influence whether heart disease will develop.

## ..... After You Read .....

### Mini Glossary

**allele (uh LEEL):** any of the different forms of a gene

**codominance:** occurs when both alleles can be observed in a phenotype

**gene (JEEN):** a section on a chromosome that has genetic information for one trait

**genotype (JEE nuh tipe):** the two alleles that control the phenotype of a trait

**heterozygous (he tuh roh ZI gus):** an organism's genotype when the two alleles of a gene are different

**homozygous (hoh muh ZI gus):** an organism's genotype when the two alleles of a gene are the same

**incomplete dominance:** occurs when an offspring's phenotype is a blend of the parents' phenotypes

**phenotype (FEE nuh tipe):** how a trait appears or is expressed

**polygenic inheritance:** occurs when multiple genes determine the phenotype of a trait

**Punnett square:** a model used to predict possible genotypes and phenotypes of offspring

1. Review the terms and their definitions in the Mini Glossary. Compare and contrast genotype and phenotype.

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2. Complete the Punnett square below. Predict the genotypes of offspring produced by crossing a heterozygous pea plant with round seeds and a homozygous pea plant with wrinkled seeds. Round ( $R$ ) is dominant to wrinkled ( $r$ ).

	$R$	$r$
$r$	$Rr$	
$r$	$Rr$	

3. Predict the ratio of round phenotype to wrinkled phenotype in the offspring from the cross in Question 2.

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### What do you think NOW?

Reread the statements at the beginning of the lesson. Fill in the After column with an A if you agree with the statement or a D if you disagree. Did you change your mind?



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END OF  
LESSON