

SECTION 2 **Traits and Inheritance**



California Science Standards

7.2.c., 7.2.d

BEFORE YOU READ

After you read this section, you should be able to answer these questions:

- What did Mendel’s experiments tell him about heredity?
- Are there exceptions to Mendel’s laws of heredity?
- What causes differences among organisms?

STUDY TIP

Organize As you read, make combination notes. Explain genes, alleles, phenotype, and genotype in both words and pictures or diagrams.

READING CHECK

1. **Define** What is an allele?

What Did Mendel Learn About Heredity?

Mendel knew from his pea plant experiments that there must be two sets of instructions for each characteristic. All of the first-generation plants showed the dominant trait. However, they could give the recessive trait to their offspring. Today, scientists call these instructions for inherited characteristics **genes**. Offspring have two sets of genes—one from each parent.

The two sets of genes that parents give to offspring are never exactly the same. The same gene might have more than one version. The different versions of a gene are called **alleles**.

Alleles may be dominant or recessive. If a single dominant allele is present, it will mask a recessive allele. An organism can have a recessive trait only if both of its alleles for the gene are recessive. Inherited characteristics are usually identified by two letters (for example, *Aa*). Dominant alleles are identified by the capital letters (*A*). Recessive alleles are given lowercase letters (*a*).

PHENOTYPE

The genes of an organism affect its traits. The appearance of an organism is called its **phenotype**. An example of phenotype in humans is curly hair or straight hair. The phenotypes for flower color in Mendel’s pea plants were purple and white.



Purple flowers and white flowers are the two possible phenotypes for the characteristic of flower color in pea plants

READING CHECK

2. **Define** What is a phenotype?

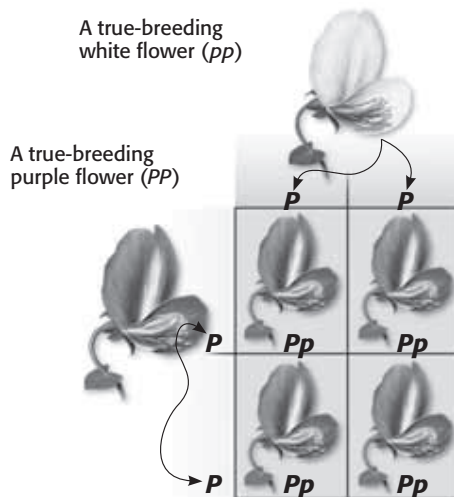
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GENOTYPE

The two alleles present for a trait make up an organism's **genotype**. A plant with two dominant or two recessive alleles (PP or pp) is said to be *homozygous*. *Homo* means "the same." A plant that has the genotype Pp is said to be *heterozygous*. *Hetero* means "different." Because the allele for purple flowers (P) is dominant, only one P allele is needed for a plant to have purple flowers. ✓

PUNNETT SQUARES

A Punnett square is used to predict the possible genotypes of offspring from certain parents. In a Punnett square, the alleles for one parent are written along the top of the square. The alleles for the other parent are written along the side of the square. The possible genotypes of the offspring are found by combining the letters at the top and side of each square.



All of the offspring for this cross have the same genotype— Pp .

The figure shows a Punnett square for a cross of two true-breeding plants. One has purple flowers and the other has white flowers. The alleles for a true-breeding purple-flowered plant are written as PP . The alleles for a true-breeding white flowered plant are written as pp . Offspring get one of their two alleles from each parent. All of the offspring from this cross will have the same genotype: Pp . Because they have a dominant allele, all of the offspring will have purple flowers.

READING CHECK

3. Identify What kind of alleles does a heterozygous individual have?

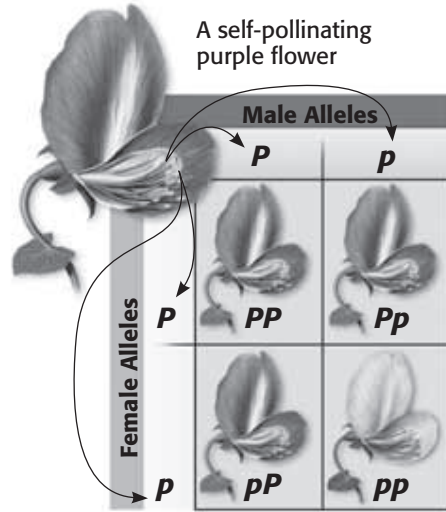
TAKE A LOOK

4. Identify Is the plant with white flowers homozygous or heterozygous? How can you tell?

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MORE EVIDENCE FOR INHERITANCE

In his next experiments, Mendel let the first-generation plants self-pollinate. He did this by covering the flowers of the plant. This way, no pollen from another plant could fertilize its eggs. The Punnett square below shows a cross of a plant with the genotype Pp that self-pollinated.



This Punnett square shows the possible results from the cross $Pp \times Pp$.

TAKE A LOOK

5. List What are the possible genotypes of the offspring in this cross?

Notice that one square shows the genotype Pp and another shows pP . These are exactly the same genotype. They both have one p allele and one P allele. The combinations PP , Pp , and pP have the same phenotype—purple flowers. This is because they all have at least one dominant allele, P . ✓

READING CHECK

6. Explain Why do the genotypes PP , Pp , and pP all have the same phenotype?

Only one combination, pp , produces plants that have white flowers. The ratio of dominant phenotypes to recessive phenotypes is 3:1. This is the same ratio Mendel found.

What Are the Chances That Offspring Will Receive a Certain Allele?

Each parent has two alleles for each gene. When it reproduces, it will pass one of them to its offspring. When these alleles are different, as in Pp , offspring are equally likely to receive either of the alleles. Think of a coin toss. When you toss the coin, there is a 50% chance you will get heads and a 50% chance you will get tails. The chance of the offspring receiving one allele or the other is as random as a coin toss.

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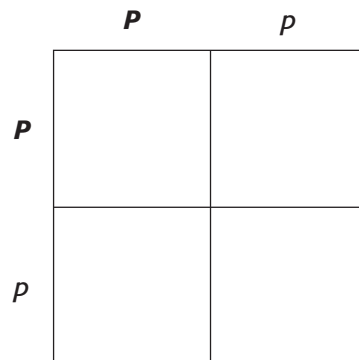
PROBABILITY

The mathematical chance that something will happen is known as **probability**. Probability is usually written as a fraction or percentage. If you toss a coin, the probability of getting tails is $1/2$, or 50%. You will get tails half of the time.

To find the probability that you will get two heads in a row, multiply the probability of tossing the first head ($1/2$) by the probability of tossing the second head ($1/2$). The probability of tossing two heads in a row is $1/4$.

GENOTYPE PROBABILITY

Finding the probability of certain genotypes for offspring is like predicting the results of a coin toss. To have white flowers, a pea plant must receive a *p* allele from each parent. Each offspring of a $Pp \times Pp$ cross has a 50% chance of receiving either allele from either parent. So, the probability of inheriting two *p* alleles is $1/2 \times 1/2$, which equals $1/4$, or 25%.



Math Focus

7. Complete Fill in the Punnett square to show the cross between two heterozygous parents. What percentage of the offspring are homozygous?

Are There Exceptions to Mendel’s Principles?

Mendel’s experiments helped show the basic principles of how genes are passed from one generation to the next. Mendel studied sets of traits such as flower color and seed shape. The traits he studied in pea plants are easy to predict because there are only two choices for each trait. ✓

Traits in other organisms are often harder to predict. Some traits are affected by more than one gene. A single gene may affect more than one trait. As scientists learned more about heredity, they found exceptions to Mendel’s principles.

READING CHECK

8. Explain Why were color and seed shape in pea plants good traits for Mendel to study?

SECTION 2 Traits and Inheritance *continued*

ONE GENE, MANY TRAITS

In Mendel’s studies, one gene controlled one trait. However, some genes affect more than one trait. For example, the genetic disorder known as sickle cell anemia is caused by an allele of a single gene. This gene carries instructions for the shape of a protein in red blood cells. When a person has an allele for sickle cell disease, this protein has the wrong shape. This causes the red blood cells to be a different shape than normal red blood cells.

Critical Thinking

9. Explain How is the gene involved in sickle cell anemia different from the genes for pea plant traits that Mendel studied?



Sickle-shaped red blood cells cannot carry oxygen as well as normal red blood cells. Also, they tend to get stuck in small blood vessels. Both the ability of the cell to carry oxygen and the ability of the cell to move through the body is affected by just one allele.

MANY GENES, ONE TRAIT

Some traits, such as the color of your skin, hair, or eyes, are the result of several genes acting together. Another characteristic affected by more than one gene is your height. In humans, different combinations of many alleles can result in a variety of heights. ✓

READING CHECK

10. Identify Give an example of a single trait that is affected by more than one gene.

IMPORTANCE OF ENVIRONMENT

Genes are not the only things that affect traits in organisms. Traits are also affected by factors in the environment. For example, human height is affected by many genes, but it is also influenced by nutrition. An individual who has plenty of food to eat may be taller than one who does not.

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Would you believe that these grasshoppers are from the same species? They have a different color pattern because they ate different food when they were young. Some grasshoppers eat certain plants that make them poisonous to predators. These grasshoppers have a yellow and black color pattern. Grasshoppers that eat other kinds of plants are not poisonous. They have a green coloration.

Do the Same Kinds of Organisms Have the Same Set of Genes?

How many genes do you have? Would you guess that you have a hundred or a thousand genes? Scientists estimate that humans have around 30,000 genes! For most genes, a person has two versions, or alleles. There are many ways these alleles can combine in a single person. One reason people look different from each other is that they do not have the same set of alleles. ✓

The differences between the sets of alleles in individuals in a population are called *genetic variation*. Genetic variation is found in many organisms. The many breeds of dogs are an example of this variation. Genetic variation in corn snakes is shown below.



Genetic variation explains why these corn snakes are different colors.

TAKE A LOOK

11. Infer One of these grasshoppers is poisonous and one is not. Circle the grasshopper you think is poisonous. Explain your answer.

READING CHECK

12. Explain What is one reason people look different from each other?

Section 2 Review

7.2.c, 7.2.d 

SECTION VOCABULARY

allele one of the alternative forms of a gene that governs a characteristic, such as hair color

gene one set of instructions for an inherited trait

genotype the entire genetic makeup of an organism; also the combination of genes for one or more specific traits

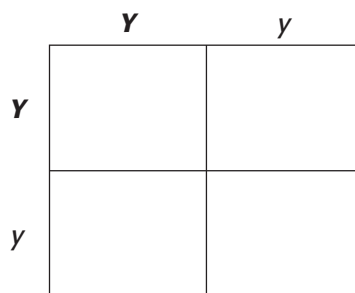
phenotype an organism's appearance or other detectable characteristic

probability the likelihood that a possible future event will occur in any given instance of the event

1. Identify Relationships How are genes and alleles related?

2. Explain How is it possible for two individuals to have the same phenotype but different genotypes for a trait?

3. Complete Mendel allowed a pea plant that was heterozygous for yellow seeds (Yy) to self-pollinate. Fill in the Punnett square below for this cross. Y identifies yellow seeds, and y identifies green seeds. What percentage of the offspring will have green seeds?



4. Discuss Why is human height an exception to Mendel's principles of heredity?
