11.1 Traits

Tyler has free earlobes like his father. His mother has attached earlobes. Why does Tyler have earlobes like his father? In this section you will learn about traits and how they are passed on to offspring. Look at your earlobes. Are they free or attached? (Figure 11.1). The type of earlobes you have is a trait that you inherited from your parents. A **trait** is a characteristic that an organism can pass on to its offspring.

Studying traits

Breeds and traits Did you know there are over 150 dog breeds, but they are all the same species (*Canis familiaris*)? A pug looks completely different than a black lab, yet they both came from the same ancestors. For thousands of years, dog breeders have selected certain traits to produce dog breeds for different purposes. People knew how to breed in order to obtain certain traits long before scientists knew about DNA, chromosomes, or meiosis.

Genetics is the study of heredity An organism's **heredity** is the set of traits it receives from its parents. **Genetics** is the study of heredity. Ancient dog breeders thought that the traits inherited by a dog were a blend of those from the mother and father. For example, a large dog crossed with a small dog in many cases would produce a medium-sized dog—a blend of both parents. It turns out that heredity is not that simple. A monk named Gregor Mendel was one of the first to find that out.

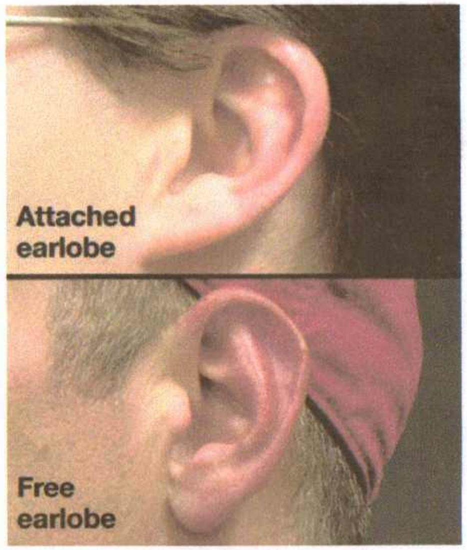


Figure 11.1: *The type of earlobes you have is a trait you inherited from your parents.*

VOCABULARY

trait - a characteristic that an organism can pass on to its offspring.

heredity - a set of traits an organism receives from its parents.

genetics - the study of heredity.

The priest and the pea

Who was Gregor Mendel?

Gregor Mendel (1822 to 1884) was an Austrian monk. He is often called the "father of genetics." Through many years of experiments in breeding pea plants, Mendel arrived at some important conclusions about inheritance. However, nobody in his lifetime (including Mendel) realized the importance of his work. It was ignored by scientists until the early 1900s. Eventually Mendel's ideas led to the science of genetics.

Gregor Mendel

Disappearing traits

Mendel worked in a garden at the monastery where he lived. Through his work, he became interested in the traits of plants and how those traits were passed on to offspring. For example, he noticed that a trait that appeared in the parent generation of plants did not show up in their offspring (the first generation), but in the second generation, the trait showed up again (Figure 11.2)! Mendel wanted to find out why. So, he decided to study inheritance in peas. Peas were a good choice because they grow quickly and are easy to breed.

Peas and pollination

Peas are flowering plants. They have male and female parts on the same plant. Flowering plants reproduce by *pollination*. During pollination, pollen containing sperm from the male part of the plant is carried to the female part of the plant called the *ovule*. Fertilization occurs when a sperm from the pollen travels to an egg in the ovule. In a pea plant, pollen can fertilize eggs on the same plant (self-pollination). Or, the pollen can be carried by the wind or an animal to another plant. Figure 11.3 shows how pollination can occur.

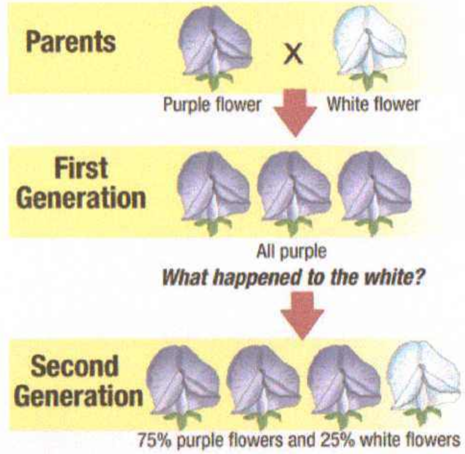


Figure 11.2: *Why do traits disappear and then reappear?*

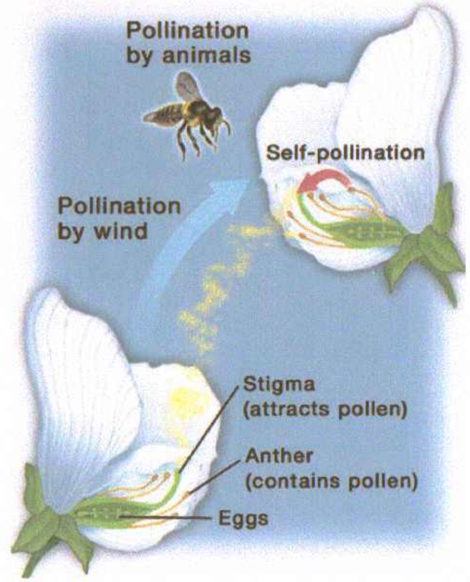


Figure 11.3: *Flowering plants reproduce by pollination.*

Mendel's experiment

Pea plant traits

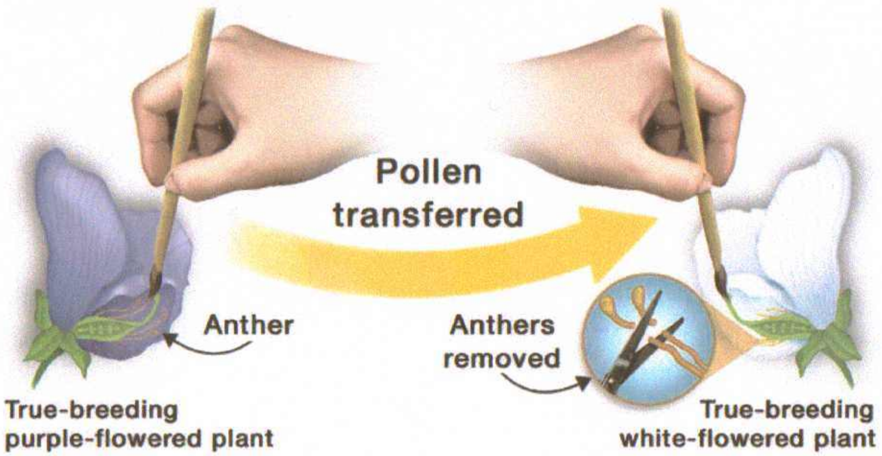
Mendel studied pea plants and identified several traits that had only two forms. For example, he observed that peas produced plants with either purple flowers or white flowers. Figure 11.4 shows four of the traits Mendel studied and their two forms.

True-breeding plants

For his experiments, Mendel was careful to start out with true-breeding plants. When a **true-breeding plant** self-pollinates, it will always produce offspring with the same form of the trait as the parent plant. For example, a true-breeding plant with purple flowers will only produce plants with purple flowers.

Mendel's procedure for his experiments

Mendel wanted to find out what would happen if he crossed two plants with different forms of a trait. He used a method called cross-pollination. In **cross-pollination**, the parts that contain pollen (anthers) are removed from one plant so it cannot self-pollinate. Next, the pollen from the other plant is used to fertilize the plant without pollen. The example below shows how Mendel crossed a purple-flowered plant with a white-flowered plant.



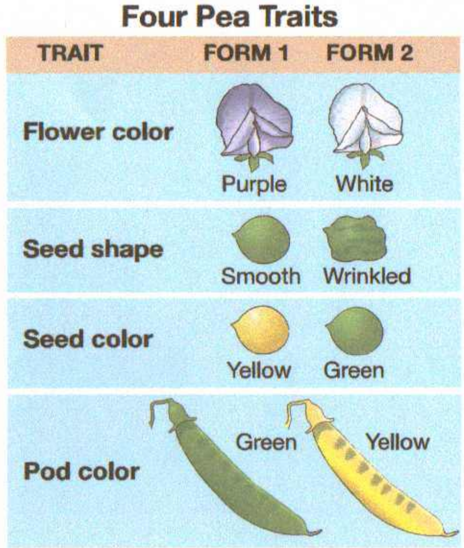


Figure 11.4: *Four of the traits Mendel studied in pea plants.*

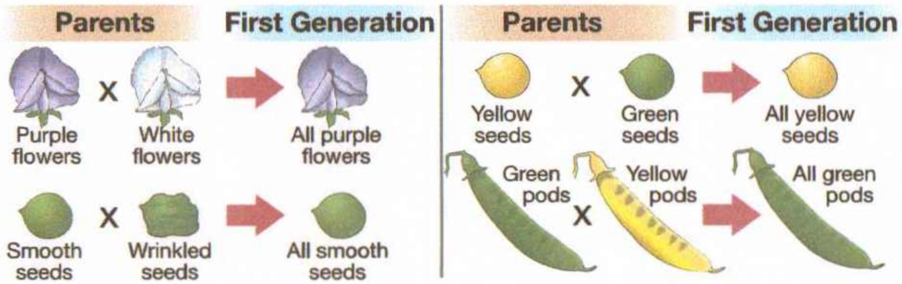
ă VOCABULARY

true-breeding plant - a plant that will always produce offspring with the same form of a trait when it self-pollinates.

cross-pollination - when the pollen from one plant is used to fertilize another plant.

The first generation

When Mendel crossed true-breeding, purple-flowered plants with true-breeding, white-flowered plants, the first generation produced all purple-flowered plants. Mendel got similar results for the other traits he studied. In each case, one form of the trait always showed up in the first generation and the other form of the trait always seemed to disappear.



The second generation

Next, Mendel allowed the first generation of plants to self-pollinate. When the purple-flowered plants of the first generation self-pollinated, white flowers showed up again in the second generation! Figure 11.5 shows Mendel's crosses with peas for the flower-color trait.

Calculating ratios

Mendel counted the plants in the second generation. He found 705 plants with purple flowers and 224 plants with white flowers. He calculated the ratio of purple-flowered plants to white-flowered plants. A *ratio* is a way to compare two numbers. Here's how to calculate the ratio of purple flowers to white flowers:

ratio symbol

1. Write as a fraction

3. Write as a ratio, rounded to the nearest whole number

$$705 \text{ purple} : 224 \text{ white} = \frac{705}{224} = \frac{(705 \div 224)}{(224 \div 224)} = \frac{3.15}{1} = 3{:}1$$

2. Divide top and bottom by the smallest number

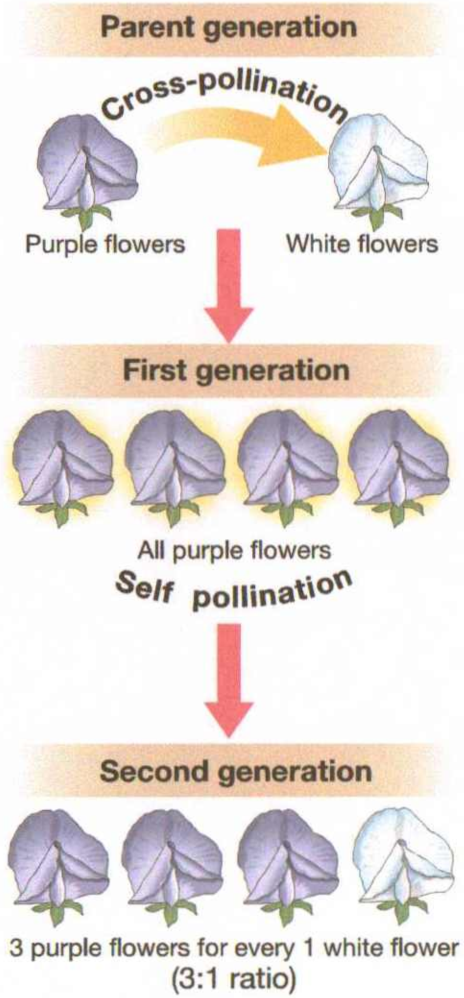


Figure 11.5: *Mendel's experiment.*

Mendel's conclusions

Second generation results Mendel got similar results for the second generation of all the traits he studied. The data from four of the traits he studied is shown in Table 11.1. For practice, calculate the ratio for the last three traits.

Table 11.1: The second generation from Mendel's peas

Trait	Form 1	Form 2	Ratio
Flower color	purple 705	white 224	3:1
Seed shape	round 5,474	wrinkled 1,850	?
Seed color	yellow 6,002	green 2,001	?
Pod color	green 428	yellow 152	?

Genes From the results, Mendel proved that all traits do not blend. For instance, purple flowers mixed with white flowers did not produce pink flowers. Mendel concluded that traits like flower color must be determined by individual *units*. Today, we call those units genes. A **gene** is a unit that determines traits.

Dominant and recessive alleles Mendel concluded that for each trait he studied, a pea plant must contain *two forms* of the same gene. Different forms of the same gene are called **alleles**. The **dominant allele** is the form of a gene that, when present, covers up the appearance of the recessive allele. The **recessive allele** is the form of a gene that is hidden when the dominant allele is present. The gene for flower color in peas has a dominant allele that causes purple flowers and a recessive allele that causes white flowers (Figure 11.6).

Alleles are different forms of the same gene. Organisms have at least two alleles for each gene—one from each parent.

VOCABULARY

gene - a unit that determines traits.

alleles - different forms of a gene.

dominant allele - the form of a gene that, when present, covers up the appearance of the recessive allele.

recessive allele - the form of a gene that is hidden when the dominant allele is present.

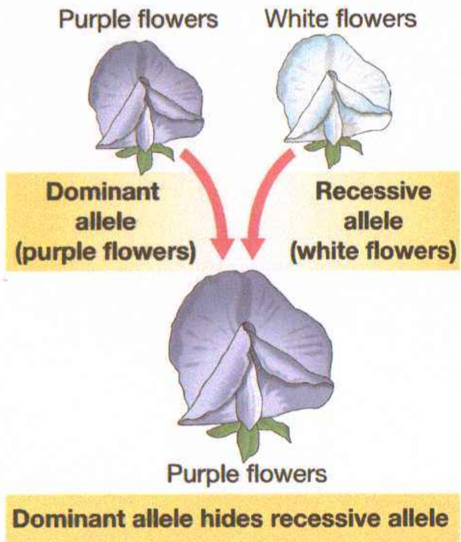


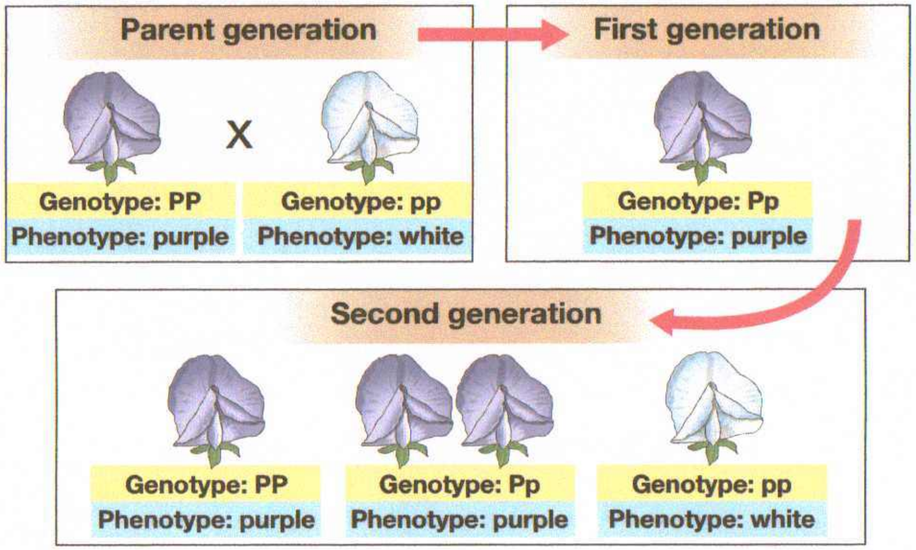
Figure 11.6: *Flower color in peas is determined by two alleles of the gene—one from each parent.*

Phenotype and genotype

An organism's **phenotype** is the form of a trait that it displays. For flower color, a pea plant can display a phenotype of purple or white flowers. An organism's **genotype** is the alleles of a gene it contains. Based on his data, Mendel concluded that a phenotype can be determined by more than one genotype.

Symbols for genes

Mendel used upper and lower case letters to symbolize the alleles of a gene. For flower color, he used upper case ***P*** for purple (the dominant allele) and lower case ***p*** for white (the recessive allele). A pea plant with purple flowers could have a genotype of either ***PP*** or ***Pp***. A pea plant with white flowers could only have a genotype of ***pp***. As long as at least one dominant allele is present, the plant will always have a phenotype of purple flowers. Figure 11.7 shows the genotypes and phenotypes of four pea plant traits. The graphic below shows the alleles present in each generation of pea plants from Mendel's experiment.



VOCABULARY

phenotype - the form of a trait that an organism displays.

genotype - the alleles of a gene an organism contains.

Flower color: Purple (P), White (p)

Genotype	Phenotype
PP	Purple
Pp	Purple
pp	White

Seed shape: Round (R), Wrinkled (r)

Genotype	Phenotype
RR	Round
Rr	Round
rr	Wrinkled

Seed color: Yellow (Y), Green (y)

Genotype	Phenotype
YY	Yellow
Yy	Yellow
yy	Green

Pod color: Green (G), Yellow (g)

Genotype	Phenotype
GG	Green
Gg	Green
gg	Yellow

Figure 11.7: *The genotypes and phenotypes of four of the traits Mendel studied in pea plants.*