6.3 Mendel and Heredity

KEY CONCEPT Mendel's research showed that traits are inherited as discrete units.

MAIN IDEAS

- Mendel laid the groundwork for genetics.
- Mendel's data revealed patterns of inheritance.

VOCABULARY

trait, p. 177
genetics, p. 177
purebred, p. 178
cross, p. 178
law of segregation, p. 179

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Connect When a magician makes a coin disappear, you know the coin has not really vanished. You simply cannot see where it is. Maybe it is up a sleeve or in a pocket. When organisms reproduce, some traits seem to disappear too. For centuries, no one could explain why. Then a careful, observant scientist showed that behind this phenomenon were inherited units, or genes.

MAIN IDEA

Mendel laid the groundwork for genetics.

When we think of how offspring resemble or differ from their parents, we typically refer to specific traits. **Traits** are distinguishing characteristics that are inherited, such as eye color, leaf shape, and tail length. Scientists recognized that traits are hereditary, or passed from one generation to the next, long before they understood how traits are passed on. **Genetics** is the study of biological inheritance patterns and variation in organisms.

The groundwork for much of our understanding of genetics was laid in the middle of the 1800s by an Austrian monk named Gregor Mendel, shown in **FIGURE 6.7.** Scientists of the time commonly thought parents' traits were blended in offspring, like mixing red and white paint to get pink paint. But this idea failed to explain how certain traits remained without being "diluted." Mendel, a shrewd mathematician, bred thousands of plants, carefully counting and recording his results. From his data, Mendel correctly predicted the results of meiosis long before chromosomes were discovered. He recognized that traits are inherited as discrete units from the parental generation, like different colored marbles mixed together that can still be picked out separately. By recognizing that organisms inherit two copies of each discrete unit, what we now call genes, Mendel also described how traits were passed between generations.

Connect Give two examples of traits not listed above.

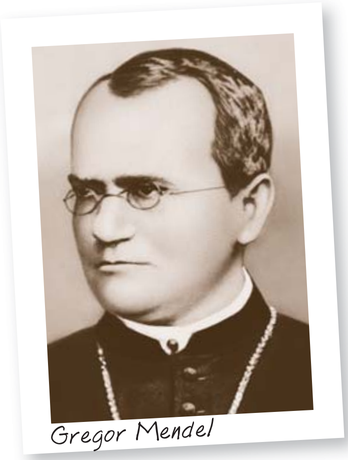


FIGURE 6.7 Gregor Mendel is called "the father of genetics" for discovering hereditary units. The significance of his work went unrecognized for almost 40 years.

MAIN IDEA

Mendel's data revealed patterns of inheritance.

Mendel studied plant variation in a monastery garden. He made three key choices about his experiments that played an important role in the development of his laws of inheritance: control over breeding, use of purebred plants, and observation of "either-or" traits that appeared in only two alternate forms.

FIGURE 6.8 MENDEL'S PROCESS

Mendel controlled the fertilization of his pea plants by removing the male parts, or stamens.

He then fertilized the female part, or pistil, with pollen from a different pea plant.

Experimental Design

Mendel chose pea plants for his experiments because they reproduce quickly, and he could easily control how they mate. The sex organs of a plant are in its flowers, and pea flowers contain both male and female reproductive organs. In nature, the pea flower typically self-pollinates; that is, the plant mates with itself. If a line of plants has self-pollinated for long enough, that line becomes genetically uniform, or **purebred.** As a result, the offspring of purebred parents inherit all of the parent organisms' characteristics. Mendel was able to mate plants with specific traits by interrupting the self-pollination process. As you can see in **FIGURE 6.8**, he removed the male parts of flowers and fertilized the female parts with pollen that contained sperm cells from a different plant. Because he started with purebred plants, Mendel knew that any variations in offspring resulted from his experiments.

Mendel chose seven traits to follow: pea shape, pea color, pod shape, pod color, plant height, flower color, and flower position. All of these traits are simple "either-or" characteristics; they do not show intermediate features. The plant is tall or short. Its peas are wrinkled or round. What Mendel did not know was that most of the traits he had selected were controlled by genes on separate chromosomes. The selection of these particular traits played a crucial role in enabling Mendel to identify the patterns he observed.

VOCABULARY

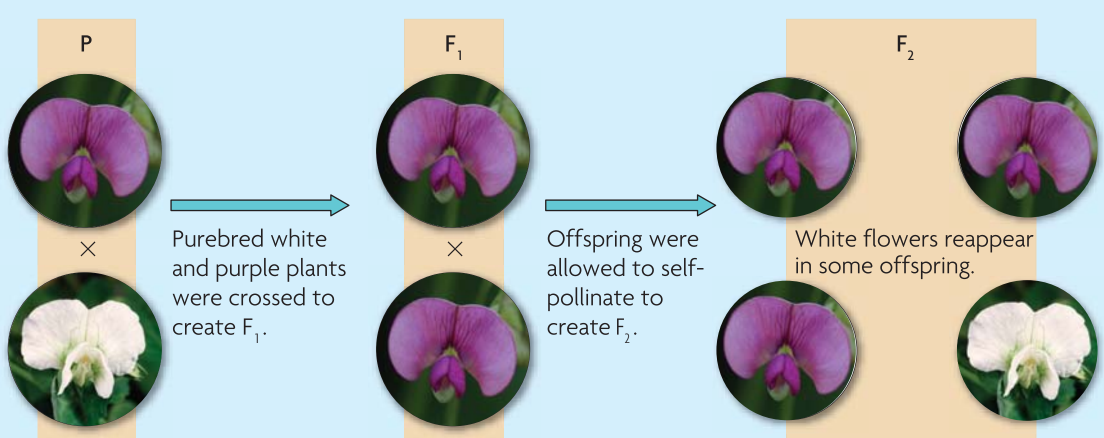
In Latin, the word *filius* means "son" and *filia* means "daughter."

Results

In genetics, the mating of two organisms is called a **cross.** An example of one of Mendel's crosses is highlighted in **FIGURE 6.9.** In this example, he crossed a purebred white-flowered pea plant with a purebred purple-flowered pea plant. These plants are the parental, or P, generation. The resulting offspring, called the first filial—or F_1—generation, all had purple flowers. The trait for white flowers seemed to disappear. When Mendel allowed the F_1 generation to self-fertilize, the resulting F_2 generation produced both plants with purple flowers and plants with white flowers. Therefore, the trait for white flowers had not disappeared; it had been hidden, or masked.

FIGURE 6.9 Mendel's Experimental Cross

Traits that were hidden when parental purebred flowers were crossed reappeared when the F_1 generation was allowed to self-pollinate.



Mendel did not cross only two plants, however; he crossed many plants. As a result, he was able to observe patterns. He noticed that each cross yielded similar ratios in the F_2 generation: about three-fourths of the plants had purple flowers, and about one-fourth had white flowers. A ratio is a comparison that tells how two or more things relate. This ratio can be expressed as 3:1 (read "three to one") of purple:white flowers. As you can see in **FIGURE 6.10**, Mendel's data show this approximately 3:1 ratio for each of his crosses.

FIGURE 6.10 MENDEL'S MONOHYBRID CROSS RESULTS

F_2 TRAITS	DOMINANT	RECESSIVE	RATIO
Pea shape	5474 round	1850 wrinkled	2.96:1
Pea color	6022 yellow	2001 green	3.01:1
Flower color	705 purple	224 white	3.15:1
Pod shape	882 smooth	299 constricted	2.95:1
Pod color	428 green	152 yellow	2.82:1
Flower position	651 axial	207 terminal	3.14:1
Plant height	787 tall	277 short	2.84:1

Source: Mendel, *Abhandlungen* (1865).

Conclusions

From these observations, Mendel drew three important conclusions. He demonstrated that traits are inherited as discrete units, which explained why individual traits persisted without being blended or diluted over successive generations. Mendel's two other key conclusions are collectively called the **law of segregation,** or Mendel's first law.

- Organisms inherit two copies of each gene, one from each parent.
- Organisms donate only one copy of each gene in their gametes. Thus, the two copies of each gene segregate, or separate, during gamete formation.

Section 6.5 covers Mendel's second law, the law of independent assortment.

Infer **Explain why Mendel's choice of either-or characteristics aided his research.**

Connecting CONCEPTS

Meiosis As you learned in **Section 6.2,** during meiosis, homologous chromosomes pair up in prophase I and are separated in anaphase I. The overall process produces haploid cells that have a random assortment of chromosomes.

6.3 ASSESSMENT

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REVIEWING MAIN IDEAS

1. Mendel had no understanding of DNA as the genetic material, yet he was able to correctly predict how **traits** were passed between generations. What does Mendel's work in **genetics** show about the value of scientific observation?
2. Why is it important that Mendel began with **purebred** plants?

CRITICAL THINKING

3. **Analyze** Mendel saw purple flowers in the F_1 generation, but both purple and white flowers in the F_2. How did this help him see that traits are inherited as discrete units?
4. **Evaluate** If Mendel had examined only one trait, do you think he would have developed the **law of segregation**? Explain.

Connecting CONCEPTS

5. **Scientific Process** You have learned that scientific thinking involves observing, forming hypotheses, testing hypotheses, and analyzing data. Use examples from Mendel's scientific process to show how his work fit this pattern.