Chapter 9: Introduction to Patterns of Inheritance

Figure 9.1 Experimenting with thousands of garden peas, Mendel uncovered the fundamentals of genetics. (credit: modification of work by Jerry Kirkhart / Biology 2E OpenStax)

Genetics is the study of heredity, the ability to pass on traits from one generation to the next. Johann Gregor Mendel set the framework for genetics long before chromosomes or genes had been identified. Mendel selected a simple biological system, the common garden pea plant, and conducted methodical, quantitative analyses using large sample sizes. Mendel's work identified the fundamental principles of heredity, and as a result, he is often referred to as the "father of genetics."

Today, the work put forth by Mendel forms the basis of classical, or Mendelian, genetics. It is important to note that not all traits are passed from parents to offspring according to Mendelian genetics. However, Mendel's experiments serve as an excellent starting point for thinking about how inheritance works.

9.1 Gregor Mendel and Genetic Crosses

Learning objectives

By the end of this section, you will be able to:

- *Explain the history of Mendel and his work*
- *Explain the difference between characteristics and traits*
- *Understand the difference between continuous and discontinuous variation*
- *Describe the expected outcomes of different Mendelian crosses*
- *Be able to define and explain all bolded terms*

Johann Gregor Mendel (1822–1884) (Figure 9.2) was a lifelong learner, teacher, scientist, and man of faith. As a young adult, he joined the Augustinian Abbey in what is now the Czech Republic. Supported by the monastery, he taught physics, botany, and natural science courses at the secondary and university levels. In 1856, he started studying inheritance patterns in honeybees and plants. His research would span well over a decade, and much of what he found became a cornerstone for the field of genetics.

Figure 9.2 Johann Gregor Mendel set the framework for the study of genetics. (credit: Clark et al. / Biology 2E OpenStax)

Ultimately, Mendel settled on pea plants as his primary model system. Pea plants were an ideal model organism for several reasons. First, pea plants grow to maturity within one season, meaning that several generations could be evaluated over a relatively short time. Second, large quantities of pea plants could be cultivated simultaneously. This allowed Mendel to perform quantitative statistical tests that supported his results.

Pea plants also have seven different heritable characteristics that could be studied. A **characteristic** is a physical feature of an organism. The characteristics Mendel studied in pea plants were stem length, flower color and position, seed texture and color, and pod texture and color. Each of these characteristics has two easily identifiable traits (Figure 9.3). A **trait** is defined as variation in the physical form of a characteristic that is heritable. For example, pea plants produce either yellow or green seeds. The seeds are either wrinkled or smooth. These different variations, yellow or green, or wrinkled or smooth, are referred to as traits.

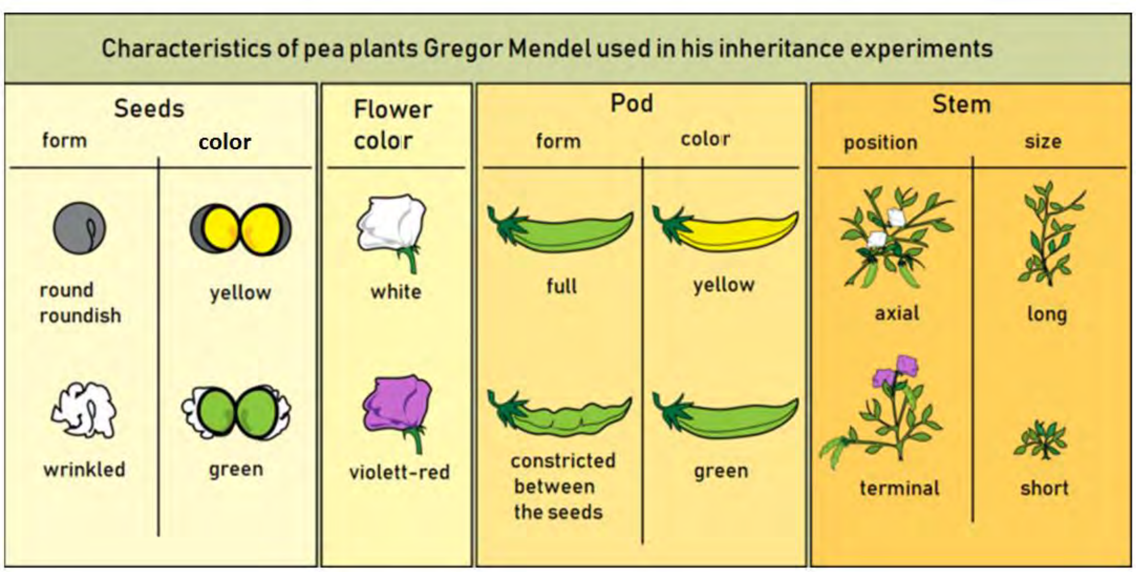

Figure 9.3 The seven characteristics Mendel studied in pea plants, and the two traits for each. (credit: Modified by Elizabeth O'Grady original work of Mariana Ruiz / Public Domain)

In 1865, Mendel presented the results of his experiments, which were based on nearly 30,000 pea plants, to the local Natural History Society. In 1866 he published his work, *Experiments in Plant Hybridization,*[1] in the proceedings of the Natural History Society of Brünn. Although he published his findings, Mendel's work went virtually unnoticed. At this time, the scientific community thought, incorrectly, that the process of inheritance involved a blending of parental traits. The **blending hypothesis of inheritance** stated that when two individuals made an offspring, their original parental traits were lost because their traits blended together when the offspring was formed. For example, if two horses with different coat colors, white and black, were mated, the coat colors would blend together, resulting in an offspring with an intermediate grey color. Once blended, the colors, black and white, would not appear again in the offspring's future generations.

We now know that this is not the case. Many people supported the blending hypothesis because of what is commonly referred to as continuous variation. **Continuous variation** is when a population displays a wide range of values for a character, such as height in humans. We now know this occurs when a character is influenced by several different genes. Continuous variation can also be observed with human characteristics such as skin, hair, and eye color. Offspring often appear to be a "blend" of their parents' traits; however, this is not completely true and will be discussed later in section 9.3.

Mendel worked with traits that show discontinuous variation. **Discontinuous variation** is when each individual exhibits one of two easily distinguishable traits, such as violet or white flowers. Mendel's decision to use traits that show discontinuous variation allowed him to see experimentally that offspring were not a result of "blending." Mendel hypothesized that each trait was kept distinct from one another and, as a result, could be passed on and reappear in future generations. In 1868 Mendel became abbot of the monastery and exchanged his scientific pursuits for his pastoral duties. He was not recognized for his extraordinary scientific contributions during his lifetime. It was not until 1900 that his work was rediscovered, reproduced, and revitalized by scientists on the brink of discovering the chromosomal basis of heredity.

Mendel's Model System

As mentioned earlier, Mendel studied inheritance using the common garden pea plant, *Pisum sativum*. This species of plant naturally self-fertilizes itself, such that pollen encounters ova (eggs) within individual flowers. The flower petals remain sealed tightly until after pollination, preventing pollination from other plants. The result is highly inbred, or "true-breeding," pea plants. These plants always produce offspring that look like the parent plant. By experimenting with true-breeding pea plants, Mendel avoided the appearance of unexpected traits in offspring, which might occur if the plants were not true-breeding.

Mendelian Crosses

Mendel performed **hybridizations**, or **cross-fertilizations**, which involve mating two true-breeding individuals that have different traits. For example, Mendel would take pollen from a true-breeding violet-flowered plant and use it to fertilize the egg of a true-breeding white-