

Genetics

Gregor Mendel's experiments

Before Gregor Mendel's discoveries, the **blending inheritance** was a widely popular theory to explain heredity. The blending inheritance is a model where the offspring would have a mix of characteristics that the parents have. According to blending inheritance, a tall plant and a short plant would produce an offspring of medium height. If this were true, by now all humans would be of the same height! This model did not explain some of Mendel's observations



To understand his observations, Mendel experimented with **pea plants** (*Pisum sativum*). The pea plants were good experimental subjects because they grow quickly, are easy to raise, and have several visible characteristics that exist in two different forms. For example, the flower colour may be either white or purple. The seven characteristics that Mendel studied are shown in the diagram below. In Mendel's pea plant experiments, Mendel needed to control pollination, the fertilization step in the sexual reproduction of plants.

- Pea plants have both the male flower part (anther) and the female flower part (stigma). They naturally self-pollinate (a flower fertilizes itself).
- In order to study the offspring of two different parent plants, Mendel prevented self-pollination by removing the anthers of some pea plants.
- Mendel cross-pollinated by dusting the stigma with the pollen from the anther of a different pea plant.
- The resulting offspring is a **hybrid**.

Seed		Flower	Pod		Stem	
Form	Cotyledon	Color	Form	Color	Place	Size
						
Grey & Round	Yellow	White	Full	Green	Axial pods	Tall
						
White & Wrinkled	Green	Violet	Constricted	Yellow	Terminal pods	Short

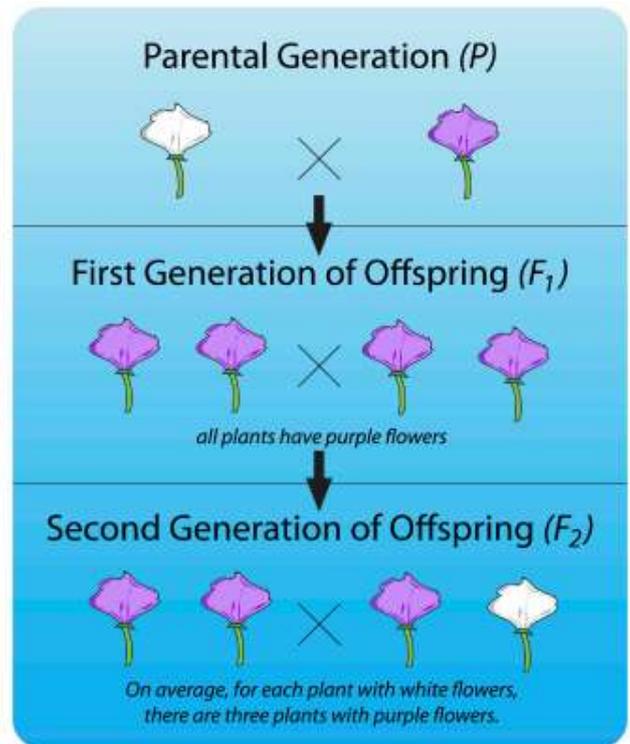
Genetics

Mendel's first set of experiments

At first, Mendel experimented with just one characteristic at a time. He began with flower colour. Mendel cross-pollinated purple- and white-flowered parent plants.

Experimental steps

1. Mendel allowed each variety of pea plants to self-pollinate for several generations. He wanted to ensure that the offspring of each variety would display the same characteristics (a pea plant with purple flowers will only produce plants with purple flowers). These pea plants formed the **P (parent) generation**.
2. Mendel cross-pollinated two P generation plants with different characteristics (a pea plant with purple flowers and a pea plant with white flowers). The offspring formed the **F1 generation**.
3. The plants of the F1 generation were allowed to self-pollinate. The offspring formed the **F2 generation**.



Results

All the F1 generation plants were alike.

When plants in the F1 generation are self-pollinated, the plants in the F2 generation are no longer the same (exhibit two different characteristics).

Furthermore, the F2 generation plants displayed the two different characteristics in a consistent ratio (3:1).

Example: on average, there were three purple-flowered plants to one white-flowered plant.

The law of segregation

When reproductive cells form, the pair of alleles separates, or segregates. Each reproductive cell, or gamete, receives one allele. During fertilization, two gametes combine, giving the offspring two alleles. The inherited alleles can be the same or different.

Genetics

Mendel's second set of experiments

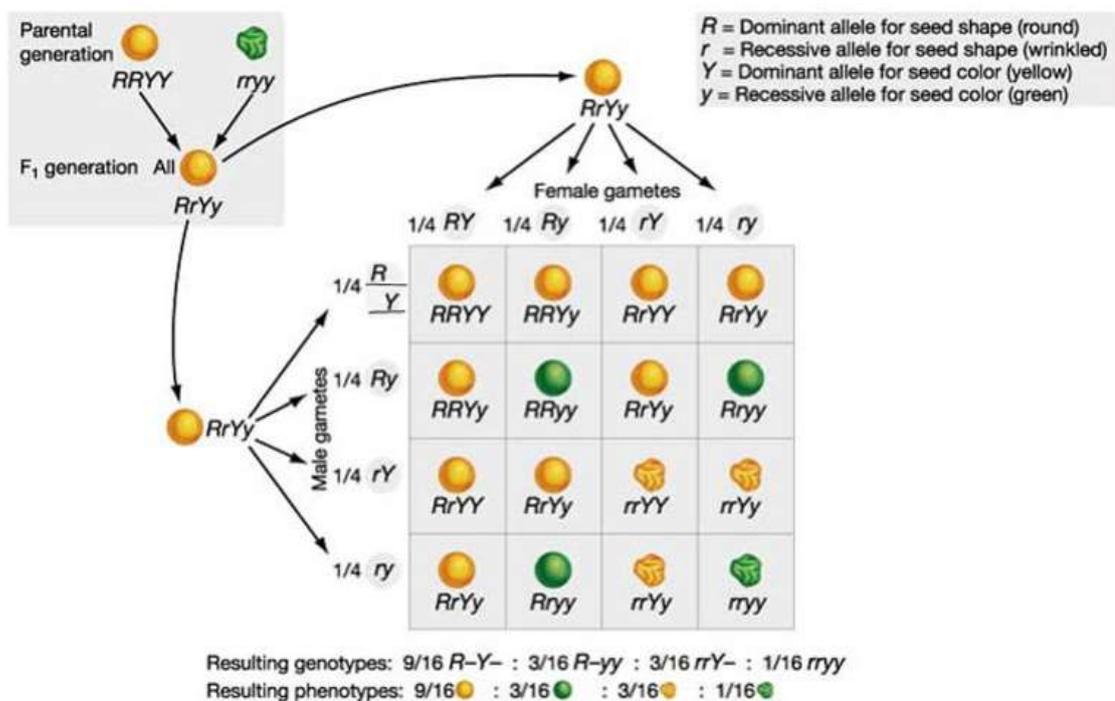
In his second set of experiments, Mendel experimented with two characteristics at a time, such as a yellow round seeds with green wrinkled seeds. He wanted to know if different characteristics are inherited together. For example, were yellow seeds always round and green seeds always wrinkled? The experimental steps were the same as the ones in the first set of experiments.

Results

All the plants in the **F1 generation** were the same.

When plants in the F1 generation were self-pollinated, the **F2 generation** plants showed all possible combinations of the two characteristics.

The F2 generation plants displayed all possible combinations in a consistent ratio (9:3:3:1).



The Law of Independent Assortment

The genes controlling different characteristics are inherited separately and therefore are not related.

Mendel's conclusions form the basis of modern genetics

- > Some factor, known today as a gene, controls what characteristics are observed.
- > A pair of genes controls each characteristic. Each parent contributes one copy of the gene.
- > There are different versions of a gene, known today as an allele that controls each characteristic.
- > When an organism inherits two different alleles, only the dominant allele is expressed (the recessive allele is not expressed).

Genetics

How Mendel worked backward to get ahead

Mendel used hundreds or even thousands of pea plants in each experiment he did. Therefore, his results were very close to those you would expect based on the rules of probability. For example, in one of his first experiments with flower colour, there were 929 plants in the F₂ generation. Of these, 705 (76 %) had purple flowers and 224 (24 %) had white flowers. Thus, Mendel's results were very close to the 75 percent purple and 25 percent white you would expect by the laws of probability for this type of cross.

Of course, Mendel had only phenotypes to work with. He knew nothing about genes and genotypes. Instead, he had to work backward from phenotypes and their percents in offspring to understand inheritance. From the results of his first set of experiments, Mendel realized that there must be two factors controlling each of the characteristics he studied, with one of the factors being dominant to the other. He also realized that the two factors separate and go to different gametes and later recombine in the offspring. This is an example of Mendel's good luck. All of the characteristics he studied happened to be inherited in this way.

Mendel also was lucky when he did his second set of experiments. He happened to pick characteristics that are inherited independently of one another. We now know that these characteristics are controlled by genes on non-homologous chromosomes. What if Mendel had studied characteristics controlled by genes on homologous chromosomes? Would they be inherited together? If so, how do you think this would have affected Mendel's conclusions?

Mendel's Laws and Genetics

Mendel's work was largely ignored at the beginning. Mendel was far ahead of his time and working from a remote monastery. He had no reputation among the scientific community and no previously published work.

Mendel's work, titled *Experiments in Plant Hybridization*, was published in 1866, and sent to prominent libraries in several countries, as well as 133 natural science associations. Mendel himself even sent carefully marked experiment kits to Karl von Nageli, the leading botanist of the day. The result - it was almost completely ignored. Von Nageli instead sent hawkweed seeds to Mendel, which he thought was a better plant for studying heredity. Unfortunately hawkweed reproduces asexually, resulting in genetically identical clones of the parent.

Charles Darwin published his landmark book on evolution in 1869, not long after Mendel had discovered his laws. Unfortunately, Darwin knew nothing of Mendel's discoveries and didn't understand heredity. This made his arguments about evolution less convincing to many people. This example demonstrates the importance for scientists to communicate the results of their investigations.

Rediscovering Mendel's Work

Mendel's work was virtually unknown until 1900. In that year, three different European scientists — named Hugo De Vries, Carl Correns, and Erich Von Tschermak-Seysenegg — independently arrived at Mendel's laws. All three had done experiments similar to Mendel's. They came to the same conclusions that he had drawn almost half a century earlier. Only then was Mendel's actual work rediscovered.

As scientists learned more about heredity over the next few decades, they were able to describe Mendel's ideas about inheritance in terms of genes. In this way, the field of genetics was born.