GREGOR MENDEL

Big Picture

Gregor Mendel is famous today for his ground-breaking investigations and discoveries in the field of genetics. His pea plant experiments in the 19th century explained concepts such as dominant alleles and recessive alleles. Mendel concluded his experiments with two laws: the law of segregation and the law of independent assortment.

Figure: Gregor Mendel
Image Credit: *The History of Biology*, Erik Nordenskiöld, Public Domain

Key Terms

Heredity: The passing of characteristics from parents to offspring.

Genetics: The science of heredity.

Hybrid: The resulting offspring from a cross between two different types of parents.

Gene: Segment of DNA that codes for a single protein or RNA. Controls what characteristics are expressed.

Alleles: Variants of a specific gene.

> **Dominant Allele**: The allele that is expressed as long as a dominant allele is present.

> **Recessive Allele**: The allele that is expressed as long as no dominant alleles are present.

Law of Segregation: Mendel's first law of inheritance. The law states that there are two factors controlling a given characteristic in which one dominates the other. These factors separate during reproduction and go to different gametes, or a mature reproductive cell that eventually unites with another gamete to reproduce.

Law of Independent Assortment: Mendel's second law of inheritance. The factors controlling the different characteristics are inherited separately and therefore are not related.

Mendel's Pea Plant Experiments

Blending Inheritance

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. This model did not explain some of Mendel's observations.
- Example: 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!

Characteristics of Pea Plants

To understand his observations, Mendel experimented with pea plants. The pea plants were good experimental subjects because they grow quickly, are easy to raise, and have several visible characteristics that exit in two different forms. For example, the flower color 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**.

Figure: Diagram showing that seven characteristics observed by Mendel

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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

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Mendel's First Set of Experiments

In his first set of experiments, Mendel experimented with just one characteristic (such as flower color) at a time.

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.
   - Example: a pea plant with purple flowers will only produce plants with purple flowers
   - These pea plants formed the P generation.
2. Mendel cross-pollinated two P generation plants with different characteristics.
   - Example: a pea plant with purple flowers and a pea plant with white flowers
   - The offspring formed the F_1 generation.
3. The plants of the F_1 generation were allowed to self-pollinate.
   - The offspring formed the F_2 generation.

Results

- All the F_1 generation plants were alike.
- When plants in the F_1 generation are self-pollinated, the plants in the F_2 generation are no longer the same (exhibit two different characteristics).
- Furthermore, the F_2 generation plants displayed the two different characteristics in a consistent ratio (3:1).
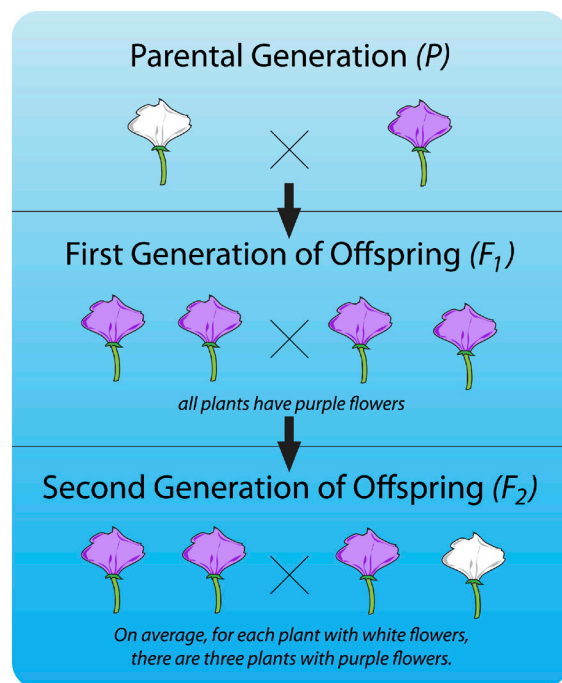- Example: on average, there were three purple-flowered plants to one white-flowered plant

Parental Generation (P)

First Generation of Offspring (F_1)

all plants have purple flowers

Second Generation of Offspring (F_2)

On average, for each plant with white flowers, there are three plants with purple flowers.

Image Credit: CK-12 Foundation, CC-BY-NC-SA 3.0

*P generation stands for **p**arental generation. F generation stands for **f**ilial generation (filial means "of a son or daughter").*

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.

See biology study guide Mendelian Inheritance to learn how to predict an offspring's characteristic.

Results

- All the plants in the F_1 generation were the same.
- When plants in the F_1 generation were self-pollinated, the F_2 generation plants showed all possible combinations of the two characteristics.
- The F_2 generation plants displayed all possible combinations in a consistent ratio (9:3:3:1).

Mendel's Conclusions

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).

The Law of Segregation

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.

The Law of Independent Assortment

The **law of independent assortment**: The genes controlling different characteristics are inherited separately and therefore are not related.