Mendel's Laws

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Mendel's Laws

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Synonyms

Mendelian inheritance

Definition

The set of three laws, proposed by Gregor J. Mendel in the mid-1860s, to explain the biological inheritance or heredity is known as Mendel's laws. These laws are the law of segregation, law of independent assortment, and law of dominance, and they form the core of classical genetics to date.

Introduction

Gregor Johann Mendel (1822–1884) was a friar-cum-science teacher in Brno (Austria-Hungary), and known as the father of genetics due to his groundbreaking genetics experiments on sweet pea plants. Though he performed and published his scientific work in the 1860s, significance of his work was not widely recognized until 1900. His scientific results describe the transmission of hereditary information from parent generation to progeny generation. These results helped him to frame three laws of biological inheritance, which led to the foundation of classical genetics. Mendel's contribution is significant in genetics as he framed these laws during a time when even words like "chromosomes" or "genes" were not discovered (Hartl and Ruvolo 2011).

Mendel crossed white flower and purple flower pea plants (parents or P generation) and found out that the progenies (F1 generation) were purple-flowered plants rather than a blend. Interestingly, when he self-fertilized these progenies, he got both purple flower and white flower plants (F2 generation) in the ratio of 3:1. The results of this cross are summarized in Fig. 1.

First Law: Law of Dominance

When individuals with one or more sets of contrasting characters (now known as phenotypes) are crossed, then the characters that appear in F1 generation are called dominant characters, and the characters that remain hidden are called recessive characters. The above example, where P generation plants were crossed together and only purple-colored flower F1 generations were obtained, shows that the dominant purple flower allele (B) will hide the phenotypic effects of the recessive white flower allele (b). This is known as the law of dominance (Hartwell et al. 2017).

J. Vonk, T. K. Shackelford (eds.), *Encyclopedia of Animal Cognition and Behavior*,
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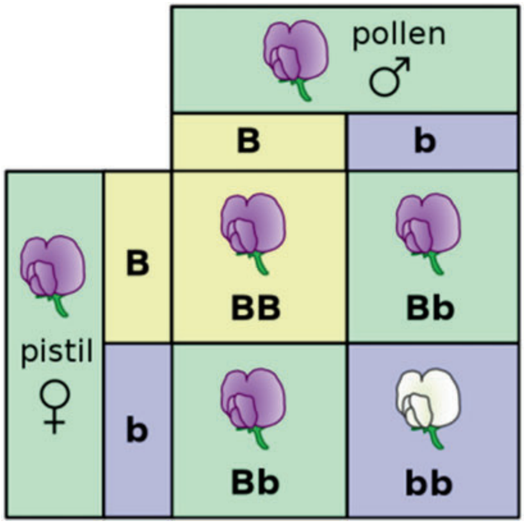


Mendel's Laws, Fig. 1 Punnett square describing self-fertilization of F1 pea plants (both purple). Here B and b represent the factors (now known as alleles). (Image credit: Madeleine Price Ball, CC0 licensed)

White phenotypes will appear only in the absence of dominant purple flower alleles. The uppercase letters are used to denote dominant alleles, whereas the lowercase letters are used to denote recessive alleles. Mendel used the term "factors" instead of alleles during that time.

Second Law: Law of segregation

This law is also referred to as *law of purity of gametes*. During the formation of male and female gametes (generally sperm and ova in animals or pollen grains and ovule in plants), factors (alleles) responsible for a particular character separate and are passed into different gametes. This process implies that the gametes are either pure for dominant alleles or for recessive. These gametes can unite randomly in different possible combinations during fertilization and produce the genotype for the traits of the progenies (Pierce 2017). In a zygote, the two members of an allele pair remain together without being contaminated. This is known as law of segregation.

In Fig. 1 above, both pollen and pistil form male and female gametes, respectively, with either B or b allele. These male and female gametes combine randomly during fertilization to produce F1 generation of purple flower and white flower plants in the ratio of 3:1.

Third Law: Law of Independent Assortment

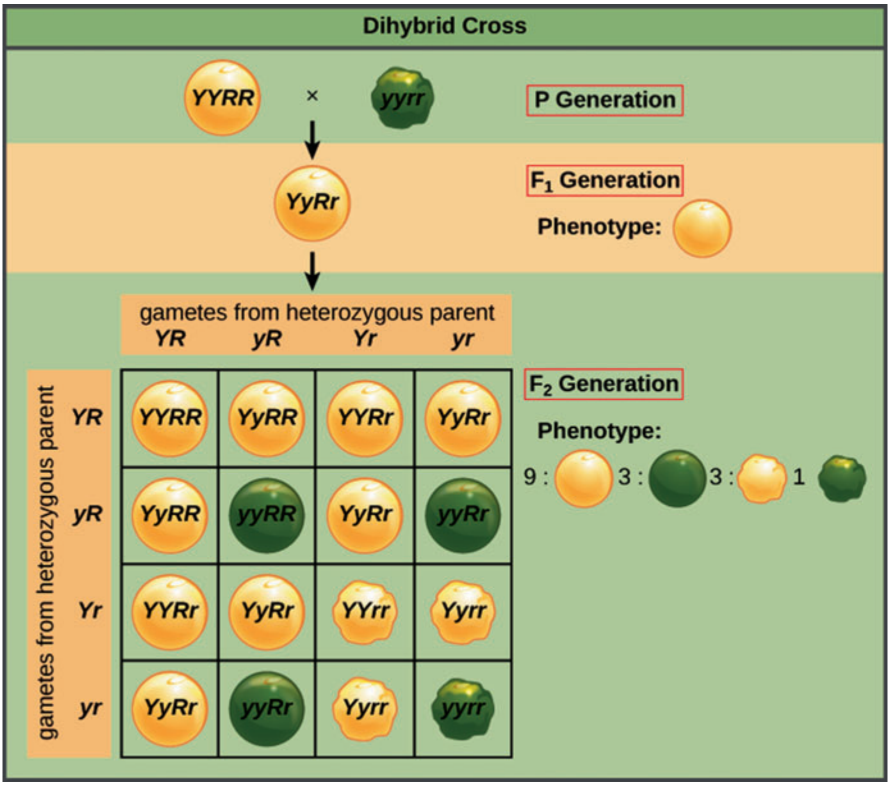
This law is also known as *inheritance law* and is defined as alleles of different genes which distribute independently of one another during gamete formation (Watson et al. 2013).

As shown in Fig. 1, mixing a single trait (monohybrid cross) in Mendel's experiment constantly resulted in a 3:1 ratio between dominant and recessive phenotypes. However, when he performed experiments on two traits (dihybrid cross), he obtained F2 generation in the ratio of 9:3:3:1 (Fig. 2). These results led Mendel to conclude that different traits (e.g., seed shape and color) are inherited independently of one another and there is no relation between two traits.

Conclusion

Historically, biologists in the nineteenth century believed in the apparent blending of inherited traits in the overall appearance of the progeny, which proved to be a major roadblock for the understanding and acceptance of Mendel's work. It was only in the year 1900 (16 years after Mendel first published his studies) where three European scientists, i.e., Hugo de Vries, Carl Correns, and Erich von Tschermak, rediscovered Mendel's work by performing similar experiments independently (Snustad and Simmons 2015). William Bateson was a huge promoter of Mendel's work later in Europe and also coined the terms genetics, gene, and allele to describe the basic constituents of Mendelian genetics.

With the advancement in the field of genetics, scientists observed few deviations from Mendel's laws of inheritance. These include incomplete dominance, codominance, and lethal genes.



Mendel's Laws, Fig. 2 Dihybrid cross between yellow round seed plant and green wrinkled seed plant. Here, Y (yellow) R (round) is the dominant allele over y (green) r (wrinkled). (Image credit: https://opentextbc.ca/biology/chapter/8-2-laws-of-inheritance/ CC license)

Cross-References

- ▶ Alleles
- ▶ Assortment
- ▶ Chromosomes
- ▶ Genes
- ▶ Heredity
- ▶ Homozygosity
- ▶ Mendelian Crosses

References

Hartl, D. L., & Ruvolo, M. (2011). *Genetics: Analysis of genes and genomes*. Sudbury: Jones & Bartlett Learning.

Hartwell, L. H., Goldberg, M. L., Fischer, J. A., & Hood, L. (2017). *Genetics: From genes to genome*. Columbus: McGraw-Hill Higher Education.

Pierce, B. A. (2017). *Genetics: A conceptual approach*. New York: W.H. Freeman.

Snustad, D. P., & Simmons, M. J. (2015). *Principles of genetics*. New Jersey: Wiley.

Watson, J. D., Baker, T. A., Stephen, P. B., Alexander, G., Michael, L., & Richard, L. (2013). *Molecular biology of the gene*. London: Pearson.