3.4: Mendel's Laws and Genetics

Do you look like your parents?

You probably have some characteristics or traits in common with each of your parents. Mendel's work provided the basis to understand the passing of traits from one generation to the next.

Mendel’s Laws and Genetics

You might think that Mendel's discoveries would have made a big impact on science as soon as he made them. But you would be wrong. Why? Because Mendel's work was largely ignored. 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 - the passing of traits from parents to offspring - 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. At the link that follows, you can watch an animation of Mendel explaining his laws of inheritance in genetic terms. [http://www.dnalc.org/view/16182-Animation-4-Some-genes-are-dominant-.html](http://www.dnalc.org/view/16182-Animation-4-Some-genes-are-dominant-.html)

Genetics of Inheritance

Today, we known that characteristics of organisms are controlled by genes on chromosomes(see Figure below). The position of a gene on a chromosome is called its **locus**. In sexually reproducing organisms, each individual has two copies of the same gene, as there are two versions of the same chromosome (**homologous chromosomes**). One copy comes from each parent. The gene for a characteristic may have different versions, but the different versions are always at the same locus. The different versions are called **alleles**. For example, in pea plants, there is a purple-flower allele (**B**) and a white-flower allele (**b**). Different alleles account for much of the variation in the characteristics of organisms.

Chromosome, Gene, Locus, and Allele. This diagram shows how the concepts of chromosome, gene, locus, and allele are related. What is the different between a gene and a locus? Between a gene and an allele?
During meiosis, homologous chromosomes separate and go to different gametes. Thus, the two alleles for each gene also go to different gametes. At the same time, different chromosomes assort independently. As a result, alleles for different genes assort independently as well. In these ways, alleles are shuffled and recombined in each parent’s gametes.

**Genotype and Phenotype**

When gametes unite during fertilization, the resulting zygote inherits two alleles for each gene. One allele comes from each parent. The alleles an individual inherits make up the individual’s *genotype*. The two alleles may be the same or different. As shown in Table below, an organism with two alleles of the same type (*BB* or *bb*) is called a *homozygote*. An organism with two different alleles (*Bb*) is called a *heterozygote*. This results in three possible genotypes.

<table>
<thead>
<tr>
<th>Alleles</th>
<th>Genotypes</th>
<th>Phenotypes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><em>BB</em> (homozygote)</td>
<td>purple flowers</td>
</tr>
<tr>
<td><em>B</em> (purple)</td>
<td><em>Bb</em> (heterozygote)</td>
<td>purple flowers</td>
</tr>
<tr>
<td><em>b</em> (white)</td>
<td><em>bb</em> (homozygote)</td>
<td>white flowers</td>
</tr>
</tbody>
</table>

The expression of an organism’s genotype produces its *phenotype*. The phenotype refers to the organism’s characteristics, such as purple or white flowers. As you can see from Table above, different genotypes may produce the same phenotype. For example, *BB* and *Bb*genotypes both produce plants with purple flowers. Why does this happen? In a *Bb* heterozygote, only the *B* allele is expressed, so the *b* allele doesn’t influence the phenotype. In general, when only one of two alleles is expressed in the phenotype, the expressed allele is called the *dominant* allele. The allele that isn’t expressed is called the *recessive* allele.

**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 (see "Probability and Inheritance" concept). For example, in one of his first experiments with flower color, there were 929 plants in the F2 generation. Of these, 705 (76 percent) had purple flowers and 224 (24 percent) 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
nonhomologous 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? Would he have been able to develop his second law of inheritance?

To better understand how Mendel interpreted his findings and developed his laws of inheritance, you can visit the following link. It provides an animation in which Mendel explains how he came to understand heredity from his experimental results. [http://www.dnalc.org/view/16154-Animation-2-Genes-Come-in-Pairs.html](http://www.dnalc.org/view/16154-Animation-2-Genes-Come-in-Pairs.html)

**Summary**

- Mendel’s work was rediscovered in 1900. Soon after that, genes and alleles were discovered. This allowed Mendel’s laws to be stated in terms of the inheritance of alleles.
- The gene for a characteristic may have different versions. These different versions of a gene are known as alleles.
- Alleles for different genes assort independently during meiosis.
- The alleles an individual inherits make up the individual’s genotype. The individual may be homozygous (two of the same alleles) or heterozygous (two different alleles).
- The expression of an organism’s genotype produces its phenotype.
- When only one of two alleles is expressed, the expressed allele is the dominant allele, and the allele that isn’t expressed is the recessive allele.
- Mendel used the percentage of phenotypes in offspring to understand how characteristics are inherited.

**Making Connections**

Media, iframe, embed and object tags are not supported inside of a PDF.

**Explore More**

Use these resources to answer the questions that follow.


  1. What is a gene?
  2. The gene for flower color in pea plants can occur in the white or red form. What are these two different forms of the same gene?
  3. How many copies of a gene are in a gamete?
  4. How many copies of a gene are in a zygote?
5. State Mendel's law of segregation.

Explore More II

- **Modern Genetics** at [http://www.concord.org/activities/modern-genetics](http://www.concord.org/activities/modern-genetics).

Review

1. If Darwin knew of Mendel’s work, how might it have influenced his theory of evolution? Do you think this would have affected how well Darwin’s work was accepted?
2. Explain Mendel’s laws in genetic terms, that is, in terms of chromosomes, genes, and alleles.
3. Explain the relationship between genotype and phenotype. How can one phenotype result from more than one genotype?