5.1 Mendelian Genetics

Understanding Inheritance
Genetics is the study of inheritance. It studies the mechanisms by which traits are passed between parents and offspring.

The principles of genetics were determined by Gregor Mendel (1860s). Most of his research came from studying inheritance in garden peas.
Characteristics (traits) of peas studied by Mendel

<table>
<thead>
<tr>
<th>Character</th>
<th>Dominant trait</th>
<th>Recessive trait</th>
<th>Character</th>
<th>Dominant trait</th>
<th>Recessive trait</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seed shape</td>
<td>Spherical</td>
<td>Wrinkled</td>
<td>Flower position</td>
<td>Axial</td>
<td>Terminal</td>
</tr>
<tr>
<td>Seed color</td>
<td>Yellow</td>
<td>Green</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flower color</td>
<td>Purple</td>
<td>White</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pod shape</td>
<td>Inflated</td>
<td>Constricted</td>
<td>Stem height</td>
<td>Tall</td>
<td>Dwarf</td>
</tr>
<tr>
<td>Pod color</td>
<td>Green</td>
<td>Yellow</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>
Alleles

All traits are coded for in the DNA of an individual. The area on the DNA that codes for a particular trait is called a gene.

From the diagram on the last slide, you may notice that for every trait listed, there are 2 different versions.

These different versions of a gene are called alleles.

e.g. for *flower colour*, there are 2 alleles – *purple* and *white*
Alleles

Each individual receives **2 alleles for every trait** – one from the mother and one from the father. The combination of alleles that is inherited determines what characteristics an individual shows.

![Homologous chromosomes](image)

**Homologous chromosomes**
Dominant traits

**Dominant trait** is always expressed, if present. It masks a recessive trait, if the recessive trait was also inherited in an individual

**Dominant allele** (P - purple flowered pea plant)

a. homozygous dominant (PP – receives an allele for the dominant trait from each parent)

b. heterozygous dominant (Pp – receives one allele for the dominant trait and one for the recessive trait (p-white flowers). The recessive trait is hidden by the dominant trait, so this individual plant has purple flowers)
Recessive traits

In order for an individual to express the recessive form of a trait, they must inherit 2 alleles for the recessive trait from it’s parents.

**Recessive allele** (p – white flowered pea plant)

To show white flowers, the plant must have be **homozygous recessive** (pp).
Genotype

A **genotype** is the allele combination that an individual inherits from its parents.

It is usually written as a letter code, where a capital letter represents the dominant form of the allele, and a lower case represents the recessive form of the allele.

- **PP** – homozygous dominant
- **Pp** – heterozygous
- **pp** – homozygous recessive
Phenotype

Based on the genotype and the type of inheritance, the individual will exhibit certain characteristics. This is called their **phenotype**.

- **PP** – purple flowered pea plant
- **Pp** – purple flowered pea plant
- **pp** – white flowered pea plant

**Note:** a homozygous dominant and a heterozygous individual both exhibit the same phenotype, even though their genotypes are different.
Monohybrid Crosses

A **monohybrid cross** allows an experimenter to make a prediction about the possible outcomes that can arise from crossing 2 individuals of known genotype.

To do this, a **Punnett square** can be used to show how alleles in parents segregate (in meiosis) to create gametes, and then how these gametes potentially combine in fertilization.
Monohybrid Cross

• The experiment tracks the inheritance of a single trait.

• Mendel’s “Law of segregation”
  a. pairs of genes separate during gamete formation (meiosis).
  b. the fusion of gametes at fertilization pairs genes once again.
Law of Segregation

**diploid (2n)**

- **Pp**
  - meiosis I
  - **p**
  - meiosis II
  - **p**

- **P**
  - Pollen
  - haploid (n)
  - **P**
  - **P**
  - **p**
  - **p**
  - **p**
Monohybrid Cross

Example:
Cross between two homozygotes for purple flowers (PP) and white flowers (pp)

PP = purple flowers
Pp = purple flowers
pp = white flowers
Mendel’s P (parental) generation

Mendel took 2 true-breeding plants showing opposing characteristics (purple flowered pea plant and white flowered pea plant), and crossed them.

This is known as the P generation.
Punnett Square for the P generation

\[ PP \times pp \]

\[
\begin{array}{c|c}
  p & p \\
  \hline
  Pp & Pp \\
  \hline
  Pp & Pp \\
\end{array}
\]
Analysis of the cross

**Genotypic ratio:** 1 Pp : 0

**Phenotypic ratio:** 1 purple : 0 white
Mendel then crosses 2 individuals from the $F_1$ generation

Mendel took 2 purple plants that he produced from crossing the $P$ generation (2 $F_1$ generation plants), and crossed them.

$$Pp \times Pp$$

$F_2$ generation

GR: 1 PP: 2 Pp: 1 pp
PR: 3 purple: 1 white

The phenotypic ratio of this cross (a cross between 2 heterozygous parents) is known as the **Mendelian ratio**.