Chapter 7 - Inheritance

All Lectures Uploaded on YouTube:

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- Inheritance is the process by which traits are passed from parents to offspring.
- Traits may be **similarities** or **differences** (variation) between parents and offspring.
- **Gregor Mendel's** experiments with pea plants revealed the principles of genetics.
- Traits are controlled by **genes**, which can be **dominant** or **recessive**, and are inherited in **predictable patterns**.

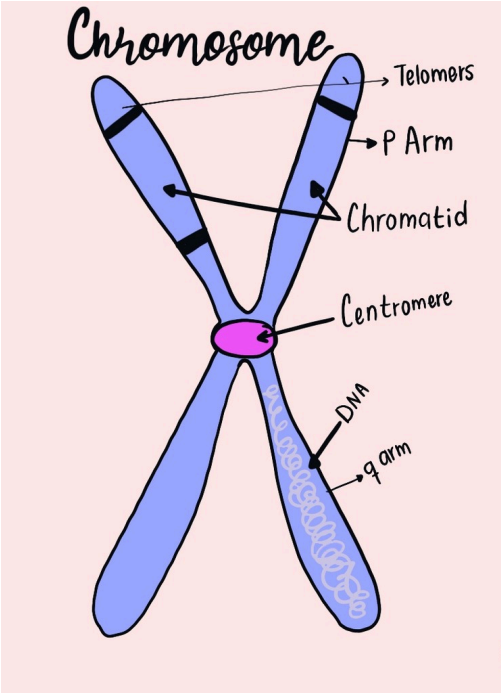
7.1. Structure of Chromosome

Chromosomes

- Thread-like structures in the nucleus of cells.
- Made of **DNA (Deoxyribonucleic Acid)** and proteins.
- During interphase, they are present as **chromatin** (thin fibrous network).
- DNA carries genetic information for development, functioning, and reproduction.

7.1.1. Parts of a Chromosome

A chromosome has three main parts: **chromatids, the centromere, and the telomeres**.



1. **Chromatids**
    - Before DNA replication (S-phase): one thread-like structure = single chromatid.
    - After replication, a chromosome consists of **two identical sister chromatids** joined at the centromere.
    - Sister chromatids = duplicated copies of the chromosome.
2. **Centromere**
    - Constricted region where sister chromatids attach.
    - Has a protein complex called a **kinetochore**, which helps spindle fibres attach during **mitosis** and **meiosis**.
    - Ensures equal distribution of chromosomes into daughter cells.
3. **Telomeres**
    - End regions of chromosomes.
    - Prevent degradation and loss of important genetic information during cell division.

7.2. Genotypes and Phenotypes

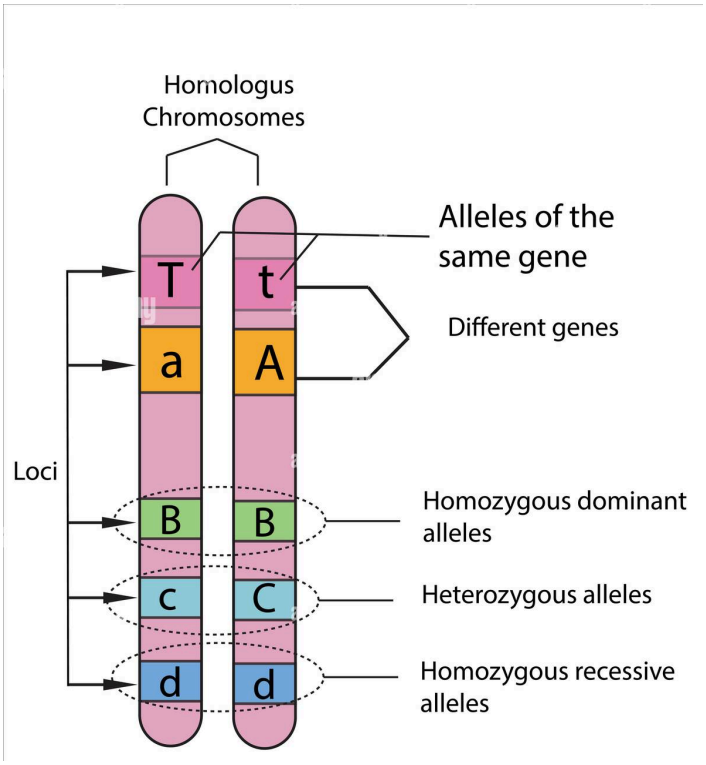
- Understanding inheritance requires knowledge of terms like **gene, allele, genotype, phenotype, and gene pool**.
- These explain how traits are inherited and expressed in organisms.

7.2.1. Genes, Alleles, and Loci

i) Genes

- A **gene** = unit of inheritance.

- It is a **specific segment of DNA** (a unique nucleotide sequence) that codes for a particular **polypeptide/protein**.
- Each characteristic of the body is controlled by **factor(s)** called genes.
- Mendel first proposed the idea of "gene," calling them "factors."
- Genes are represented by **alphabetical symbols**.
- Parental traits are passed to offspring via genes.



ii) Locus (plural: Loci)

- Genes are found on **chromosomes** at specific positions called **loci**.
- A locus is present on both members of a **homologous pair of chromosomes**

- The **genome** = complete set of an individual's genes.
- Genome = set of chromosomes carrying genetic information, represented by "n" (haploid).
- Cells with **two sets of chromosomes** = diploid (2n)
- In humans: genome = 23 chromosomes (haploid), 46 in diploid cells.
- Gametes (sperm/egg) contain a haploid number, somatic (body) cells contain a diploid number.

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iii) Allele

- A gene can exist in two or more forms, called **alleles**.
- Alleles are versions of the same gene that occupy the same position (locus) on a chromosome.
- Example in humans:
    - **E** = free earlobes
    - **e** = attached earlobes

- Both "E" and "e" are located at the same locus and are **alleles of each other**.
- Even though "E" and "e" are different, they are both considered **alleles**.

Homozygous and Heterozygous

- **Homozygous**: Both alleles are the same (e.g., AA or aa).
- **Heterozygous**: Alleles are different (e.g., Aa).
- **Dominant allele**: Expressed in both homozygous and heterozygous condition
- **Recessive allele**: Expressed only in a homozygous condition.

7.2.2. Genotype and Phenotypes

i) Genotype

- The genetic makeup of a trait at each locus is called the **genotype**.
- It usually consists of a pair of genes (alleles).
- Example:
    - **EE** or **Ee** = free earlobes
    - **ee** = attached earlobes
- If both alleles are **same** (EE, ee) → **Homozygous**
- If alleles are **different** (Ee) → **Heterozygous**
- **Homozygous individuals** = "True breed" → always produce the same offspring if self-fertilised.
- **Heterozygous individuals** = "Non-true breed" → can produce offspring with variation.

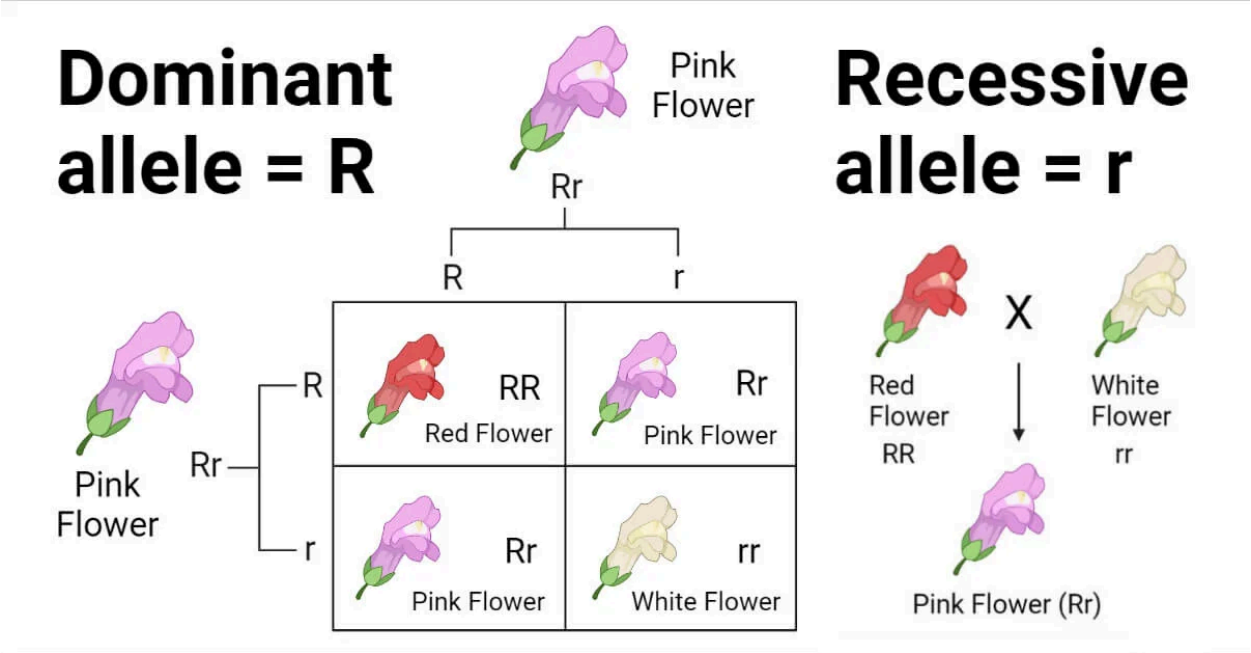
Examples from pea plants:

- **RR (pure round)** × self → always round seeds.
- **Rr (non-pure round)** × self → round + wrinkled seeds.

ii) Phenotype

- The **physical appearance** of a trait is called the phenotype.
- Determined by genotype.
- Example:
    - EE or Ee = free earlobes (dominant)
    - ee = attached earlobes (recessive)

- Phenotype is visible, even if the organism carries hidden (recessive) genes.
- **Dominant phenotype** = appears in both homozygous (EE) and heterozygous (Ee).
- **Recessive phenotype** = appears only in homozygous condition (ee).
- Representation:
    - Dominant allele → capital letter (E)
    - Recessive allele → small letter (e)

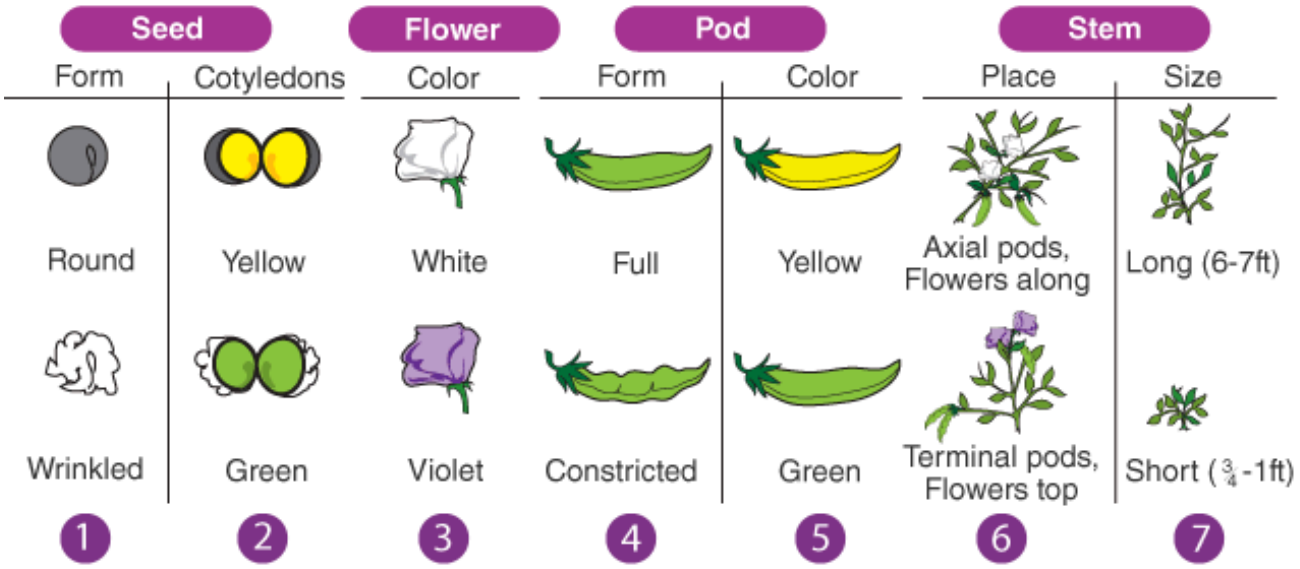


Self-Fertilisation

- A type of reproduction where an organism's own sperm fertilises its own eggs.
- Common in plants and hermaphroditic animals.
- Produces offspring genetically identical to the parent (less variation).
- Leads to **true-breeding plants** after repeated generations of self-fertilisation.

7.3. Mendelian Inheritance

- Rediscovered in **1900**, originally studied by **Gregor Johann Mendel** in **1866**.
- Mendel is called the **Father of Genetics**.
- He explained how traits pass from generation to generation through pea plant experiments.
- His principle of inheritance is called **Mendelian Inheritance**.

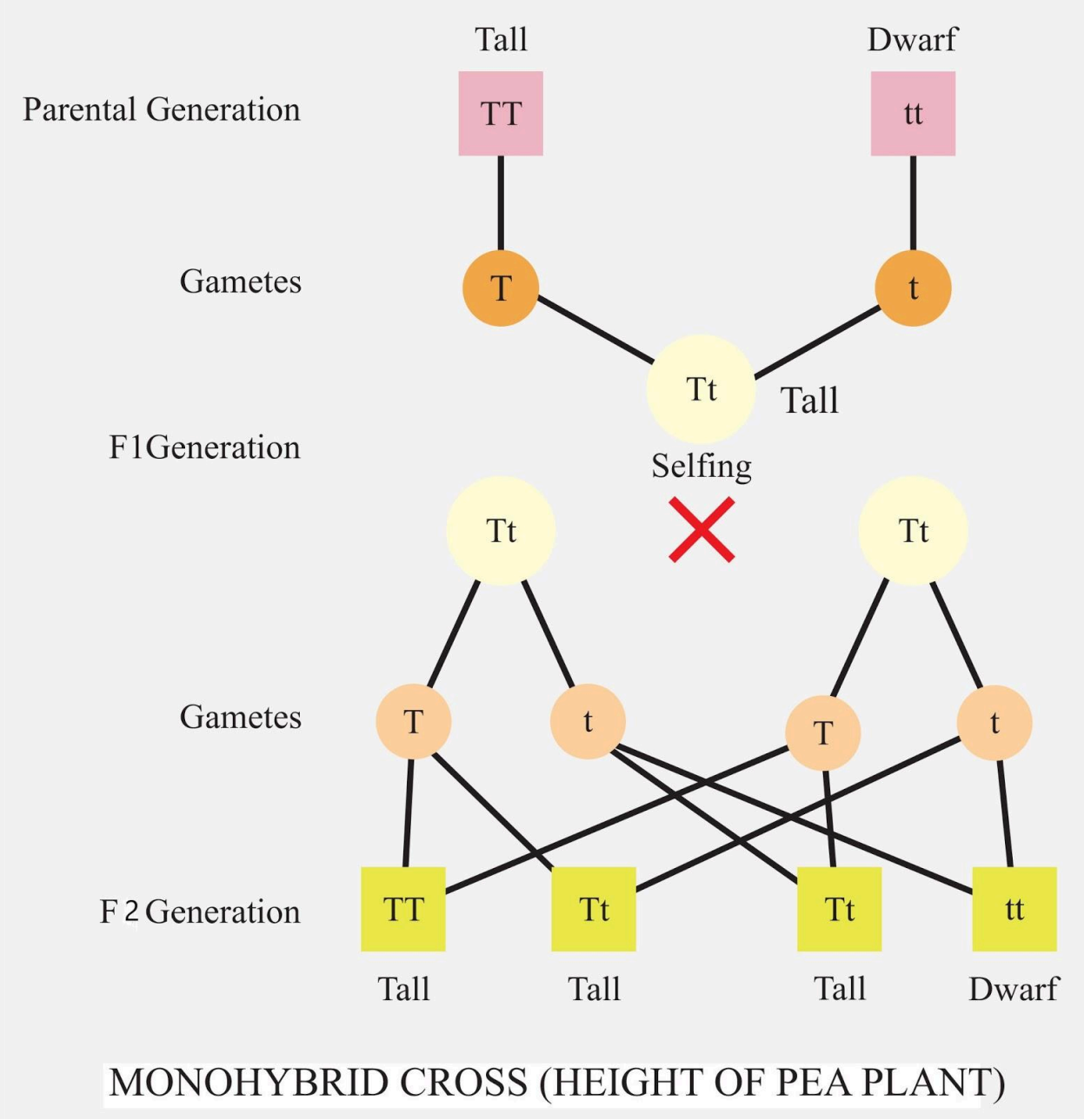


Mendel's Experiment

- Developed **true-breeding plants** through repeated self-fertilisation.
- Worked with **seven pairs of contrasting traits** in pea plants.

Hybridization

- Mendel cross-fertilised plants with different traits.
- Example:
    - Round-seed plant × Wrinkled-seed plant (monohybrid cross).
    - Round, yellow-seed plant × Wrinkled, green-seed plant (dihybrid cross).
- These experiments helped explain **dominance, recessiveness, and segregation of traits**.



7.3.1. Inheritance of a Single Trait by Monohybrid Cross

- A **monohybrid cross** involves the study of the inheritance of a single trait (e.g., seed shape).
- Mendel crossed two plants differing in **one trait**.

Mendel's Procedure & Observations

1. **Parental Cross (P1 Generation):**
    - True-breeding round seed plant (RR) × True-breeding wrinkled seed plant (rr).
    - True breed is always homozygous
    - Gametes: R and r.
    - **F1 Generation:** All offspring (Rr) ⟶ round seeds (round is dominant).
2. **Self-fertilisation of F1:**
    - F1 (Rr × Rr).
    - **F2 Generation ratio:**
        - **Phenotype ratio:** 3 round: 1 wrinkled.
        - **Genotype ratio:** 1 RR: 2 Rr: 1 rr.
    - Thus, 25% true-breed round (RR), 50% heterozygous round (Rr), 25% wrinkled (rr).

Conclusion / Interpretation of Results

Mendel concluded:

1. Traits are controlled by **factors (genes)** passed from parents to offspring.
   Each plant carries **two alleles** for each trait (one from each parent).
2. **Dominant alleles** (R) are expressed, while **recessive alleles** (r) are hidden in F1 but reappear in F2.
3. During **gamete formation**, alleles segregate independently into different gametes.
4. The gene pair is **restored** upon fertilisation.

Law of Segregation

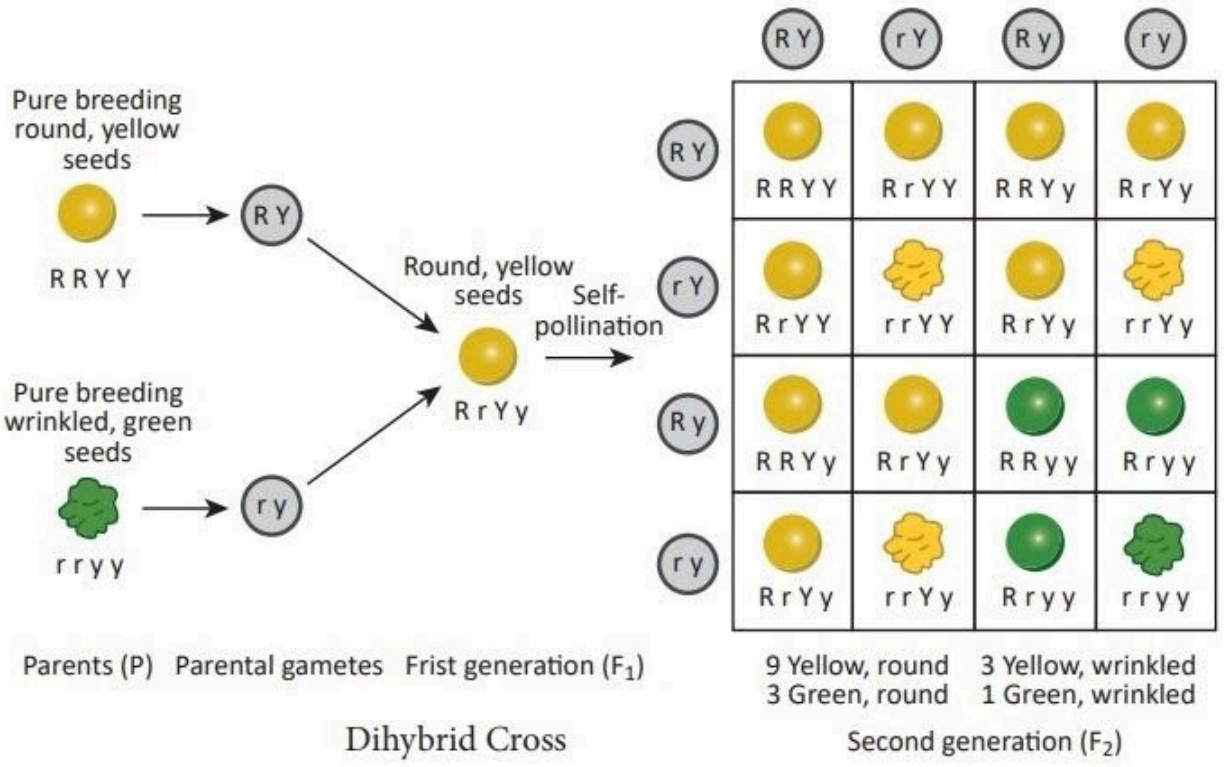
- In monohybrid crosses, **alleles of a gene pair segregate** during gamete formation (meiosis) and recombine randomly during fertilisation.

7.3.2. Inheritance of Two Traits by Dihybrid Cross

A **dihybrid cross** involves the study of inheritance of **two traits simultaneously** (e.g., seed shape and seed color).

Mendel's Procedure & Observations

1. **Parental Cross (P1 Generation):**
    - True-breeding round yellow (RRYY) × True-breeding wrinkled green (rryy).
    - **F1 Generation:** All offspring (RrYy) ⟶ round yellow (dominant traits).
2. **Self-fertilization of F1 (RrYy × RrYy):**
    - Mendel expected a 3:1 ratio (like in monohybrid), but observed a **9:3:3:1 ratio**.
3. **F2 Generation combinations:**
    - Round yellow:9
    - Round green:3
    - Wrinkled yellow:3
    - Wrinkled green:1



Dihybrid Cross

Conclusion / Interpretation of Results

- New combinations appeared (e.g., round green, wrinkled yellow).
- Mendel concluded:
    1. Alleles of one gene pair (R and r) **assort independently** of the alleles of another gene pair (Y and y).
    2. This is called the **Law of Independent Assortment**.

3. F1 individuals (RrYy) produced gametes in equal proportions: RY, Ry, rY, ry.

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