

2. PRINCIPLES OF INHERITANCE AND VARIATION

Single Page Simple Synopsis

Genetics is the branch of biology that studies inheritance (how traits are passed from parents to offspring) and variation (the differences between individuals within a species).

1. Basic Terms:

- **Gene:** The basic functional unit of heredity, located on chromosomes.
- **Allele:** Alternative forms of a single gene
Ex: T for tall and t for dwarf that control contrasting traits.
- **Genotype & Phenotype:** The genetic makeup of an individual (genotype) and the observable physical expression of those genes (phenotype).
- **Homozygous:** Having identical alleles for a trait **Ex:** TT or tt is homozygous.
- **Heterozygous:** Having different alleles. **Ex:** Tt is heterozygous.

2. Mendel's Laws of Inheritance:

- **Law of Dominance:** In a heterozygous organism, one trait (the dominant allele) will mask the presence of the other trait (the recessive allele).
- **Law of Segregation:** Alleles pairs separate during gamete formation so that each gamete receives only one allele. They are reunited upon fertilization without any blending.
- **Law of Independent Assortment:** Alleles of two or more different genes are sorted into gametes independently of one another.

3. Post Mendelian Discoveries:

- **Incomplete Dominance:** Neither allele is completely dominant, resulting in an intermediate phenotype. **Ex:** A pink snapdragon flower when red and white are crossed.
- **Co-dominance:** Both alleles are fully and simultaneously expressed
Ex: ABO blood typing where both A and B proteins are expressed.
- **Chromosomal Theory of Inheritance:** Proposed by Sutton and Boveri, this theory states that chromosomes are the vehicles of genetic heredity. This was further expanded by T.H. Morgan.

4. Causes of Genetic Variation:

- **Mutation:** Sudden, permanent changes in the DNA sequence.
- **Genetic Recombination:** The exchange of genetic material between homologous chromosomes during meiosis (crossing over), creating new allele combinations.
- **Genetic Disorders:** Alterations in genes or chromosomes can lead to heritable disorders:
- **Mendelian Disorders:** Caused by mutations in a single gene
Ex: Hemophilia, Sickle Cell Anemia, Color Blindness.
- **Chromosomal Disorders:** Caused by an excess, absence, or abnormal arrangement of chromosomes **Ex:** Down Syndrome, Klinefelter's Syndrome

ROOT POINTS

1. **Genetics** is the scientific branch dealing with the **inheritance** and **variation** of characters from parents to offspring.
2. **Inheritance** serves as the basis of heredity, representing the process by which characters pass from parent to progeny.
3. **Variation** is defined as the degree to which offspring differ from their parents in their characteristics.
4. **Gregor Mendel** conducted hybridization experiments on garden peas for seven years.
5. **Mendel** studied **seven pairs of contrasting traits** in pea plants, including stem height, flower color, and seed shape.
6. For **Mendel's** experiments, he selected **14 true-breeding pea plant varieties** as pairs.
7. A **monohybrid cross** involves crossing plants that differ in only one character, such as tall versus dwarf stems.
8. In Mendel's height cross, all **F₁ plants were tall**, and the dwarf trait was not expressed.
9. Upon self-pollinating F₁ plants, the **F₂ generation** expressed both the tall and dwarf traits.
10. The **F₂ phenotypic ratio** was observed to be 3/4 tall and 1/4 dwarf.
11. **Genes** contain the specific information required to express a particular trait in an organism.
12. **Alleles** are slightly different forms of the same gene that code for a pair of contrasting traits.
13. **Homozygous** refers to identical allelic pairs (TT or tt), whereas **heterozygous** pairs (Tt) are dissimilar.
14. In a pair of dissimilar factors, the one that expresses itself is the **dominant factor**, while the hidden one is **recessive**.
15. The **Punnett Square**, created by Reginald C. Punnett, is a graphical tool used to calculate the probability of genotypes.
16. Random fertilization in a monohybrid cross result in an F₂ genotypic ratio of **1:2:1 (TT:Tt:tt)**.
17. The phenotypic ratio of 3:1 in F₂ is due to the **dominance** of one allele over the other.
18. The **Law of Dominance** states that characters are controlled by discrete units (factors) occurring in pairs.
19. The **Law of Segregation** explains that alleles do not blend and are recovered unchanged in the F₂ generation.
20. **Incomplete dominance** occurs when the F₁ phenotype is an intermediate blend of both parents, as in snapdragon flowers.
21. **Co-dominance** is seen when the F₁ generation resembles both parents, such as in human ABO blood groups.

22. **ABO blood groups** are controlled by gene I, which possesses three different alleles: IA, IB, and i.
23. The presence of three alleles for one gene in a population is an example of **multiple alleles**.
24. A **dihybrid cross** involves crossing plants that differ in two characters, such as seed color and seed shape.
25. In Mendel's dihybrid cross, yellow color and round shape were found to be the **dominant traits**.
26. The F₂ phenotypic ratio for a dihybrid cross is typically **9 : 3 : 3 : 1**.
27. The **Law of Independent Assortment** states that the segregation of one pair of traits is independent of another pair.
28. **Thomas Hunt Morgan** verified the chromosomal theory using the fruit fly, *Drosophila melanogaster*.
29. **Linkage** is the term for the physical association of genes on the same chromosome.
30. **Recombination** refers to the generation of non-parental gene combinations during inheritance.
31. **Alfred Sturtevant** mapped the position of genes on chromosomes using recombination frequencies as a measure of distance.
32. Number of pairs of contrasting characters in pea plants which were studied by Mendel in his experiments is **seven**. [NEET-2015]
33. The mechanism that causes a gene to move from one linkage group to another is called **translocation**. [NEET-2016]
34. The term '**Linkage**' was coined by **T.H Morgan**. [NEET-2017]
35. Expressed sequence Tags (ESTs) refer to '**genes expressed as RNA**'. [NEET-2019]
36. Variations caused by mutation as proposed by Hagedorn are '**random & directionless**'. [NEET-2019]
37. Experimental verification of the chromosomal theory of inheritance was done by **Morgan**. [NEET-2020]
38. Experimental verification of chromosomal theory of inheritance was done by Morgan [NEET-2020]
39. **Punnett square** is the diagram where formation of Zygotes, the F₁, F₂ plants can be understood where formation of zygotes. [NEET-2021]
40. The chromosomal theory of inheritance was proposed by **Sutton & Boveri**. [NEET-2022]
41. **Non-Mendelian inheritance pattern** is the pattern of Inheritance of polygenic trait. [NEET-2025]