

Genetics

- **Genetics:** It is the branch of science that deals with the principles of inheritance and its practices.
- Mendel was the first to carry out the study on the transmission of characteristics from parents to offspring.
- Mendel proposed that heredity is controlled by genes.
- **Mendel's law of inheritance**
- Mendel experimented on garden pea plant (*Pisum sativum*) having many visible contrasting characters.
- He used seven contrasting pairs of characters or traits in garden pea.

Trait	Dominant trait	Recessive trait
Seed shape	Round	Wrinkled
Seed colour	Yellow	Green
Flower colour	Violet	White
Pod shape	Full	Constricted
Flower position	Axial	Terminal
Stem height	Tall	Dwarf
Pod colour	Green	Yellow

- Mendel crossed pea plants having these seven pairs of contrasting characters/traits and produced offspring from them.
- His experiments included three steps –
 - Selection of true breeding plants
 - Obtaining F₁ plants by cross pollination

- Self pollination of F1 plants to obtain F2 generation
- Important terms:
- **Genes:** Functional unit of heredity
- **Alleles:** Alternative forms of the same gene; for example, the gene for plant height in pea plant has two alleles T or t
- **Phenotype:** It is the physical expression of character; for example, tall and dwarf plants.
- **Genotype:** It is the genetic constitution of an organism; for example, TT or Tt is the genotype for tall plants while tt is the genotype for dwarf plants.
- **Dominant:** It is the character/trait that is able to express itself over another contrasting trait; for example, tall plant is dominant over dwarf plant.
- **Recessive:** It is the character/trait that is unable to express itself over another contrasting trait.
- **Test cross:** It is a cross between organisms with unknown genotype and recessive parents. This cross is used for determining whether the given individual has homozygous or heterozygous genotype.
- **Monohybrid cross:** It is a cross between two parents that have one pair of contrasting characters; for example, a cross between tall (TT or Tt) and dwarf (tt) plants.
- The phenotypic ratio obtained in monohybrid cross is 3:1 while genotypic ratio is 1:2:1.
- Based on observations on monohybrid crosses, two laws were proposed –
 1. **First law or law of dominance:** It states that only one parental trait gets expressed in the F1 generation while both the traits get expressed in the F2 generation.
 2. **Law of segregation:** It states that two alleles segregate from each other when characters are transferred from parents to offspring during reproduction.
- **Dihybrid cross:** It is the cross between two parents that have two pairs of contrasting characters; for example, the cross between round yellow seed and wrinkled green seeds.
- The phenotypic ratio obtained in dihybrid cross is 9:3:3:1.

- On the basis of observation of dihybrid cross, the law of independent assortment was proposed.

Law of independent assortment: It states that the members of different pairs of alleles assort independently into gametes.

- **Incomplete dominance**

- It is the phenomenon where one allele is incompletely dominant over the other member of the allelic pair.
- Both phenotypic and genotypic ratios are the same in the case of incomplete dominance, i.e., 1:2:1.

- **Co-dominance**

- It is the phenomenon where both the alleles of a gene are equally dominant and get expressed together in heterozygous condition; for example, ABO blood group in humans.
- Blood group ABO is an example of multiple alleles.

- **Sex determination**

- **Female heterogamy:** Presence of two kinds of sex chromosomes in the female; only one kind is present in the male; for example, birds (the female has ZW sex chromosome while the male has ZZ sex chromosome)
- **Male heterogamy:** Presence of two kinds of sex chromosomes in the male; only one kind is present in the female; for example, humans, Drosophila (the female has XX sex chromosome while the male has XY sex chromosome)
- In humans, the genetic make up of the sperm determines the sex of the baby. The genotype of male is XY and the genotype of a female is XX.
- Examples of sex linked Genetic Disorders
- **Haemophilia** – Sex-linked recessive disorder that affects the clotting of blood.
- **Colour blindness** – recessive X linked disease in which the person is not able to differentiate between two colours – red and green

- **Heredity-** transmission of characteristics or traits from parents to offsprings.

- **Variations**- difference among individuals of a species and also among offsprings of same parents.
- Variations are of two types- heritable and non-heritable.
- **Basis of heredity**- each trait is influenced by both maternal and paternal DNA.

Mendel's work

- Proposed- heredity is controlled by factors. Factors are now called genes.
- Performed experiments on garden pea (*Pisum sativum*)
- Used seven contrasting pairs of characters or traits to study heredity.
- **Dominant trait**- able to express itself over another contrasting trait
- **Recessive trait**-unable to express its effect in the presence of a dominant trait
- Mendel represented- dominant trait as upper case (e.g., T for tallness) and recessive trait as lower case (e.g., t for shortness)
- **Homozygous**- when the factors or genes of a trait are similar e.g., TT or tt
- **Heterozygous**- when the factors or genes of a trait are different e.g., Tt
- **Genotype**-genetic constitution of an organism e.g., pure tall- TT
- **Phenotype**-observable traits or characteristics of an organism e.g., tallness, shortness etc.
- **Genotypic ratio**-expected ratio of genotypes produced by a particular cross
- **Phenotypic ratio**-expected ratio of phenotypes produced by a particular cross
- **Monohybrid cross**-involves only one pair of contrasting characters
- **Phenotypic ratio in monohybrid cross is 3:1**
- **Dihybrid cross**-involves two pairs of contrasting characters
- **Phenotypic ratio in dihybrid cross is 9:3:3:1**

Stages of Mendel's experiment

- Selection of parents- true breeding with contrasting pairs of traits e.g., pure tall (TT) and pure dwarf (tt) pea plants were selected
- Obtaining F₁ plants- F₁ generation is the first filial generation, formed after crossing desirable parents e.g., crossing pure tall (TT) and dwarf (tt) plants gives heterozygous tall (Tt) F₁ plants
- Self-pollination of F₁ plants- involves crossing F₁ plants to obtain F₂ plants
- **Dihybrid cross**: It is the cross between two parents that have two pairs of contrasting characters; for example, the cross between round yellow seed and wrinkled green seeds.
- The phenotypic ratio obtained in dihybrid cross is 9:3:3:1.
- On the basis of observation of dihybrid cross, the law of independent assortment was proposed.

Principles of Mendel

- Each characteristic in an organism is represented by two factors
- Two factors are - dominant and recessive
- Two contrasting factors when present in an individual do not blend
- When more than two factors are involved, they are independently inherited
- Heredity occurs at cellular level
- Inside the nucleus of a cell, heredity material is present in the form of DNA
- DNA associates with proteins to form chromosomes
- Every somatic (body) cell of the human body has 23 pairs (46) of chromosomes
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 - **In humans,** the genetic make up of the sperm determines the sex of the baby.
- **Sex determination in honey bees**
 - Show a special mechanism of sex determination called the haplo-diploidy.
 - Unfertilized eggs develop into males.
 - Fertilized eggs develop into females.
- **Sex-Linked Inheritance**
 - The appearance of a trait because of the presence of an allele either on X chromosome or Y chromosome is called Sex-linked Inheritance.
- **Diseases observed in X-linked Inheritance**
 - Haemophilia
 - Colour-Blindness
- **Criss-Cross Inheritance**
 - The transfer of a gene from mother to son or father to daughter is called as criss-cross inheritance. For e.g. in X-chromosome linkage