CHAPTER- 05
PRINCIPLES OF INHERITANCE AND VARIATION

part 4
12 biology

Genetics is the study of principles and mechanism of heredity and variation. Gregor Johann Mendel is known as 'father of Genetics'.

- **Inheritance** is the process by which characters are passed on from parent to progeny. It is the basis of heredity.
- **Variation** is the degree by which progeny differ from their parents. Variation may be in terms of morphology, physiology, cytology and behavioristic traits of individual belonging to same species.
- Variation arise due to
    - Reshuffling of gene/chromosomes.
    - Crossing over or recombination
    - Mutation and effect of environment.

Mendel's Law of Inheritance : Mendel conducted hybridization experiments on garden pea (*Pisum sativum*) for seven years and proposed the law of inheritance in living organisms.

Selection of pea plant: The main reasons for adopting garden pea (Pisum sativum) for experiments by Mendel were –

- Pea has many distinct contrasting characters.
- Life span of pea plant is short.
- Flowers show self pollination, reproductive whorls being enclosed by corolla.
- It is easy to artificially cross pollinate the pea flowers. The hybrids thus produced were

Working method: Mendel's success was also due to his meticulous planning and method of work –

- He studied only one character at a time.
- He used all available techniques to avoid cross pollination by undesirable pollen grains.
- He applied mathematics and statistics to analyse the results obtained by him.
- Mendel selected 7 contrasting characters of garden pea for his hybridization experiments

Contrasting Characters Studied by Mendel in Pea

Character	Contrasting character (Dominant/Recessive)
Stem height	Tall/Dwarf
Flower colour	Violet/White
Flower position	Axial/Terminal
Pod shape	Inflated/Constricted
Pod colour	Green/Yellow

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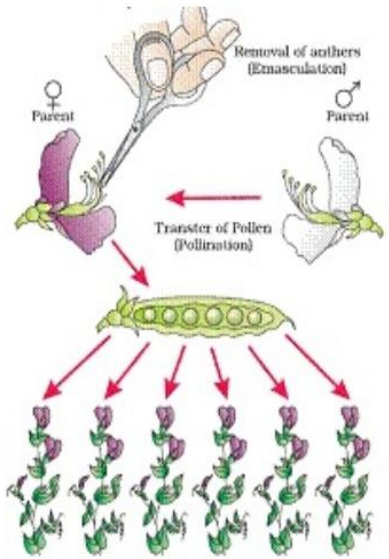
- Mendel conducted artificial hybridization/cross pollination using true breeding pea lines. True breeding lines are those that undergo continuous self-pollination and shows stable trait inheritance.
- Hybridization experiment includes emasculation (removal of anther) and transfer of pollen (pollination).



Inheritance of one gene (Monohybrid cross)

Mendel crossed tall and dwarf pea plant and collected all the seeds obtained from this cross. He grew all the seeds to generate plants of first hybrid generation called F1 generation. He observed that all the plants are tall. Similar observation was also found in other pair of traits.

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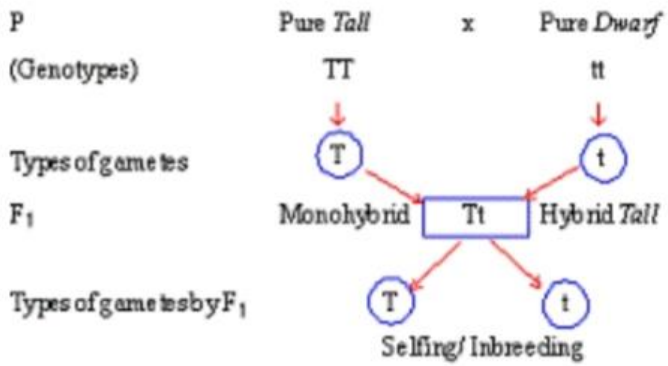
Mendel self-pollinated the F1 plants and found that in F2 generation some plants are also dwarf. The proportion of dwarf plants is 1/4th and tall plants of 3/4th.



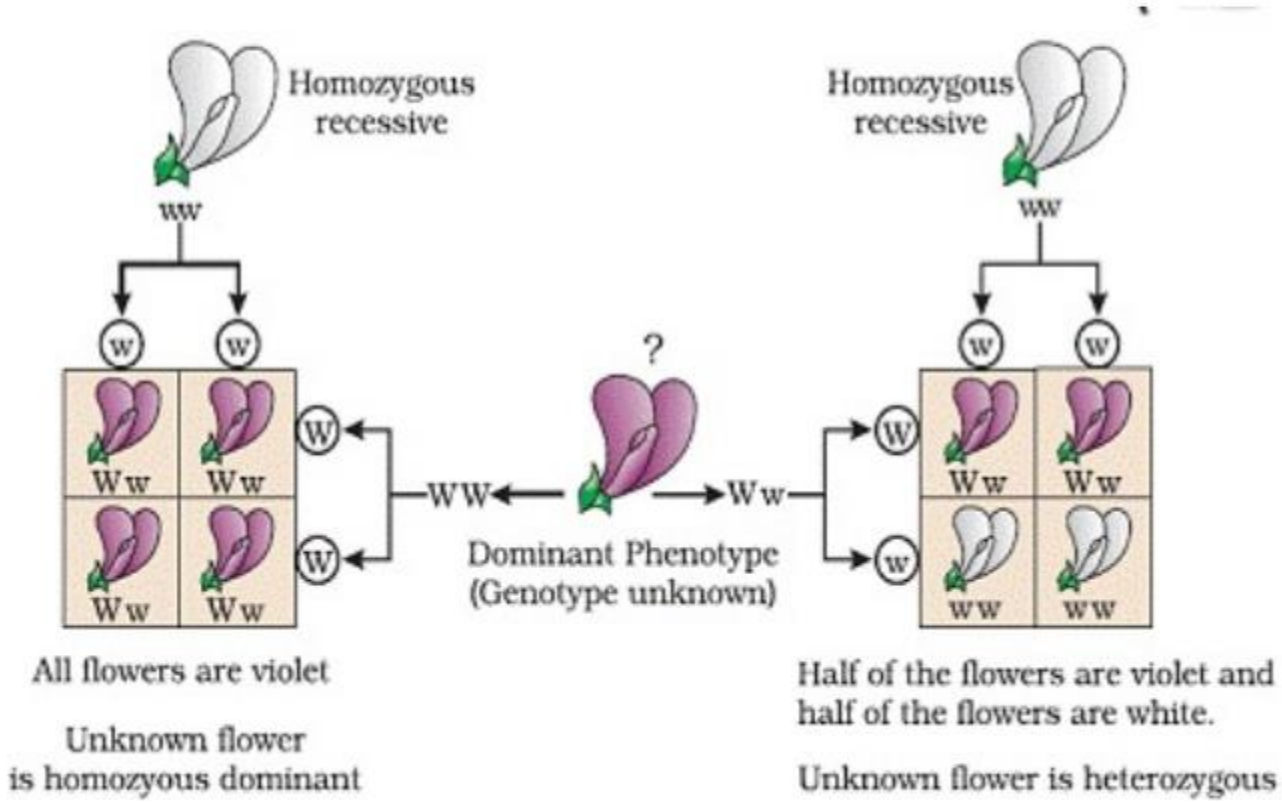
F_2 *Punnet's square* or *Checker board*

Phenotypic ratio
3 *Tall* : 1 *Dwarf*
75% : 25%

Genotypic ratio in F_2
Pure *Tall* : Hybrid *Tall* : Pure *Dwarf*
1 TT : 2 Tt : 1 tt

- Mendel called the '**factors**' that passes through gametes from one generation to next generation. Now a day it is called as genes (unit of inheritance).
- Genes that code for a pair of contrasting traits are known as **alleles**.
- Alphabetical symbols are used to represent each gene, capital letter (TT) for gene expressed in F1 generation and small letter (tt) for other gene.
- Mendel also proposed that in true breeding tall and dwarf variety allelic pair of genes for height is **homozygous** (TT or tt). TT, Tt or tt are called **genotype** and tall and dwarf are called **phenotype**.
- The hybrids which contain alleles which express contrasting traits are called **heterozygous** (Tt).
- The monohybrid ratio of F2 hybrid is 3:1(phenotypic) and 1:2:1(genotypic).

Test cross is the cross between an individual with dominant trait and a recessive organism in order to know whether the dominant trait is homozygous or heterozygous.



Principle or Law of Inheritance

Based on observations of monohybrid cross, Mendel proposed two law of inheritance-

1. **Law of dominance**- states that –

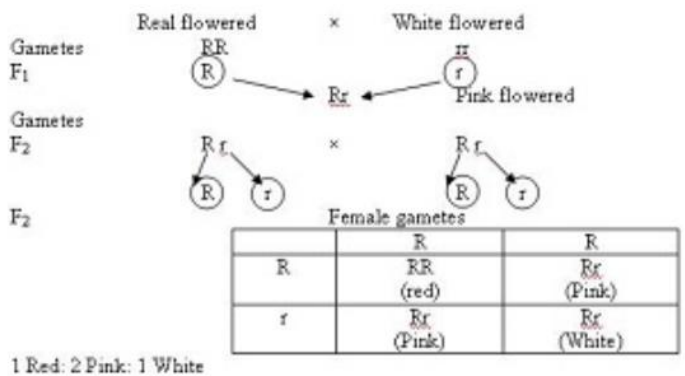
a. Characters are controlled by discrete units called factors.
b. Factors always occur in pair.
c. In a dissimilar pair of factors one member of pair dominate the other.

	Dominance	Recessive
(i)	When a factor (allele) expresses itself in the presence or absence of its dominant factor called dominance.	It can only express itself in the absence of or its recessive factor allele.
(ii)	It forms a complete functional enzyme that perfectly express it.	It forms a incomplete defective enzyme which fails to express itself when present with its dominant allele, i.e., in heterozygous condition.

2. **Law of Segregation-** alleles do not blends and both the characters are recovered during gametes formation as in F2 generation. During gametes formation traits segregate (separate) from each other and passes to different gametes. Homozygous produce similar kinds of gametes but heterozygous produce to different kinds of gametes with different traits.

Incomplete dominance

- It is a post Mendelian discovery. Incomplete dominance is the phenomenon of neither of the two alleles being dominant so that expression in the hybrid is a fine mixture or intermediate between the expressions of two alleles.
- In snapdragon (Mirabilis jalapa), there are two types of pure breeding plants, red flowered and white flowered. On crossing the two, F1 plants possess pink flowers. On selfing them, F2 generation has 1red: 2 pink: 1white. The pink flower is due to incomplete dominance.



Co-dominance

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- It is the phenomenon of two alleles lacking dominance-recessive relationship and both expressing themselves in the organism.
- Human beings, ABO blood grouping are controlled by gene *I*. The gene has three alleles I^A, I^B and *i*. Any person contains any two of three allele I^A, I^B are dominant over *i*.
- The plasma membrane of the red blood cells has sugar polymers that protrude from its surface and the kind of sugar is controlled by the gene.
- When I^A and I^B are present together, both express their own types of sugars because of co-dominance.

	Incomplete Dominance		Co-Dominance
1.	Effect of one of the two alleles is more conspicuous.	1.	Effect of both the alleles are equally conspicuous.
2.	It produces a mixture of the expression of two alleles.	2.	There is no mixing of the effect of the two alleles.
3.	The F1 does not resemble either of the parents.	3.	The F1 resembles both the parents.