Genetics

MENDEL'S LAWS OF INHERITANCE

Gregor Mendel, conducted hybridisation experiments on garden peas for seven years (1856-1863) and proposed the laws of inheritance in living organisms.

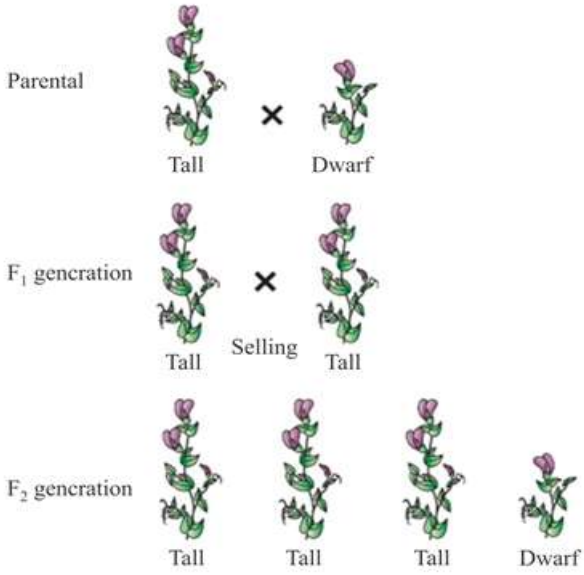
Contrasting Traits Studied by Mendel in Pea –

S.No.	Characters	Contrasting Traits
1.	Stem height	Tall/dwarf
2.	Flower colour	Violet/white
3.	Flower position	Axial/terminal
4.	Pod shape	Inflated/constricted
5.	Pod colour	Green/yellow
6.	Seed shape	Round/wrinkled
7.	Seed colour	Yellow/green

INHERITANCE OF ONE GENE

Mendel where he crossed tall and dwarf pea plants to study the inheritance of one gene. He collected the seeds produced as a result of this cross and grew them to generate plants of the first hybrid generation. This generation is also called the Filial$_1$ progeny or the F_1. Mendel observed that all the F_1 progeny plants were tall, like one of its parents; none were dwarf.

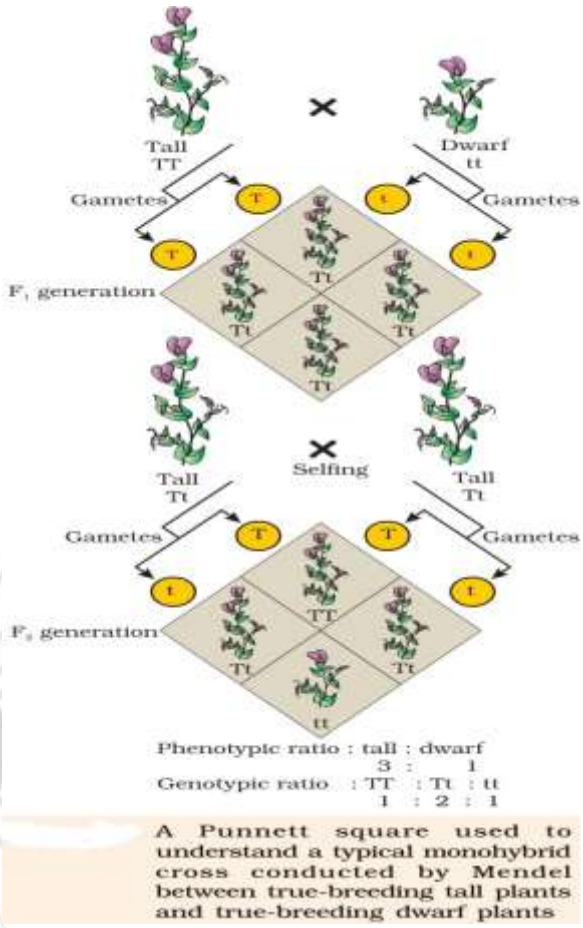
Mendel then self-pollinated the tall F_1 plants and to his surprise found that in the Filial$_2$ generation some of the offspring were 'dwarf'; the character that was not seen in the F_1 generation was now expressed.



Diagrammatic representation of monohybrid cross

Based on these observations, Mendel proposed that something was being stably passed down, unchanged, from parent to offspring through the gametes, over successive generations. He

called these things as 'factors'. Now we call them as genes. Genes, therefore, are the units of inheritance. They contain the information that is required to express a particular trait in an organism. Genes which code for a pair of contrasting traits are known as alleles, i.e., they are slightly different forms of the same gene.



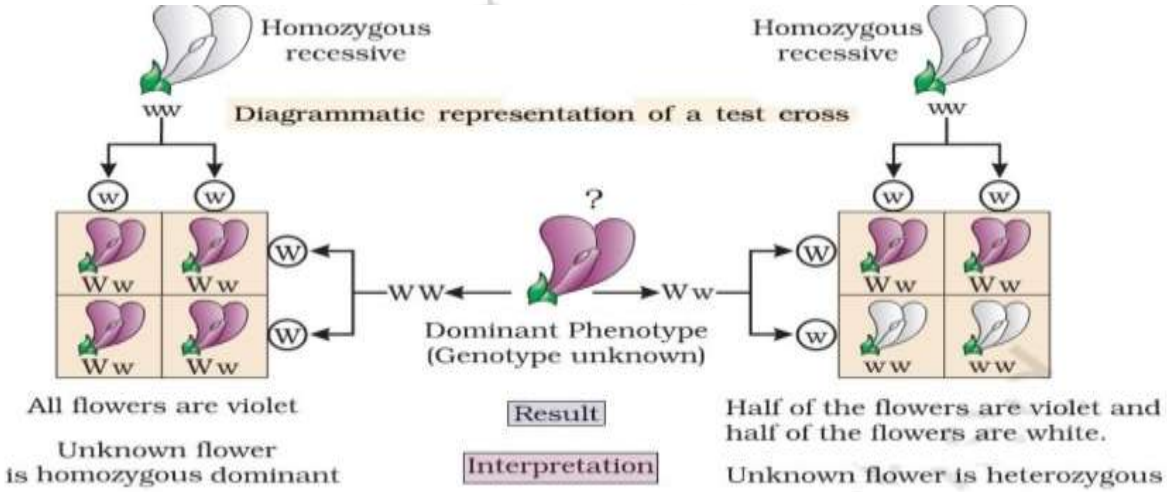
A Punnett square used to understand a typical monohybrid cross conducted by Mendel between true-breeding tall plants and true-breeding dwarf plants

If we use alphabetical symbols for each gene, then the capital letter is used for the trait expressed at the F1 stage and the small alphabet for the other trait. For example, in case of the character of height, T is used for the Tall trait and t for the 'dwarf', and T and t are alleles of each other.

TT, tt the allelic pair of genes for height are identical or homozygous. TT and tt are called the genotype of the plant while the descriptive terms tall and dwarf are the phenotype.

As Mendel found the phenotype of the F1 heterozygote Tt to be exactly like the TT parent in appearance, he proposed that in a pair of dissimilar factors, one dominates the other (as in the F_1) and hence is called the dominant factor while the other factor is recessive . In this case T (for tallness) is dominant over t (for dwarfness), that is recessive.

Tt hybrids contain alleles which express contrasting traits, the plants are heterozygous. Mendel crossed the tall plant from F2 with a dwarf plant. This he called a test cross. The progenies of such a cross can easily be analyzed to predict the genotype of the test organism.



Laws –

(1) Law of Dominance –

1. Characters are controlled by discrete units called factors.
2. Factors occur in pairs.
3. In a dissimilar pair of factors one member of the pair dominates (dominant) the other (recessive).

(2) Law of Segregation –

This law is based on the fact that the alleles do not show any blending and that both the characters are recovered as such in the F_2 generation though one of these is not seen at the F_1 stage. Though the parents contain two alleles during gamete formation, the factors or alleles of a pair segregate from each other such that a gamete receives only one of the two factors. Of course, a homozygous parent produces all gametes that are similar while a heterozygous one produces two kinds of gametes each having one allele with equal proportion.

Exception –

Law (1) – Incomplete Dominance

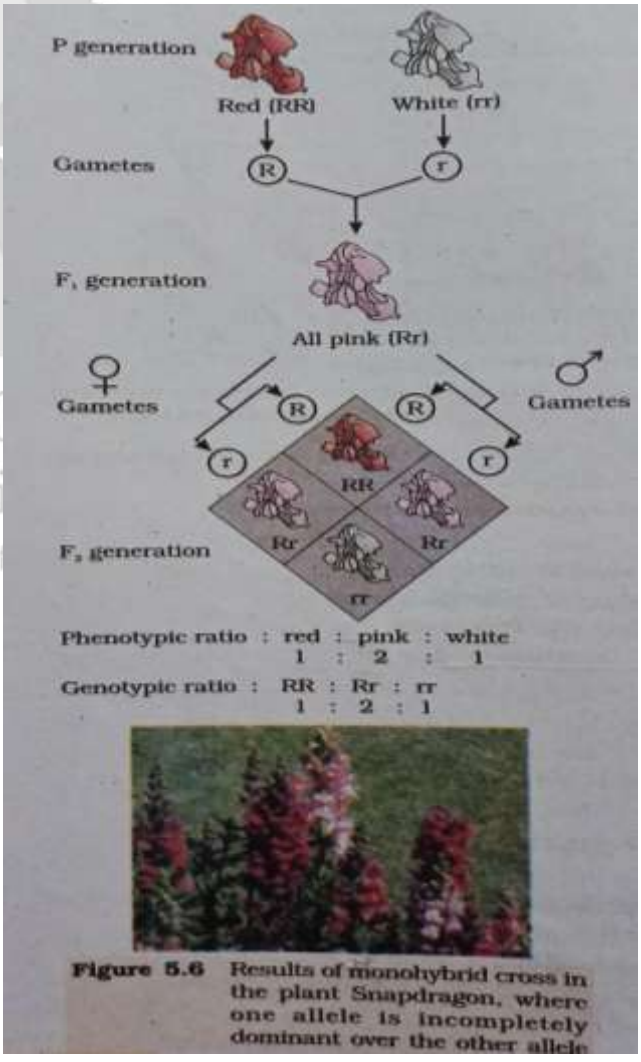


Figure 5.6 Results of monohybrid cross in the plant Snapdragon, where one allele is incompletely dominant over the other allele

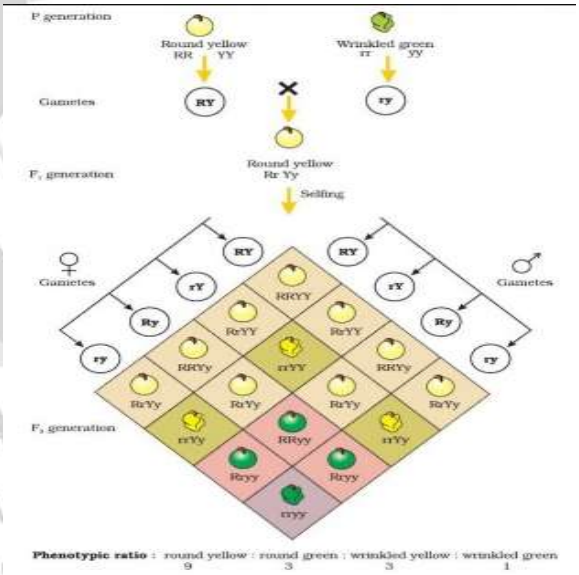
Law (2) – Co-dominance

Table Showing the Genetic Basis of Blood Groups in Human Population

Allele from Parent 1	Allele from Parent 2	Genotype of offspring	Blood types of offspring
I^A	I^A	$I^A I^A$	A
I^A	I^B	$I^A I^B$	AB
I^A	i	$I^A i$	A
I^B	I^A	$I^A I^B$	AB
I^B	I^B	$I^B I^B$	B
I^B	i	$I^B i$	B
i	i	$i\,i$	O

INHERITANCE OF TWO GENES

Let us use the genotypic symbols Y for dominant yellow seed colour and y for recessive green seed colour, R for round shaped seeds and r for wrinkled seed shape. The genotype of the parents can then be written as RRYY and rryy.



Results of a dihybrid cross where the two parents differed in two pairs of contrasting traits: seed colour and seed shape

Law (3) – Law of Independent Assortment

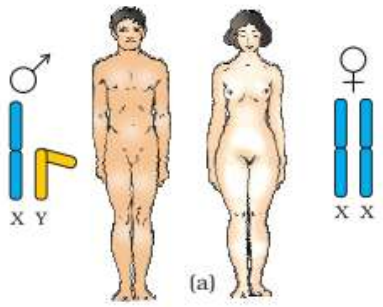
The law states that 'when two pairs of traits are combined in a hybrid, segregation of one pair of characters is independent of the other pair of characters'.

Linkage and Recombination

When the two genes in a dihybrid cross were situated on the same chromosome, the proportion of parental gene combinations was much higher than the non-parental type. Physical association or linkage of the two genes and coined the term linkage.

SEX DETERMINATION

Due to the involvement of the X-chromosome in the determination of sex, it was designated to be the sex chromosome, and the rest of the chromosomes were named as autosomes.



Males have autosomes plus XY; while female have autosomes plus XX.

Out of 23 pairs of chromosomes present, 22 pairs are exactly same in both males and females; these are the autosomes. A pair of X-chromosomes is present in the female, whereas the presence of an X and Y chromosome are determinant of the male characteristic.

There is an equal probability of fertilisation of the ovum with the sperm carrying either X or Y chromosome. In case the ovum fertilises with a sperm carrying X-chromosome the zygote develops into a female (XX) and the fertilisation of ovum with Y-chromosome carrying sperm results into a male offspring. Thus, it is evident that it is the genetic makeup of the sperm that determines the sex of the child. It is also evident that in each pregnancy there is always 50 per cent probability of either a male or a female child.