

BOTANY (HONS.) PAPER III Unit IV

Mendel's Principles and its modifications

Genetics

Genetics is a branch of biology concerned with the study of genes, genetic variation, and study of hereditary characters (genetic characters passed on from generation to generation) in organisms.

Gregor Johann Mendel

Gregor Johann Mendel (1822-1884) is called as Father of Genetics. Gregor Mendel, a scientist and Augustinian friar working in the 19th century, was the first to study genetics scientifically. Gregor Johann Mendel (1822-1884) is called as Father of Genetics. He was born in 1822 to a family of poor fathers an area that is now part of Czech Republic.

Earlier in 1847, Mendel worked as priest in Augustinian Monastery at Brunn and was ordained. But he has great interest in plant hybridization. In 1849 Mendel join the University of Vienna for training in physics, mathematics and the natural sciences as temporary teacher. In 1854 Mendel again took up the profession of a teacher and continued there for fourteen years. During this long period he conducted his famous garden pea experiments in the monastery garden which develops the concept of Mendel's Principles of Genetics

Mendel experimented on garden pea (*Pisum sativum*) in the monastery garden for about nine years (1856-1864) and published his results in a less known journal-The Annual proceedings of the Natural History Society of Brunn in 1865.

Mendel's Experiments:

Mendel performed cross breeding experiments on garden pea (*Pisum sativum*). He examined the inheritance behaviour of seven pairs of contrasting characters in this plant but considered only one pair at once a time. For example at a time, he crossed two pea plants having

contrasting characters of height (tall and dwarf pea plants) by artificial pollination and obtained the result of hybrids (F1 generation). The resulting hybrid plants were then crossed with each other. He obtained the data from these crosses and analysed the results carefully (F2 generation).

List of seven pairs of contrasting characters in pea plant

<i>Character</i>	<i>Dominant</i>	<i>Recessive</i>
1. Stem length	Tall	Dwarf
2. Flower position	Axial	Terminal
3. Pod shape	Inflated	Constricted
4. Pod colour	Green	Yellow
5. Seed shape	Round	Wrinkled
6. Cotyledon colour	Yellow	Green
7. Seed coat colour	Grey	White

Mendel selected garden pea as his experimental material due to the following advantages:

1. Pea plant is easy to grow and interbreed.
2. Peas reproduce and grow to maturity in a season (an annual plant). Because of short life cycle several generations can be produced within a short period.
3. The pea plants have a number of contrasting characters.
4. The flowers are bisexual containing both male and female parts. They are self-fertilising in nature.
5. Because of easy self-fertilization, it is easy to get pure lines for several generations.
6. It is easy to hybridize because pollen from one plant can be introduced into the stigma of another plant by removing anthers.
7. It produces fertile hybrids. This enabled Mendel to continue his experiments for generations

For his experiment Mendel initially selected pea plants with contrasting characters such as tall and dwarf. These plants were pure or true breeding for particular character of height. For example, to get a pure line for tallness of the stem, he self-fertilized a tall pea plant for

several generations till the resulted offspring always produced only tall plants (P1). Likewise, he got genetically pure variety of dwarf pea plants by adopting the same technique (P2). Since garden pea is self-fertilizing, the panthers have to be removed before maturity. This operation of removal of anthers is called emasculation. The stigma is protected against any foreign pollen by bag cover. For each of the seven pairs of characters, plants with one alternative trait were used as female and those with the other alternative as male. Reciprocal crosses were also made. The population obtained as a result of crossing parent plants having contrasting characters is called the first filial generation or F_1 (filial means progeny). The F_1 plants when self-fertilised to produce second filial generation plants or F_2 plants. Similarly F_3 , F_4 etc. can be produced.

Mendelian Laws/ Principles of Genetics/ Heredity:

1. Principle of Unit Characters:

Mendel assumed that the unit of hereditary characters is the factors of determiners which occur in pairs. One of each comes from the mother while the other comes from the father. The unit character or factor is now called as gene.

2. Law of Dominance:

When a pair of contrasting characters (or allelomorphic characters or alleles) are present together, only one of them expresses itself and the other remains suppressed or hidden. The character which is expressed (or is visible) is called as dominant and the character which remains hidden is termed as recessive.

3. Law of Segregation or Purity of Gametes:

The allelic factors or genes present together in the hybrids segregate (separate) from one another and are placed in different gametes in the next generation.

4. Law of Independent Assortment:

When two or more pairs of contrasting characters are taken into consideration in a cross, each factor, assort or place itself independently of the other (during its passages from one generation to the other).

Mendelian Terminology:

1. Genotype and Phenotype:

Genotype refers to the genetic makeup or genetic constitution of an organism. Phenotype indicates the external appearance of an organism. TT and Tt are phenotypically same tall plants but genotypically different as one is pure tall (TT) and other is hybrid tall (Tt).

2. Homozygous and Heterozygous:

Every organism possesses two genes (alleles) for every character. If in an organism the two genes (alleles) for a particular character are identical (for example TT or tt), it is said to be pure or homozygous (homo = the same, zygo = a pair). If the organism possesses contrasting genes (alleles) for a particular character (for example Tt), it is said to be impure or heterozygous (hetero = different, zygo = a pair).

3. Dominant and Recessive:

A heterozygote possesses two contrasting genes (say 'Tt'), but only one of the two is able to express itself (tallness), while the other remains hidden (dwarfness). The gene which is able to express in 1, hybrid (here 'T') is known as dominant gene, while the other gene which is unable to express itself (here 't') in the presence of dominant gene is called as recessive gene.

4. Allele or Allelomorph:

Mendel stated that two genes (factors) representing two alternatives of a character are present on two separate chromosomes of a homologous pair but at the same loci or position. For example, in a gene pair Tt, T is present on one chromosome and t on the other chromosome but at the same locus or position. Each of them is called an allele to the other (T is an allele to t and vice versa).

5. Gene:

It is the unit of inheritance representing a particular characteristic. It is located in the chromosome and formed of a DNA segment. It was termed as factor or determiner.

6. Hybrid:

A progeny resulting from a cross between two parents differing at least in a single character.

7. Reciprocal Cross:

It is the second cross involving same genotypes as first cross but the sexes are reversed. If the first cross is Tall (female) x Dwarf (male), then the second or reciprocal cross will be Tall (male) x Dwarf (female).

P1 (tall male plant) x P2 (dwarf female plant) $\xrightarrow{\text{F}_1}$ progeny (tall)

P1 (tall female plant) x P2 (dwarf male plant) $\xrightarrow{\text{F}_1}$ progeny (tall)

As tall character trait/ gene are dominant

The reasons for Mendel's success are as follows:

1. Mendel studied the inheritance of one character at a time while previous researchers considered the organism all characteristics as a whole.
2. He carried out his experiments upto F2 and F3 generations.
3. His knowledge in statistics helped him to maintain accurate records of all the experiments of findings and analysed them carefully.
- 4 He grew pure lines in separate plots and conducted experiments by crossing two plants from pure strains
- 5 All this genetical experiments were conducted with utmost care and meticulous planning.