Section B and C

Volume-14

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8. INHERITANCE BIOLOGY

A. MENDELIAN PRINCIPLES

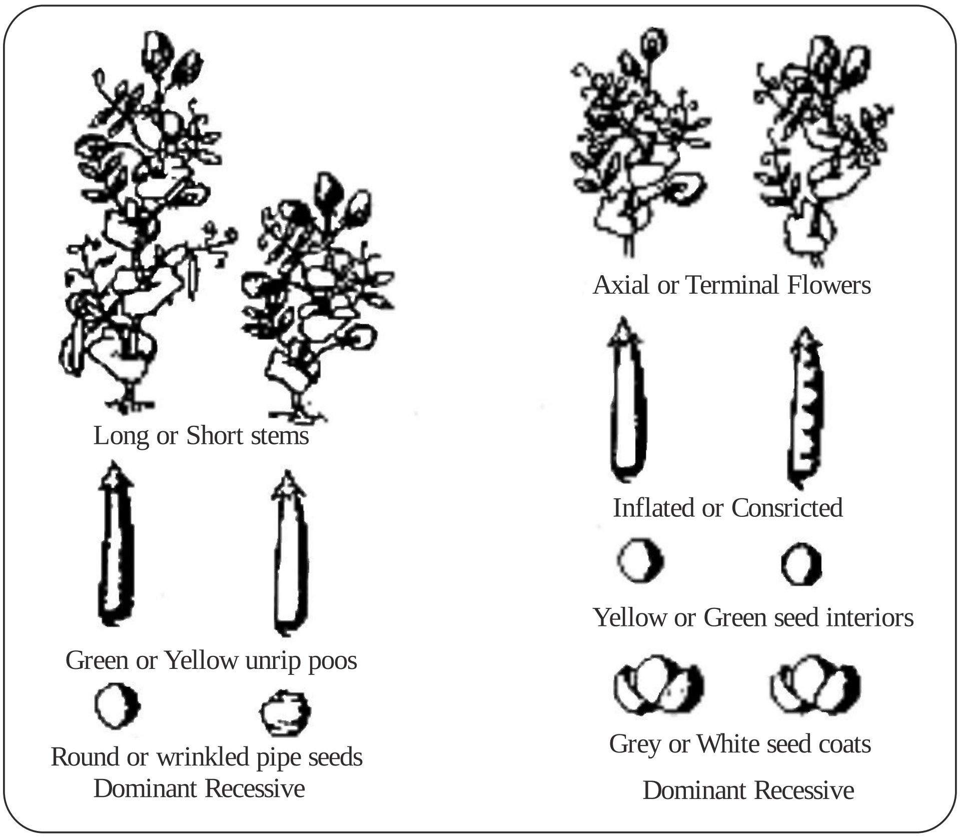
Johann Mendel was a peasant's son, born in 1822 in the village of Heinsendorf. In 1843 he entered the Augustian Monastery of Brunn, Austria and was given a new name, Gregor. Four years later he was appointed as priest, and became a teacher of Mathematics and languages in high school. In 1851 he was sent to study natural science at the University of Vienna, from where he returned to Brunn as a teacher of science in 1853. In 1856, he began to collect numerous varieties of the garden pea. He began hybridization experiments in the monastery gardens. In 1865, he presented the results of his experiments in a paper entitled *Experiments Plant Hybridization'* at the meetings of the *Natural History Society of Brunn*. The work was published in 1866 in the Proceedings of the Natural History Society of Brunn. Although this journal was distributed to libraries in Europe and America, Mendel's work was neglected for several years. It was far ahead of its time, and no one who read it in the 19th century could appreciate its significance. Mendel became involved with administrative duties in the monastery, and later died in 1884, unrecognized with his great work.

Rediscovery of Mendel's work. In 1900 Mendel's work was rediscovered. The editors of the Reports of the German Botanical Society received three papers till that year. One was from the well known Dutch botanist, Hugo *de* Vries, another from a 29 year old Austrian, Erich von Teschermak, and the third from Carl Correns, the 36 year old professor of Botany at Tubingen, Germany. All three workers became acquainted with Mendel's article only after completing their experiments, and while preparing their articles for publication. They mentioned Mendel's work, and thus independently rediscovered it.

Mendel's experiments: Mendel experimented with several varieties of the garden pea plant. He obtained seeds from traveling salesmen. Although the characteristics of the seeds were height of plants, color of flowers, form of seeds etc., marked on the packets. Every variety of seed was grown for two generations to confirm their advertised characteristics. Thus Mendel ensured that he experimented with true breeding varieties or pure lines. Mendel also made reciprocal crosses in his experiments. In these crosses, the characters remained the same, but the sexes of the parents were reversed. Thus if one cross was of tall male plants × short female plants, the reciprocal cross was of tall female plants × short male plants. After experiments with 30 different varieties of seeds, he finally chose seven different characters for his final experiments. These characters are shown in the table.

Table.1: Traits of the *Pisum sativum* Studied by Mendel

Sr.No.	Trait	Dominant value	Recessive value
1.	Height of plant	Tall	Short
2.	Position of Flower/Fruit	Axial	Terminal
3.	Color of Pod	Green	Yellow
4.	Shape of Pod	Inflated	Constricted
5.	Shape of Seed	Round	Wrinkled
6.	Color of Seed	Yellow	Green
7.	Color of Seed coat	Grey	White
8.	Color of Flower	Red	White



Mendel's choice of the pea plant: Mendel's choice of the garden pea plant *Pisum sativum* proved very satisfactory for his experiments on hybridization.

(i) Self fertilization normally occurs in the plant itself, giving it relatively homogenous genetic characteristics. Self pollination is equivalent to mating an individual with one exactly like itself,

(ii) The structure of the flower is such, that contamination by wind-blown or insect-borne foreign pollen is rare.

(iii) Cross pollination can, however, be achieved experimentally, although it is laborious. Mendel did this by opening a flower bud and removing the anthers to prevent self pollination. He then dusted the stigma with foreign pollen by using a brush. He was thus able to get the cross pollination he desired,

(iv) The garden pea plant provides several pairs of contracting traits for study,

(v) The pea plant provides a large number of progeny in a short period of time. This gives a large sample for statistical analysis.

Reasons for Mendel's success: Many workers had been trying to discover the laws of inheritance before Mendel. Why is it that Mendel succeeded while others had failed previously? The reasons are many.

(i) Mendel personally verified that he was working with pure lines before he started his experiments.

(ii) Earlier workers had tried to study the plant or animal as a whole. Mendel studied only a single character at a time.

(iii) Mendel counted all the progeny resulting from a cross. Thus inheritance was subjected to a statistical basis. His application of mathematics for studying a biological process was rare for the time.

(iv) Mendel kept accurate records of his experiments. He could thus trace the ancestry of any plant back to the beginning of the experiment,

(v) Mendel's choice of the pea plant for his experiments was arrived at as a result of careful thought,

(vi) A careful reading of Menders paper shows that he knew exactly what he was doing before he carried out his experiments. Thus Mendel's work stands out as a model of the scientific method.

2. Mendel's monohybrid cross:

Mendel carried out several crosses of pea plants considering only one pair of characters at a time. Such genetic crosses involving only one pair of contrasting genetic characteristics are called monohybrid crosses. As an example, we shall consider Mendel's cross of red-flowered anti white-flowered pea plants. The red-flowered variety was actually violet-red.

The parental generation (P_1): Red-flowered and white-flowered pea plants were used as parents. This is now known as the parental or P_1 generation. The red-flowered and white-flowered varieties were grown for at least two generations to ensure that they were true-breeding pure lines. Mendel first crossed females from the red-flowered variety with males from the white-flowered variety. He made reciprocal crosses, using the same characters but reversing the sexes of the parents (red-flowered males × white-flowered females). This shows the great care he took in all his experiments.

Mendel used the terms dominant and recessive for red-flowers and white-flowers, respectively. Red-flowers were called dominant because in the next generation, all the plants bore red-flowers. A dominant character is one which masks its recessive partner. White flowers were called recessive because the character was not visible in the cross. Mendel stated that the factors for characters or traits occurred in pairs. These factors are today called genes. They occur in fixed positions, called gene loci, on the chromosomes. Pairs of genes of contrasting characters are called alleles or allelomorphs. Red-flowered pea plants contain pairs of genes for red colour only. Similarly, white flowered pea plants contain pairs of genes for white colour only. When the two genes of a pair are for the same character, the condition is said to be homozygous. Thus both red flowered and white flowered, P_1 plants are homozygous.

Dominant genes are represented by a capital letter and recessive genes by a small letter. Thus the gene for red pea flowers is represented as R and that for white pea flowers as r. Since the genes occur in pairs, those for red pea flowers are written as RR and those for white pea flowers as rr. During the formation of gametes of the P_1 generation, the paired factors or genes separate (segregation). Thus one type of gamete contains R factors and the other type r factors. The generation of individuals produced by the P_1 generation is called the first filial generation (F_1).

The first filial generation (F_1): Mendel noticed that all the flowers of the F_1 generation were uniformly red. From this he concluded that red colour was dominant over white. Mendel realized that the F_1 red-flowered plants were different from the P_1 red-flowered plant, because they also had white-flowered parents the F_1 individuals, although red in colour, also contained factors for white flower colour. Such individuals where alternative forms (alleles) of a factor or gene (Rr) are present are called heterozygous. The F_1 plants are phenotypically red, but genotypically hybrids. The phenotype is the appearance or any detectable feature of an organism, e.g. red and white flowers. The genotype is the genetic composition of the organism. Thus F_1 red-flowered plants are similar to P_1 red-flowered plants in phenotype. They, however, differ in genotype: P_1 red-flowered plants have the RR genotype, while F_1 red-flowered plants have the Rr genotype. The P_1 red-flowered plants produce only one type of gamete R. The F_1 red-flowered plants produce two types of gametes, R and r. Mendel allowed the F_1 plants to self pollinate themselves to produce the second filial generation (F_2).

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