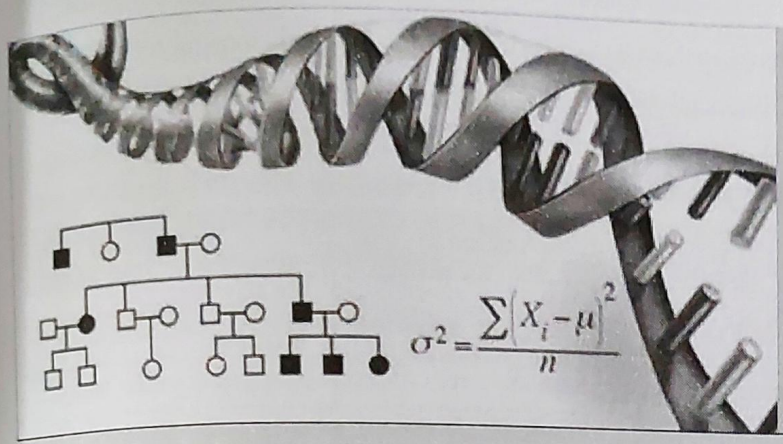

2

Mendelian Principles of Heredity

INTRODUCTION

Before dealing with Mendel's laws of inheritance, it is essential to define genetics. Genetics is defined as the branch of biology which is concerned with the study of heredity and variation in living organisms. In other words, genetics is the scientific study of the principles of heredity and variation in living organisms. **Heredity refers to** transmission of traits from parents to their offspring and the variation refers to resemblances and differences of heritable characteristics among individuals of a species.

Gregor Mendel laid the foundation of the new branch of biology *i.e.,* genetics in 1866 by deriving two principles of heredity. His principles of heredity are law of segregation and law of independent assortment which are now universally accepted. For this outstanding contribution, Mendel is known as the father of modern genetics.

MENDEL'S EXPERIMENTS

There are various aspects of Mendel' investigations, *viz.* selection of crop, selection of traits, adoption of methodology, publication of results derived, reaction on Mendel's results and, rediscovery of Mendel's results. These are briefly discussed as follows :

Selection of Material: Mendel selected garden pea [*Pisum sativum* L.] as the experimental material. Garden pea is a self pollinated, bisexual and short duration crop. This helped Mendel to grow more than one generations in a year and maintaining genetic purity. Flowers of garden pea are also suitable for artificial hybridization.

Selection of Traits: Mendel selected seven contrasting characters for his study and gave emphasis on individual character. The seven characters included plant stature [tall *versus* dwarf], position of flower [axial *versus* terminal], shape of pod [inflated *versus* constricted], colour of pod [green *versus* yellow], seed shape [round *versus* wrinkled], seed color [yellow

versus green], and seed coat color [grey *versus* white]. Mendel studied dominance behaviour of all the seven characters. In all these cases, first trait was found dominant over the second one.

TABLE 2.1 : Seven Character Studied by Mendel in Garden pea

S.No.	Characters	Dominant	Recessive
1.	Plant Stature	Tall	Dwarf
2.	Position of Flower	Axial	Terminal
3.	Shape of Pod	Inflated	Constricted
4.	Color of Pod	Green	Yellow
5.	Seed Shape	Round	Wrinkled
6.	Seed Color	Yellow	Green
7.	Seed Coat Color	Grey	White

Methodology Adopted : Mendel maintained the genetic purity of the material by selfing and laid emphasis on individual character and maintained proper records of the material. This helped Mendel to draw meaningful conclusions.

Publication of Mendel's Results : Mendel presented his paper, Experiments on Plant Hybridization, at two meetings of the Natural History Society of Brünn in Moravia on 8th February and 8th March, 1865, which was published in 1866. It was received favourably and appeared in several local newspapers

Reaction on Mendel's Results : At first Mendel's work was rejected, and it was not widely accepted until after he died. At that time most biologists held the idea of blending inheritance. His paper was criticized by several scientists at that time. Now his laws of inheritance are universally accepted.

Rediscovery of Mendel's Results : Late recognition. Mendel's results were rediscovered in 1900 independently by three researchers, *viz.* Hugo de Vries [Holland], Correns [Germany] and Tschermak [Austria]. After that Mendel's work got recognition the world over.

MENDEL'S LAWS OF INHERITANCE

Mendel derived two laws of inheritance from his experiments with garden pea. These are the Law of Segregation and the Law of Independent Assortment. These are known as Mendel's Laws of Inheritance. Mendel's laws of inheritance are explained with example as follows.

LAW OF SEGREGATION

Plant traits are of two types, *viz.*, dominant trait and recessive trait. The character which expresses in F_1 is called dominant trait and the character which is masked in F_1 is known as recessive trait. The law of segregation is the first law of inheritance. It is also known as law of purity of gametes.

The Law of Segregation states that when any individual produces gametes, the copies of a gene separate in such a way that each gamete receives only one copy. In other words, a parent plant passes on only one gene of each pair to its offspring. A gamete will receive one allele or the other. The direct proof of this was later found when the process of meiosis came to be known. In meiosis the paternal and maternal chromosomes get separated and the alleles with the traits of a character are segregated into two different gametes.

Example : A cross between purple [PP] and white [*pp*] flowered plants of field pea.

In this cross, two alleles, *viz.*, R and *r* come together in F_1 and remain in pure form without blending. The F_1 plants have purple [P*p*] flower because purple colour is dominant over white. These two alleles separate during meiosis and produce gametes either with P constitution or *p* constitution. Selfing of F_1 plants produce F_2 plants with purple and white flower in 3 : 1 ratio. This can be represented as follows :

Parents	Purple Flower [Female]	×	White flower [Male]
Genotype	PP		*pp*
Gametes	P		*p*
F_1	Purple Flower [P*p*]	×	P*p*
Gametes	P and *p*		P and *p*
F_2	1. Homozygous purple [PP], 2. heterozygous purple [P*p*] and 1 recessive white [*pp*]		
	Phenotypic ratio is 3 purple : 1 white and genotypic ratio is 1 : 2 : 1.		

LAW OF INDEPENDENT ASSORTMENT

This is the second law of inheritance proposed by Mendel. The Law of Independent Assortment, states that alleles of different genes assort independently of one another during gamete formation. Monohybrid cross with complete dominance results in a 3 : 1 phenotypic ratio. A dihybrid cross with complete dominance of each gene results in 9 : 3 : 3 : 1 phenotypic ratio. Mendel concluded that different traits are inherited independently of each other. This is actually only true for genes that are not linked to each other.

Independent assortment occurs during metaphase I of meiosis, to produce a gamete with a mixture of the organism's maternal and paternal chromosomes. Along with chromosomal crossover, this process aids in increasing genetic diversity by producing novel genetic combinations.

Example : In field pea a cross between yellow round seeds and green wrinkled seeds. Here, the yellow seed colour is dominant over green and round seed shape is dominant over wrinkled. The F_1 has yellow round. The F_1 produces four types of gametes, *viz.*, yellow round [YR], yellow wrinkled [Y*r*], green round [*y*R], and green wrinkled [*yr*]. Selfing of F_1 plants produce above four types of plants in 9 : 3 : 3 : 1 phenotypic ratio. This over all process can be represented as follows :

Parents	Yellow Round Seed [Female]	×	Green wrinkled seed [Male]
Genotype	YYRR		*yy rr*
Gametes	YR		*yr*
F_1	Yellow round [YyRr] × Y*y*R*r* Selfing		
Gametes	YR, Y*r*, *y*R & *yr*		YR, Y*r*, *y*R & *yr*
F_2	Yellow round [YR], yellow wrinkled [Y*r*], green round [*y*R] and green wrinkled [*yr*] are obtained in 9 : 3 : 3 : 1 phenotypic ratio.		

(*i*) Plants with two dominant genes (YR) are yellow round.
(*ii*) Plants with one yellow dominant gene (Y*r*) are yellow wrinkled
(*iii*) Plants with one round dominant gene (*y*R) are green round, and
(*iv*) Plants with both recessive genes (*yr*) are green wrinkled.

REASONS FOR MENDEL'S SUCCESS

Several scientists tried to find out the laws of inheritance, but only Mendel could get success in deriving the laws of inheritance. There are several reasons of Mendel's success such selection of suitable crop, selection of contrasting plant traits, maintenance of purity of material, maintenance of proper records and use of mathematics. These are presented below.

Selection of Crop : He worked with garden pea which is a self pollinated and short duration with amenable flowers for artificial crossing. Self-pollination ensures purity of lines and short duration permits growing of more than one crop in a year.

Selection of Plant Traits : He selected contrasting morphological traits such as shape, size and colour of the plant for his study. Identification of such traits is easy. Moreover, he laid emphasis on individual plant character.

Maintenance of Purity: He maintained purity of his material by continuous selfing of plants in each generation. It helped in getting clear cut results.

Maintenance of Records: He maintained proper records of each cross, progeny and generation. It helped in getting clear cut results.

Knowledge of Mathematics: He had background of mathematics which helped him in interpreting his results in scientific way, though this approach was not appreciated at that time.

REASONS FOR LATE RECOGNITION

Mendel's findings were overlooked for a long period *i.e.*, till 1900. He died in 1884 and could get recognition for his outstanding research in 1900 when similar results were independently observed by three scientists, *viz.*, de Vries, Correns and Tschermak. Important reasons for late recognition of his work are as follows.

1. Mendel interpreted his results with the help of mathematics which was not appreciated by biologists at that time.
2. Mendel could not prove his results on hawkweed, which reproduces by asexual means *i.e.* by diploid parthenogenesis. In such cases we get parental types only. Mendel was not having knowledge of embryology.
3. The Darwin's concept of blending inheritance was prevailing at that time, which resulted in late recognition of Mendel's findings.
4. After becoming abbot of the monastery, Mendel did not find sufficient time for research work and lost interest in research.

APPLICATIONS IN CROP IMPROVEMENT

Mendel's principles of heredity have wide practical applications in the field of genetics and plant breeding. The important applications of his findings are as follows.

1. Mendel's findings allowed other scientists to predict the expression of traits on the basis of mathematical probabilities.
2. His laws are useful in finding the dominance behaviour of various simply inherited plant characters.
3. Mendel's principles are used for transfer of desirable traits from one genotype to another.
4. Ultimately Mendel's principles are being used for developing superior varieties and hybrids in different crop plants.

QUESTIONS

1. Who is known as father of modern genetics and why?
2. Describe law of segregation with suitable example.
3. Describe law of independent assortment with suitable example.
4. What are the reasons of Mendel's success in deriving laws of inheritance?
5. Describe main reasons of late recognition of Mendel's research work.
6. Differentiate between the following terms
   (*i*) Genotype and phenotype
   (*ii*) Homozygous and heterozygous
   (*iii*) Back cross and test cross
   (*iv*) Direct cross and reciprocal cross.
   (*v*) Dominance and recessive trait
7. What do the following terms signify?
   (*i*) Monohybrid, Dihybrid and Polyhybrid
   (*ii*) Alleles, multiple alleles and gamete
   (*iii*) Incomplete dominance
   (*iv*) Pleiotropy

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