MENDEL'S LAWS OF INHERITANCE
(MENDELISM)

MBOTCC-10
Unit-III

M.Sc. Sem-III
(2018-20)

Introduction:

Gregor Johann Mendel conducted hybridization experiments in Garden pea (*Pisum sativum*) plants and presented his findings in an exhaustive paper entitled "Experiments on Plant Hybridization" in the meeting of the Bruun Natural History Society in 1865 which was published in the proceedings of the Society in 1866. This paper contained Mendel's hypotheses concerning the mechanism of inheritance.

Mendel's hypotheses could not attract the attention of wider contemporary scientific community due to the overwhelming influence of Darwinian evolutionary principles.

Mendel's results were rediscovered simultaneously by H. de Vries, Correns and Tschermak in 1900 which led to the birth of classical genetics.

Mendel's Experiments

Garden pea, the experimental material chosen by Mendel, had the following advantages:

(i) Well defined characters
(ii) Large bisexual flowers
(iii) Predominant self fertilization
(iv) Easy hybridization
(v) Pure lines available due to natural self fertilization for many years

Further, Mendel considered single character at a time. Seven pairs of contrasting characters were chosen by Mendel for his studies.

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Crossing Technique:

(i) As the pea flowers were bisexual, Mendel emasculated those flowers which were to be treated as a female parent for his crosses.

(ii) For each of the seven pairs of traits chosen, plants with one alternative trait were used as female and with the other alternative trait as male.

(iii) Reciprocal crosses were also made to overcome any differential contribution made by male and female flowers on the expression of characters in the progeny.

(iv) Population obtained as a result of crossing plants exhibiting contrasting characters is called the first filial generation (F_1).

(v) The progeny of F_1 plants obtained due to self fertilization represent the second filial generation or F_2. Similary F_3, F_4, etc. could also be obtained.

(vi) He pooled the data of many similar crosses, analyzed the results statistically and found that both traits reappeared in the F_2 offsprings in a definite ratio of 3:1.

(vii) Mendel used English alphabets to represent the factors (genes). The first letter of the dominant character was used to designate the character, its capital form for the dominant character and small form for the recessive character.

Terminology used:

(a) Factor – Mendel presumed that a character is determined by a pair of factors (now called genes) present in each cell of the individual.

(b) Homozygous and Heterozygous – If an individual has two identical factors for

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a character, it is said to be homozygous or homozygous for that character. Heterozygous individual possesses contrasting forms of a pair of factors.

(c) Pure Line – Generations of homozygous individuals which produce offsprings of only one type form a pure line.

(d) Alleles or Allelomorphs – Alleles or allelomorphs are a pair of factors (genes) representing the two alternatives of the same character and situated at the same locus in the homologous chromosomes.

(e) Dominant and Recessive – A heterozygous individual ~~two~~ possesses two contrasting alleles but only one of them is expressed while the other remains hidden. The allele which gains expression in F_1 hybrid is known as dominant while its alternative allele remains unexpressed in presence of the dominant factor and is called recessive.

(f) Monohybrid cross – It involves the inheritance of one pair of contrasting characters in a crossing experiment.

(g) Dihybrid cross – This is the inheritance of two pairs of contrasting traits

(h) Polyhybrid cross – This includes such crosses in which inheritance of more than two pairs of characters is considered simultaneously.

(i) Reciprocal Cross – Such crosses involve two crosses involving the same traits, but with reversed sexes. If A is a female parent and B is the male parent in a cross, then in the second reciprocal cross A will be used as male and B as female parent.

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(j) Back cross and Test cross – Crosses between F1 offsprings with either of the two parents are known as back crosses. When F1 offsprings are crossed with a recessive parent, it is called a Test cross because this can be used to test or verify the genotype of the F1 hybrid.

Contrasting Characters of Pea plant chosen by Mendel

	Character	Dominant	Recessive
1.	Stem length	Tall	Dwarf
2.	Flower position	Axillary	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's Crosses & their results:

(A) Monohybrid Cross:

(i) Mendel self-pollinated pea plants for several generations to confirm pure lines to be used as parents in his crossing experiments.

(ii) In one set of experiment, Mendel crossed pure breeding tall and dwarf plants.

(iii) Plant raised by sowing the seeds of the above cross belonged to F_1 generation which were all tall

(iv) F_1 tall plants were self-pollinated. Plants raised from these seeds belonged to F_2 generation which were both tall and dwarf in an approximate 3:1 ratio.

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(v) Dwarf plants of F_2 produced only dwarf plants generation after generation.

(vi) On self-pollination of the tall plants of F_2, only 1/3rd bred true for tallness. The rest 2/3rd produced tall and dwarf in the ratio 3:1 (F_3 generation). This means F_2 generation consisted of three types of plants:

Homozygous (Pure) Tall (TT) – 25%.
Heterozygous (Hybrid) Tall (Tt) – 50%.
Homozygous (Pure) Dwarf (tt) – 25%.

Mendel's explanation:

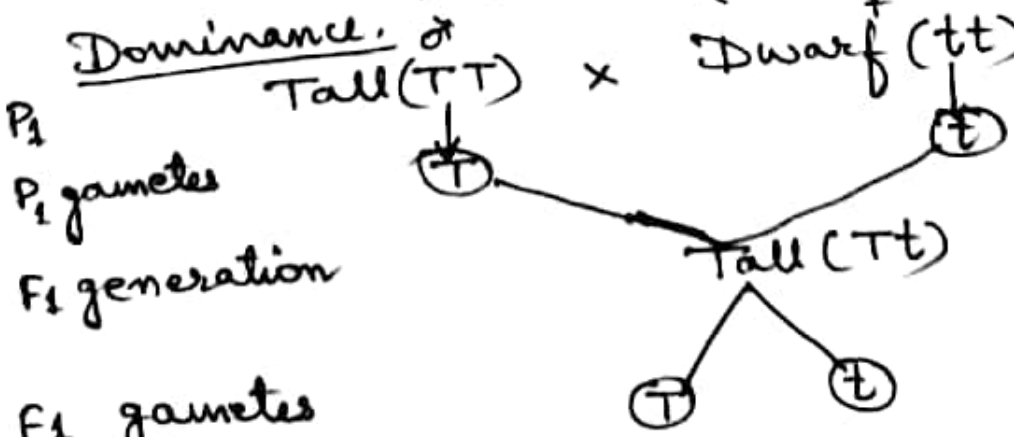
Mendel explained above results by presuming that:

(a) Tallness and dwarfness are determined by a pair of contrasting factors (genes). A plant is tall because it possesses the factor for tallness (T) and a plant is dwarf because it has factors for dwarfness (t).

(b) These factors occur in pairs and are received one from either parent.

(c) When two factors for alternative expressions of a trait are brought together by fertilization, only the dominant trait expresses itself masking the expression of the other recessive trait.

On the basis of this behaviour, tallness is described as dominant character and dwarfness as recessive character. This is known as Law of Dominance.



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F1 gametes → / ♂ ↓ ♀	T	t
T	TT Tall	Tt Tall
t	Tt Tall	tt Dwarf

F2 generation

TT – 1 } Tall
Tt – 2 }
tt – 1 – Dwarf
Tall : Dwarf = 3 : 1

Fig.- Mendel's explanation of monohybrid cross between tall and dwarf pea plants.

(d) The factors are never contaminated. When gametes are formed, these factors segregate so that each gamete gets only one of the two alternative factors. This means that factors for tallness (T) and dwarfness (t) are separate entities and in a gamete either T or t is present. When F1 hybrids (Tt) are self-pollinated, the two entities separate out and unite independently producing tall and dwarf plants. This is called Law of Segregation.

(B) Dihybrid Cross:

(i) Mendel also conducted experiments to study segregation and transmission of two pairs of contrasting characters at a time.

(ii) He studied the inheritance of round and wrinkled characters of seed coats along with green and yellow colour of seeds.

(iii) Mendel found that a cross between round yellow and wrinkled green seed bearing parents (P1) produced only round yellow seeds in F1 generation, but in F2 four types of combinations were observed. Two of these combinations were similar to the parental combinations, while the other two were new combinations.

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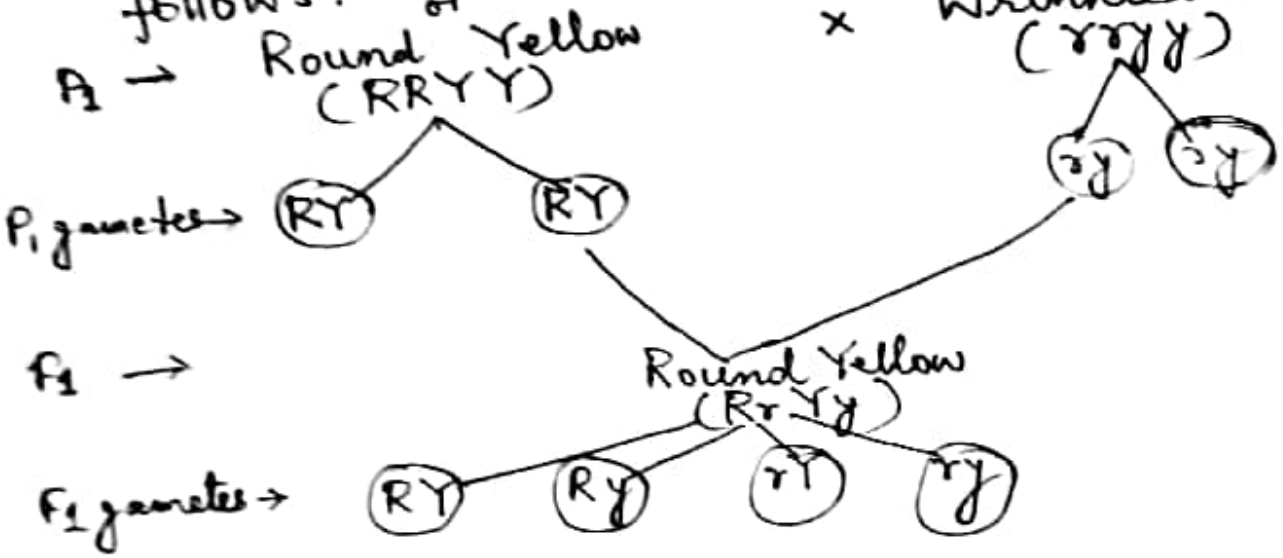
These are:
Round Yellow — 9 – Parental combination
Round Green — 3 – Non-parental comb.
Wrinkled Yellow — 3 – Non-parental comb
Wrinkled Green — 1 – Parental Combinatio

From the above results, F_2 Mendel found that the offsprings of F_2 generation were produced in a ratio of 9:3:3:1. This is called dihybrid ratio. The results can be represented as follows:



♀ \ ♂	RY	Ry	rY	ry
RY	RRYY Round Yellow	RRYy Round Yellow	RrYY Round Yellow	RrYy Round Yellow
Ry	RRYy Round Yellow	RRyy Round Green	RrYy Round Yellow	Rryy Round Green
rY	RrYY Round Yellow	RrYy Round Yellow	rrYY Wrinkled Yellow	rrYy Wrinkled Yellow
ry	RrYy Round Yellow	Rryy Round Green	rrYy Wrinkled Yellow	rryy Wrinkled Green

F_2 Progeny

Mendel explained the results by assuming that the round and yellow characters are dominant over wrinkled and green so that

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all the F_1 offsprings are round yellow.

In F_2 generation since all the four characters assorted out independent of the others, he proposed that a pair of contrasting characters behave independently of the other pair, i.e., seed colour is independent of seed coat character. Therefore at the time of gamete formation for seed the round or wrinkled character of seed coat assorted out independently of the seed colour. As a result yellow or green colour of the seeds presented four types of gametes with two parental and two new combinations, i.e., RY, ry, Ry and rY are formed from the F_1 hybrid. These four types of gametes on random mating produced four kinds of offsprings in the ratio of 9:3:3:1 in F_2 generation. This was called Law of Independent Assortment.

Mendel also conducted trihybrid and polyhybrid crosses and found similar results.

Reasons of Mendel's Success:

A combination of luck, foresight, mathematical background, scientific aptitude, honest statistical analysis and accuracy in experimentation contributed to the success of Mendel's experiments.

Methods of working, selection of traits and crossing techniques — all contributed to the success of Mendel.

It was just a chance that the seven pairs of contrasting characters chosen in pea plants for his hybridization experiments by Mendel were later found to be present on the seven pairs of chromosomes recorded in *Pisum sativum* (Pea). Had any of the two pairs of contrasting traits been present on the same chromosomes, Mendel could not have succeeded in finding these results. This latter situation led to the discovery of linkage.