MENDEL‟S LAWS OF HEREDITY

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MENDEL‟S LAWS OF HEREDITY

Mendel's laws of inheritance are based on his observations on monohybrid crosses.

He proposed the following laws of inheritance:

1. Law of Dominance (First Law):

1. The law of dominance states that when two alternative forms of a trait or character (genes) are present in an organism, only one factor expresses itself in F_1-progeny and is called dominant, while the other that remains masked is called recessive.
2. This law is used to explain the expression of only one of the parental characters in a monohybrid cross in the F_1 -generation and the expression of both in the F_2-generation.
3. It also explains the proportion of 3:1 obtained in theF_2-generation.

2. Law of Segregation (Second Law):

1. This law states that the alleles do not show any blending and both the characters are recovered as such in the F_2-generation, though one of these is not seen in the F_1 -generation.
2. Due to this, the gametes are pure for a character. The parents contain two alleles during gamete formation.
3. The factors or alleles of a pair segregate from each other such that a gamete receives only one of the two factors.

3. Law of Independent Assortment (Third Law):

1. This law states that when two pairs of traits are combined in a hybrid, segregation of one pair of character is independent of the other pair of characters at the time of gamete formation.
2. It also get randomly rearranged in the offsprings producing both parental and new combinations of characters.
3. The law was proposed by Mendel, based on the results of dihybrid crosses, where inheritance of two traits were considered simultaneously.

INTRODUCTION TO GREGOR JOHANN MENDEL

1. Gregor Johann Mendel (Fig. 6.1), known as father of Genetics was born in a farmer family near Brunn in Austria in 1822.

2. He graduated in Philosophy in 1840 and became a priest in St. Augustinian Monastery in 1847. Later he went to University of Vienna for studying natural science.
3. After return, he was engaged in school teaching. He started his experiment with garden pea, and in 1865, presented a paper entitled **"Experiments in plant hybridization"** before the Natural History Society of Brunn. He died in 1884.
4. The implication of his work, which forms the basis of genetics, was realized in 1900 when Derives in Holland, Correns in Germany and Tschermak in Austria, working independently, obtained similar findings.

Mendel's Assumption on Monohybrid Cross:

1. A cross between two parents differing in one trait/character or in which only one trait is considered is called monohybrid cross. Mendel raised separately two varieties of garden peas, tall and dwarf.
2. When the flowers of the tall variety were allowed to be fertilized with their own pollen, the offspring's were all tall; the dwarf variety on self-fertilization produced only dwarfs.
3. He crossed these two varieties of garden peas. From the cross between the tall and dwarf parental (P) generation plants, the offspring's in the first generation (F_1-First filial generation, Latin word filial meaning progeny) were all tall.
4. There was no dwarf plant in the F_1 generation. When these F_1 tall plants were fertilized by their own pollen (selfed), the offspring's of second generation (F_2) were both tall and dwarf. About three-fourths of the plants were tall and one- fourth were dwarfs.
5. This showed him that the character of dwarfness which disappeared in F_1, reappeared in F_2. Mendel planted the F_2 seeds to raise F_3 progeny.
6. About one-third of the tall F_2 plants produced only tall progeny, whereas two- third produced both tall and dwarf plants.
7. The dwarf F_2 plants produced all dwarfs. Mendel carried out monohybrid experiments with other chosen characters and got the similar results.

2. EXPLANATION OF MONOHYBRID CROSS:

1. On the basis of above assumptions, Mendel explained the result of monohybrid cross. The tall and dwarf plants of P generation were both pure breeding and genotypically homozygous-TT and tt respectively.

2. The gametes produced by the tall parent carry only T allele and dwarf parent carry only t allele.
3. Therefore, after fertilization, the zygote must have the genotype Tt and F_1 plant will be phenotypically tall because of dominance of T allele. As the t allele is recessive, expression of dwarf character will not occur.
4. When the F, tall (Tt) plants were selfed, separation of the alleles T and t occurred during the formation of gametes.
5. Half of the gametes will carry T allele and half t allele in both male and female organs. Two types of male gametes are free to unite with two types of female gametes.
6. Therefore, both tall and dwarf phenotypes will appear-in F_2.
7. As the male gamete and female gamete, both with t allele, unite to produce the genotype tt, the reappearance of dwarf plant will occur in F_2 generation. Thus the F_2 plants produced will be of three types of genotypes-TT,. Tt and tt in the ratio 1:2:1. Both TT and Tt plants will be tall and tt plants will be dwarf in the ratio 3:1 (Fig. 6.3).
8. On selfing of F_2 plants – TT tall plants will breed true, Tt tall plants will segregate in the ratio 3:1 and tt plants will also breed true.

Mendel's Conclusion: Law of Segregation:

Mendel formulated his first law, the law of segregation, from the conclusion drawn out of his monohybrid experiments.

The law of Segregation States:

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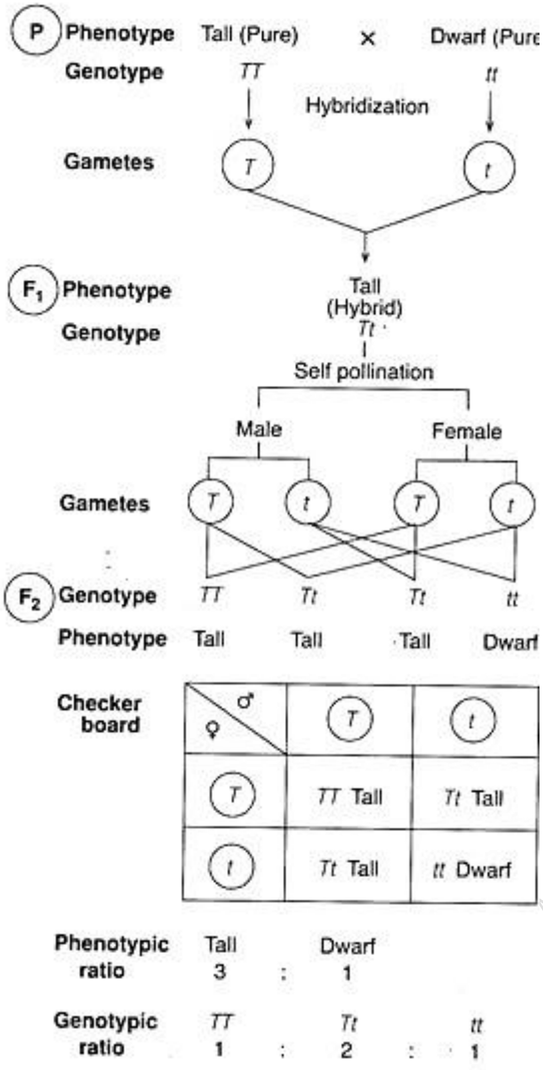

Fig. 6.3: Mendel's monohybrid experiment

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The alleles for each character existing in pairs in an organism do never blend, they segregate from each other and pass into different gametes in their original form. Thus each gamete contains only one allele for each character. A F_1 mono- hybrid will thus produce two different types of gametes in equal frequencies. The law of segregation is thus also called as law of purity of gametes.

2. MENDEL'S ASSUMPTION ON DI-HYBRID CROSS:

1. A cross between two parents differing in two traits or in which only two traits are considered called di-hybrid cross.
2. Mendel raised separately two pure varieties of garden peas, one with yellow cotyledon, round seed and another with green cotyledon, wrinkled seed.

3. From the cross between these two parental (P) generation plants, the offspring's in the F_1 generation were all with yellow cotyledon and round seed.

When these F_1 plants were self-fertilized, the offspring's of F_2 generation were of four types in the ratio 9:3:3:1 –

(a) Yellow cotyledon, round seed

(b) Yellow cotyledon, wrinkled seed

(c) Green cotyledon, round seed and

(d) Green cotyledon, wrinkled seed.

The offspring's showed that two pairs of contrasting characters combined in every possible way.

Mendel carried out di-hybrid experiments with all the chosen characters in different combinations and got the similar results.

Explanation of Di-hybrid Cross: Mendel explained the di-hybrid cross as follows:

1. As the parental plants were pure, so their genotypes will be homozygous – YYRR and yyrr producing YR and yr gametes respectively.
2. The F_1 di-hybrid will be heterozygous for both the traits (YyRr).
3. As all the F_1 plants were with yellow cotyledon and round seed, so allele Y for yellow cotyledon is dominant over allele y for green cotyledon and allele R for round seed is dominant over allele r for wrinkled seed.
4. The appearance of all the four possible phenotypic combinations in F_1 in the ratio 9:3: 3 :1 is possible if the two pairs of characters are believed to behave independent of each other. Each pair of contrasting characters bear no permanent association with particular other character.
5. If the F_1 plant (YyRr) produces only parental gametes (YR, yr), then in F_2 only two types of phenotypes (parental) are expected. But the appearance of four types of phenotypes in F_2 (two parental and two new types) confirms the production of four types of gametes (YR, Yr, yR, yr) in equal frequency.
6. The appearance of two new types of phenotypic combinations – yellow cotyledon, wrinkled seed and green cotyledon, round seed in addition to parental phenotypic combinations requires the production of Yr and yR gametes in addition to YR, yr gametes by F_2 plants.

7. Thus the allele Y may be associated with the allele R as well as r in equal frequency, giving rise to YR and Yr gametes respectively.
8. Similarly, the allele y may be associated with the allele R as well as r in equal frequency giving rise to yR and yr gametes respectively. Thus four types of gametes viz.', YR, Yr, yR and yr will be produced in the ratio 1 : 1 : 1 : 1
9. These four types of gametes (both male and female) will unite in sixteen possible combinations to produce nine types of genotypes in the ratio 1 : 2 : 1 : 2 : 4 : 2 : 1 : 2 : 1 and four types of phenotypes in the ratio 9:3: 3 : 1 (Fig. 6.4).
10. . The similar ratios will result even if the characters are present in different parental combinations: yellow cotyledon, wrinkled seed X green cotyledon, round seed. This further proves that the inheritance of individual character is independent of the other characteristics.
11. Mendel was fortunate in selecting his experimental material. It is self-fertilizing species but fertile hybrids can be produced and all the seven characters chosen by him showed independent assortment without any linkage.

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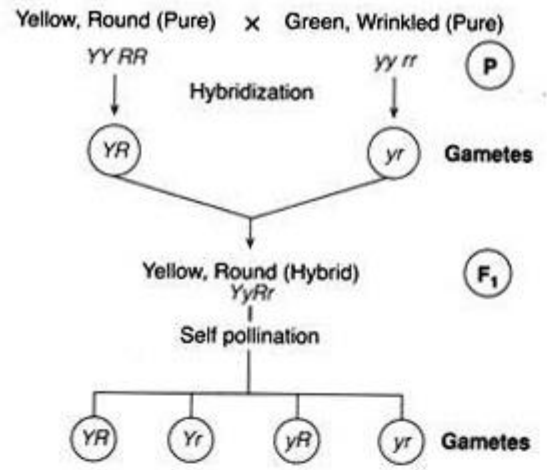

F2

♀ \ ♂	YR	Yr	yR	yr
YR	YYRR	YYRr	YyRR	YyRr
Yr	YYRr	YYrr	YyRr	Yyrr
yR	YyRR	YyRr	yyRR	yyRr
yr	YyRr	Yyrr	yyRr	yyrr

Phenotype	Genotype	Genotypic ratio	Phenotypic ratio
Yellow, Round	YYRR YYRr YyRR YyRr	1 2 2 4	9
Yellow, Wrinkled	YYrr Yyrr	1 2	3
Green, Round	yyRR yyRr	1 2	3
Green, Wrinkled	yyrr	1	1

Fig. 6.4: Mendel's dihybrid experiment

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Mendel's Conclusion:

Law of Independent Assortment:

Mendel formulated his second law from the conclusions drawn out of his di-hybrid experiments.

The law of Independent Assortment states:

When the two parents differ from each other in two or more pairs of contrasting characters or factors, then the assortment of alleles of one character is independent of assortment of alleles of other characters. Each member of an allelic pair may combine randomly with either of another pair during the formation of gametes.

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