



## BIOLOGY

### NOTES – 07

#### Bio- Botany – Chapter - 2

#### Classical Genetics

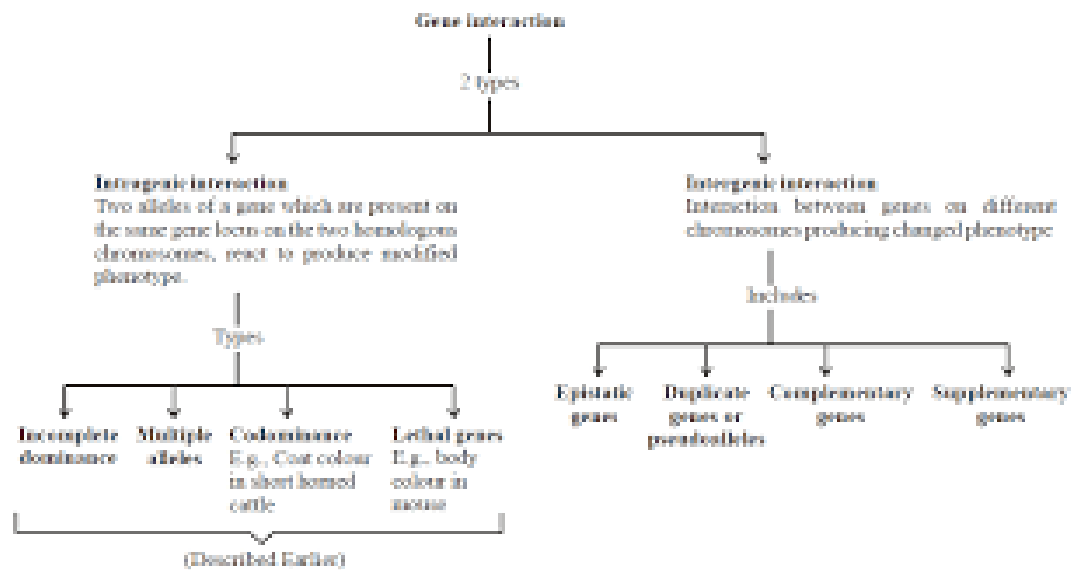


Gregor Johann Mendel

#### Genetics

#### Gene interaction

- A single phenotype is controlled by more than one set of genes, each of which has two or more alleles.
- This phenomenon is called Gene Interaction. Many characteristics of the organism including structural and chemical which constitute the phenotype are the result of interaction between two or more genes.



- Mendelian experiments prove that a single gene controls one character.
- But in the post Mendelian findings, various exception have been noticed, in which different types of interactions are possible between the genes.
- This gene interaction concept was introduced and explained by W. Bateson.
- This concept is otherwise known as Factor hypothesis or Bateson's factor hypothesis.
- According to Bateson's factor hypothesis, the gene interactions can be classified as
  - Intragenic gene interactions or Intra allelic or allelic interactions
  - Intergenic gene interactions or inter allelic or non-allelic interactions

### Intragenic gene interactions

- Interactions take place between the alleles of the same gene i.e., alleles at the same locus is called intragenic or intralocus gene interaction.
- It includes the following:
  - Incomplete dominance
  - Codominance
  - Multiple alleles



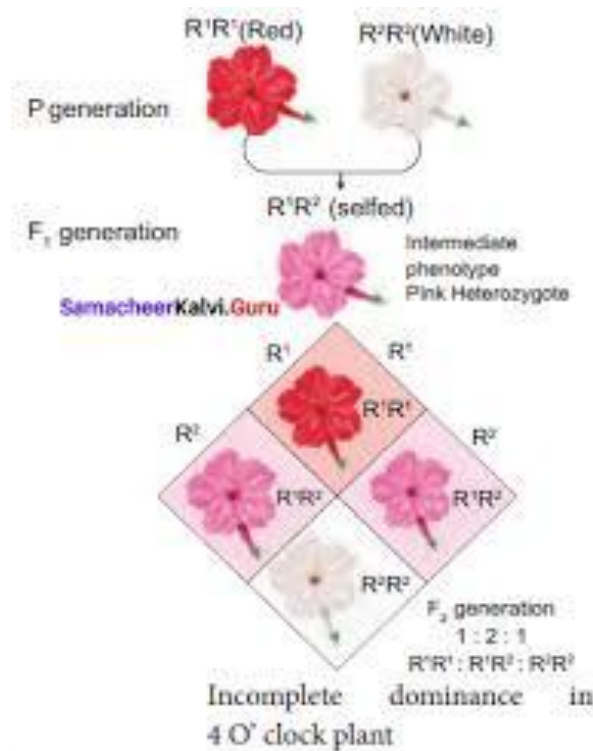
- Pleiotropic genes are common examples for intragenic interaction.

### Incomplete dominance – No blending of genes

- **The German Botanist Carl Correns's (1905) Experiment** - In 4 O' clock plant, *Mirabilis jalapa* when the pure breeding homozygous red ( $R_1R_1$ ) parent is crossed with homozygous white ( $R_2R_2$ ), the phenotype of the  $F_1$  hybrid is heterozygous pink ( $R_1R_2$ ).
- The  $F_1$  heterozygous phenotype differs from both the parental homozygous phenotype.
- This cross did not exhibit the character of the dominant parent but an intermediate colour pink.
- When one allele is not completely dominant to another allele it shows incomplete dominance. Such allelic interaction is known as incomplete dominance.
- $F_1$  generation produces intermediate phenotype pink coloured flower.
- When pink coloured plants of  $F_1$  generation were interbred in  $F_2$  both phenotypic and genotypic ratios were found to be identical as 1 : 2 : 1 (1 red : 2 pink : 1 white).
- Genotypic ratio is 1  $R_1R_1$  : 2  $R_1R_2$  : 1  $R_2R_2$ . From this we conclude that the alleles themselves remain discrete and unaltered proving the Mendel's Law of Segregation.
- The phenotypic and genotypic ratios are the same.
- There is no blending of genes. In the  $F_2$  generation  $R_1$  and  $R_2$  genes segregate and recombine to produce red, pink and white in the ratio of 1 : 2 : 1.  $R_1$  allele codes for an enzyme responsible for the formation of red pigment.
- $R_2$  allele codes for defective enzyme.  $R_1$  and  $R_2$  genotypes produce only enough red pigments to make the flower pink.
- Two  $R_1R_1$  are needed for producing red flowers.
- Two  $R_2R_2$  genes are needed for white flowers.



- If blending had taken place, the original pure traits would not have appeared and all F<sub>2</sub> plants would have pink flowers.
- It is very clear that Mendel's particulate inheritance takes place in this cross which is confirmed by the reappearance of original phenotype in F<sub>2</sub>.



### Codominance (1 : 2 : 1)

- This pattern occurs due to simultaneous (joint) expression of both alleles in the **heterozygote** - The phenomenon in which two alleles are both expressed in the heterozygous individual is known as codominance.
- Example: Red and white flowers of *Camellia*, inheritance of sickle cell haemoglobin, ABO blood group system in human beings. In human beings, I<sup>A</sup> and I<sup>B</sup> alleles of I gene are codominant which follows Mendel's law of segregation.
- The codominance was demonstrated in plants with the help of electrophoresis or chromatography for protein or flavonoid substance.



- Example: *Gossypium hirsutum* and *Gossypium sturtianum*, their F1 hybrid (amphiploid) was tested for seed proteins by electrophoresis.
- Both the parents have different banding patterns for their seed proteins.
- In hybrids, additive banding pattern was noticed.
- Their hybrid shows the presence of both the types of proteins similar to their parents.
- The heterozygote genotype gives rise to a phenotype distinctly different from either of the homozygous genotypes.
- The F1 heterozygotes produce a F2 progeny in a phenotypic and genotypic ratios of 1: 2 :1.

### Lethal genes

- **An allele which has the potential to cause the death of an organism is called a “Lethal Allele”.** In 1907, E. Baur reported a lethal gene in snapdragon (*Antirrhinum sp.*).
- It is an example for recessive lethality. In snapdragon there are three kinds of plants.
  1. Green plants with chlorophyll. (CC)
  2. Yellowish green plants with carotenoids are referred to as pale green, golden or aurea plants (Cc)
  3. White plants without any chlorophyll. (cc)
- The genotype of the homozygous green plants is CC.
- The genotype of the homozygous white plant is cc.
- The aurea plants have the genotype Cc because they are heterozygous of green and white plants.
- When two such aurea plants are crossed the F1 progeny has identical phenotypic and genotypic ratio of 1 : 2 : 1 (viz. 1 Green (CC) : 2 Aurea (Cc) : 1 White (cc))
- Since the white plants lack chlorophyll pigment, they will not survive.



- So the F<sub>2</sub> ratio is modified into 1 : 2. In this case the homozygous recessive genotype (cc) is lethal.

|                |              |                   |   |                       |
|----------------|--------------|-------------------|---|-----------------------|
| F <sub>1</sub> | Heterozygote | Antirrhinum aurea | x | Antirrhinum aurea     |
|                |              | Cc                | x | Cc                    |
| F <sub>2</sub> |              | 1CC<br>Green      | : | 2 Cc<br>Aurea         |
|                |              |                   | : | 1cc<br>White (lethal) |

- The term “lethal” is applied to those changes in the genome of an organism which produces effects severe enough to cause death.
- Lethality is a condition in which the death of certain genotype occurs prematurely.
- The fully dominant or fully recessive lethal allele kills the carrier individual only in its homozygous condition.
- So the F<sub>2</sub> genotypic ratio will be 2 : 1 or 1 : 2 respectively.

### Pleiotropy – A single gene affects multiple traits

- In Pleiotropy, the single gene affects multiple traits and alter the phenotype of the organism.
- The Pleiotropic gene influences a number of characters simultaneously and such genes are called pleiotropic gene.
- Mendel noticed pleiotropy while performing breeding experiment with peas (*Pisum sativum*). Peas with purple flowers, brown seeds and dark spot on the axils of the leaves were crossed with a variety of peas having white flowers, light coloured seeds and no spot on the axils of the leaves, the three traits for flower colour, seed colour and a leaf axil spot all were inherited together as a single unit.
- This is due to the pattern of inheritance where the three traits were controlled by a single gene with dominant and recessive alleles. Example: sickle cell anemia.