

Mendelian Genetics

1. How do certain phenotypes appear in F_2 individuals when none of the parents originally exhibited them in dihybrid cross in *Pisum Sativum*? Show the cross up to F_2 generation in a Punnett's square to substantiate your answer.

OR

Describe in details about Mendel's laws of inheritance.

OR

Describe in detail about Mendel's law of independent assortment up to F_2 generation.

(8 marks) (2050, 2076, 2079)

- Mendel's 3 laws of inheritance:

i. Law of Dominance:

- States that, "In a cross between pure homozygous organism for contrasting character only one character of the pair appear in F_1 generation.

- Character which appears in F_1 generation is dominant

- Character which doesn't appear is recessive.

- Experimental Procedure

- Collection of pea plant for experiment.

- Selection of parental plants.

- Hybridization: monohybrid cross.

- Self-breeding of F_1 for the production of second generation plants.

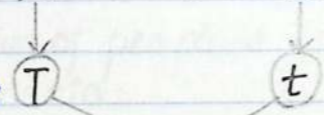
- Analysis of F_1 , F_2 generations with their parents.

Example:

Homozygous tall (TT) and homozygous dwarf (tt) pea plant are crossed in F_1 generation are tall (Tt). Monohybrid cross: hybrid tall plant. Tall is dominant, dwarf is recessive character.

Parents: Pure tall Pure dwarf

TT X tt



F_1 generation: Tt (Hybrid tall)

Conclusion

- Appeared trait tall due to dominant allele (T).
- Disappeared trait is dwarf due to recessive allele (t).

ii. Law of segregation:

- States that, "The two alleles of

a character remains together in heterozygote without contamination but they separate or segregate all time of gamete formation.

- Gametes bear only one of contrasting allele and gamet is pure for particular character.
- Known as purity of gamete.

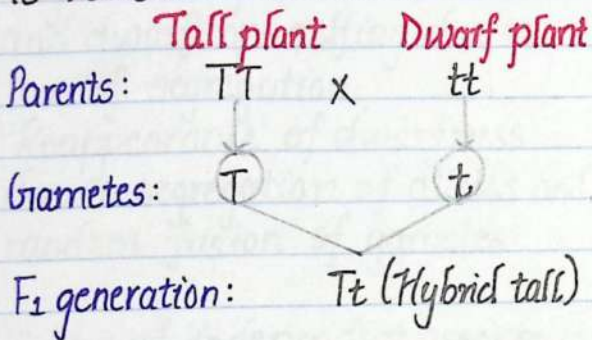
Experimental Procedure

- Collection of pea plant for experiments.
- Selection of parental plants.
- Hybridization: monohybrid cross.
- Self-breeding of F_1 for the production of second generation plants.
- Analysis of F_1 , F_2 , generations with their parents.

Example:

Homozygous tall (TT) and homozygous dwarf (tt) pea plant are crossed in F_1 generation are tall (Tt).

Monohybrid cross : hybrid tall plant. Tall is dominant, dwarf is recessive character.



Selfing:

| | | | |
|------------|------------|-------------|--------------|
| ♀ | ♂ | T | t |
| T | | TT (tall) | Tt (tall) |
| t | | Tt (tall) | tt (Dwarf) |

Phenotype ratio : 3:1

Genotype ratio : 1:2:1

Conclusion:

- F_1 generation, all heterozygous tall pea plants obtained,

dwarfism absent.

- Hybrid tall produces both tall and dwarf on selfing due to law of segregation.

- Reappearance of dwarfness due to segregation of alleles and random fusion of gametes.

iii. Law of independent assortment:

- States that, "The inheritance of one allele or one character is not affected by the inheritance of other allele or other characters."

- Second law of Mendel.

Experimental procedure:

• Collection of pea plant for experiment.

• Selection of parental plants.

• Hybridization: dihybrid cross.

• Self-breeding of F_1 for the prod

uction of second generation plants.
• Analysis of F_1 , F_2 generations with their parents.

Example:

Dihybrid cross Tall red ($TTRR$) and dwarf white ($ttrr$) are crossed, in F_1 generation tall red seeds ($TtRr$) are found. On self pollination, seeds obtained in ratio (9:3:3:1)

Parents: Tall red $TTRR$ x Dwarf white $ttrr$

Gametes: TR tr

F_1 generation: $TtRr$ (Tall red hybrid)

Self cross between F_1 hybrid:
 $TtRr$

TR Tr tR tr

For F₂ generation

| ♀ ♂ | TR | Tr | tR | tr |
|-----|------------------|--------------------|-------------------|---------------------|
| TR | TTRR Tall red | TTRr Tall red | TtRR Tall red | TtRr Tall red |
| Tr | TTRr Tall red | TTrr Tall white | TtRr Tall red | Ttrr tall white |
| tR | TtRR Tall red | TtRr Tall red | ttRR Dwarf red | ttRr Dwarf red |
| tr | TtRr Tall red | Ttrr Tall white | ttRr Dwarf red | ttrr Dwarf white |

Phenotypic ratio: 9 : 3 : 3 : 1

Tall red Tall white Tall Dwarf red Dwarf white

Genotypic ratio: 1 : 2 : 1 : 2 : 4 : 2 : 1 : 2 : 1

Conclusion:

- Tall red and dwarf white are the phenō

typic new combination.

- Trait tall does not seem always with white. Alleles for tall traits and alleles for white traits are independently separated.
- Alleles of dwarf and red colour are also separated and able to remain with another trait; to produce tall red and dwarf white.
- Genotypic and phenotypic new combination proves, alleles of one trait are independent of alleles of another trait.

2. What is dihybrid cross? Mention diagrammatic account of dihybrid cross of Mendel's experiment and discuss. (8 marks) (2071)

- Cross carried out between two parents differing in two main

character or in two pairs of contrasting character.

- Parent organisms have different pairs of alleles for each trait.

- One parent possesses homozygous dominant alleles.

- Other parent possesses homozygous recessive alleles.

Experimental procedure:

• Collection of pea plant for experiment.

• Selection of parental plants.

• Cross breed: Hybrid

• Self-breeding of F_1 for the production of second generation plants.

• Analysis of F_1 , F_2 generations with their parents.

Example:

- Tall red ($TTRR$) and dwarf white ($ttrr$) plant are crossed.

- Named as parental generation.

Parents: Tall red $TTRR$ X Dwarf white $ttrr$

Gametes: TR tr

F_1 generation: $TtRr$ (Tall red hybrid)

Self cross between F_1 hybrid.

$TtRr$

TR Tr tR tr

For F_2 generation.

| $\begin{matrix} \text{♀} \\ \text{♂} \end{matrix}$ | TR | Tr | tR | tr |
|--|--------------------|----------------------|---------------------|-----------------------|
| TR | $TTRR$ tall red | $TTRr$ tall red | $TtRR$ tall red | $TtRr$ tall red |
| Tr | $TTRr$ tall red | $TTrr$ tall white | $TtRr$ tall red | $Tttr$ tall white |
| tR | $TtRR$ tall red | $TtRr$ tall red | $ttRR$ dwarf red | $ttRr$ dwarf red |
| tr | $TtRr$ tall red | $Tttr$ tall white | $ttRr$ dwarf red | $ttrr$ dwarf white |

Phenotypic ratio : 9 : 3 : 3 : 1

Genotypic ratio : 1 : 2 : 1 : 2 : 4 : 2 : 1 : 2 : 1

Conclusion:

- Tall red and dwarf white are the phenotypic new combination.

- Trait tall does not seem always with white. Alleles for tall traits and alleles for white traits are independently separated.

- Alleles of dwarf and red colour are also separated and able to remain with another trait, to produce tall red and dwarf white.

3. Genetics have found that not all traits show simple dominant recessive relationship. Justify this statement by describing incomi

plete dominance and co-dominance with suitable illustrations.
(8 marks)

- True that not all trait show simple dominant-recessive relationship.
- Proved by the phenomenon of incomplete dominance and co-dominance.

Incomplete dominance:

- Phenomenon where none of the two genes of parents are capable of expressing itself in heterozygous condition.
- Also called blending inheritance.

Procedure:

- 2 types of flower colour in Mirabilis jalapa taken. i.e. red and white.

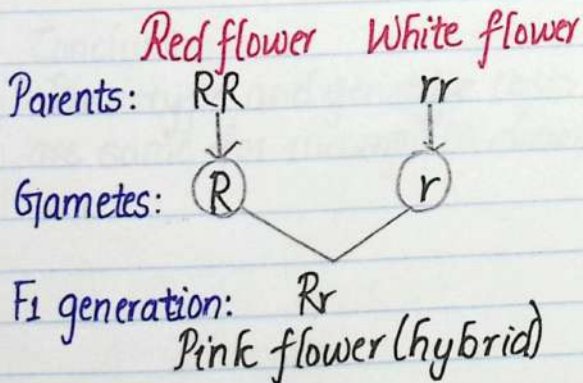
• Pure breeding plants are crossed, F_1 individual appears as pink colour.

• On selfing, 3 types of plants appear in F_2 generation i.e. red, pink and white ratio (1:2:1).

• Appearance of pink flower due to interaction of two allele present on the same gene locus.

Example:

Four O'clock plant (Mirabilis jalapa) and Snapdragon (Antirrhinum majus).



↓

Selfing

| | | |
|-----|------------|-------------|
| ♀ ♂ | R | r |
| R | RR Red | Rr Pink |
| r | Rr Pink | rr White |

| Phenotype | Genotype | Ratio |
|-----------|----------|-------|
| Red | RR | 1 |
| Pink | Rr | 2 |
| White | rr | 1 |

Conclusion:

- Phenotype and genotype ratio are same for incomplete dominance.

Codominance:

- Heterozygous condition in which both the alleles are equally dominant and express themselves fully.

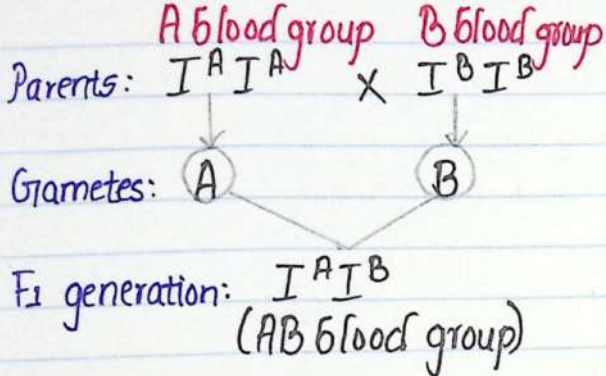
- Example:

AB blood group in humans.

Procedure:

• Allele I^A and I^B for A and B type blood group.

• Mating between homozygous A type with homozygous B type blood group would result in all heterozygous offspring. AB type blood group in F_1 generation.



Conclusion:

- AB type of blood group appears due to co-dominance of intra allelic gene interaction.

4. Differentiate between dominant and recessive. (4/6 marks)
(2055)

| Dominant | Recessive |
|---|--|
| i) Able to express itself even in the presence of | i) Unable to express its effect in the presence of |