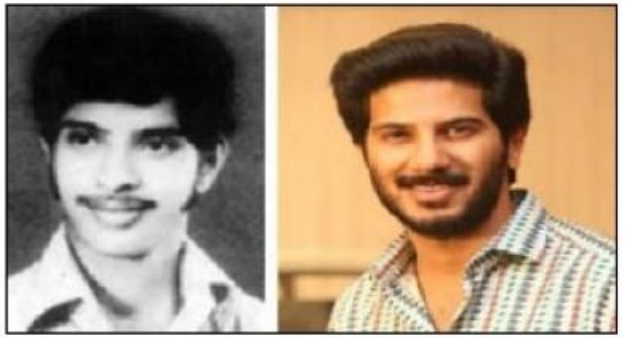

PRINCIPLES OF
INHERITANCE & VARIATION

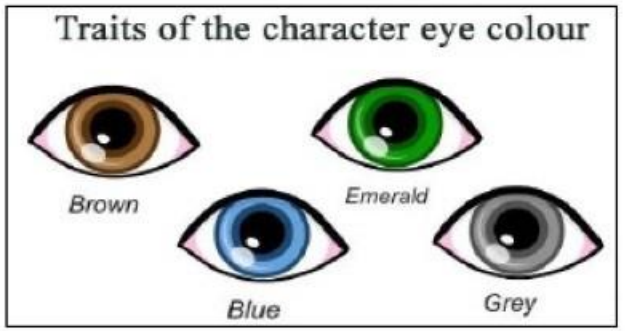
Part 1

MENDEL'S LAWS OF INHERITANCE

IMPORTANT TERMS

Genetics	Study of **inheritance, heredity & variation** of characters or Study of genes & chromosomes.
Inheritance	Transmission of characters from parents to progeny. It is the basis of **heredity.**
Variation	Difference between parents and offspring.
Character	A heritable feature among the parents & offspring. E.g. Eye colour.
Trait	Variants of a character. E.g. Brown eye, Blue eye.





IMPORTANT TERMS

Alleles (Allelomorphs)

Alternative forms of a gene.

E.g. T (tall) & t (dwarf) are two alleles of a gene for the character height.

Homozygous

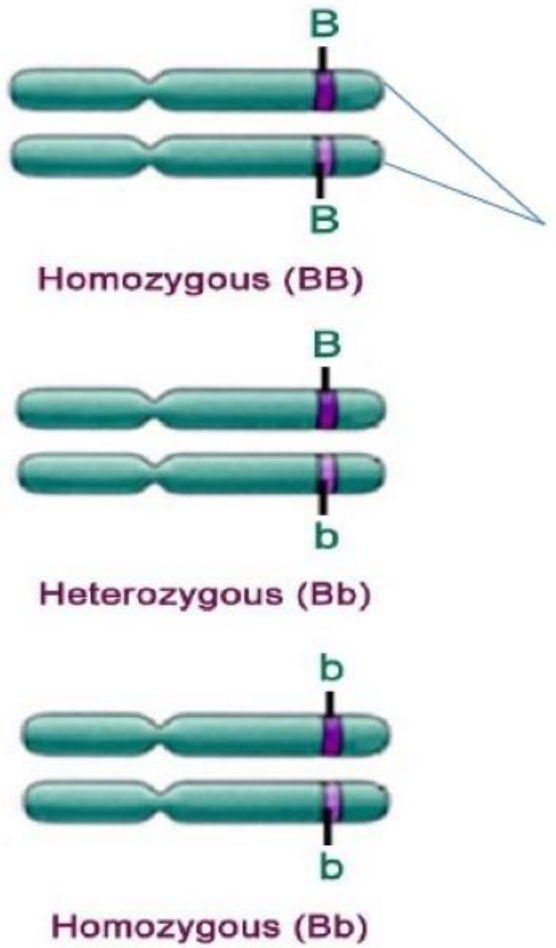
The condition in which chromosome pair carries similar alleles of a gene. Also known as pure line (True breeding).

E.g. TT, tt, YY, yy etc.

Heterozygous

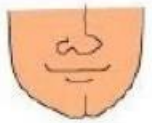
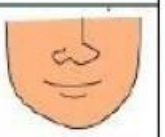
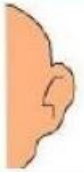
The condition in which chromosome pair carries dissimilar alleles of a gene.

E.g. Tt, Yy etc.



IMPORTANT TERMS

Dominant character	The character which is **expressed** in heterozygous condition. It indicates with capital letter.
Recessive character	The character which is **suppressed** in heterozygous condition. It indicates with small letter.
Phenotype	Physical expression of a character.
Genotype	Genetic constitution of a character.
Hybrid	An individual produced by mating of genetically unlike parents.

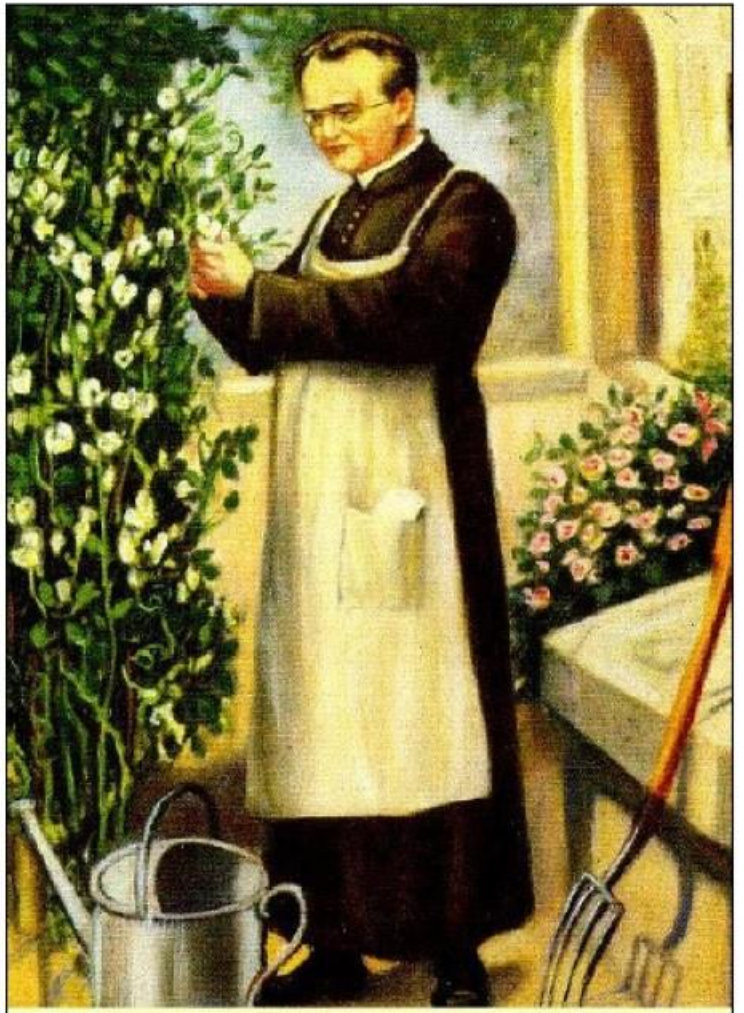
Dominant character	Recessive character
Cleft Chin 	No Cleft 
Widow's Peak 	No Widow's Peak 
Dimples 	No Dimples 
Brown/Black Hair 	Blonde Hair 
Freckles 	No Freckles 
Brown Eyes 	Gray/Blue Eyes 
Free Earlobe 	Attached Earlobe 

Gregor Mendel:

Father of Genetics

MENDEL'S LAWS OF INHERITANCE

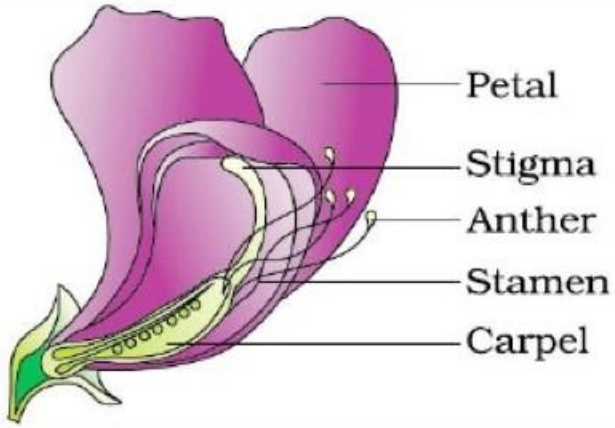
Mendel conducted some **hybridization experiments** on **garden peas *(Pisum sativum)*** for 7 years (1856-1863).



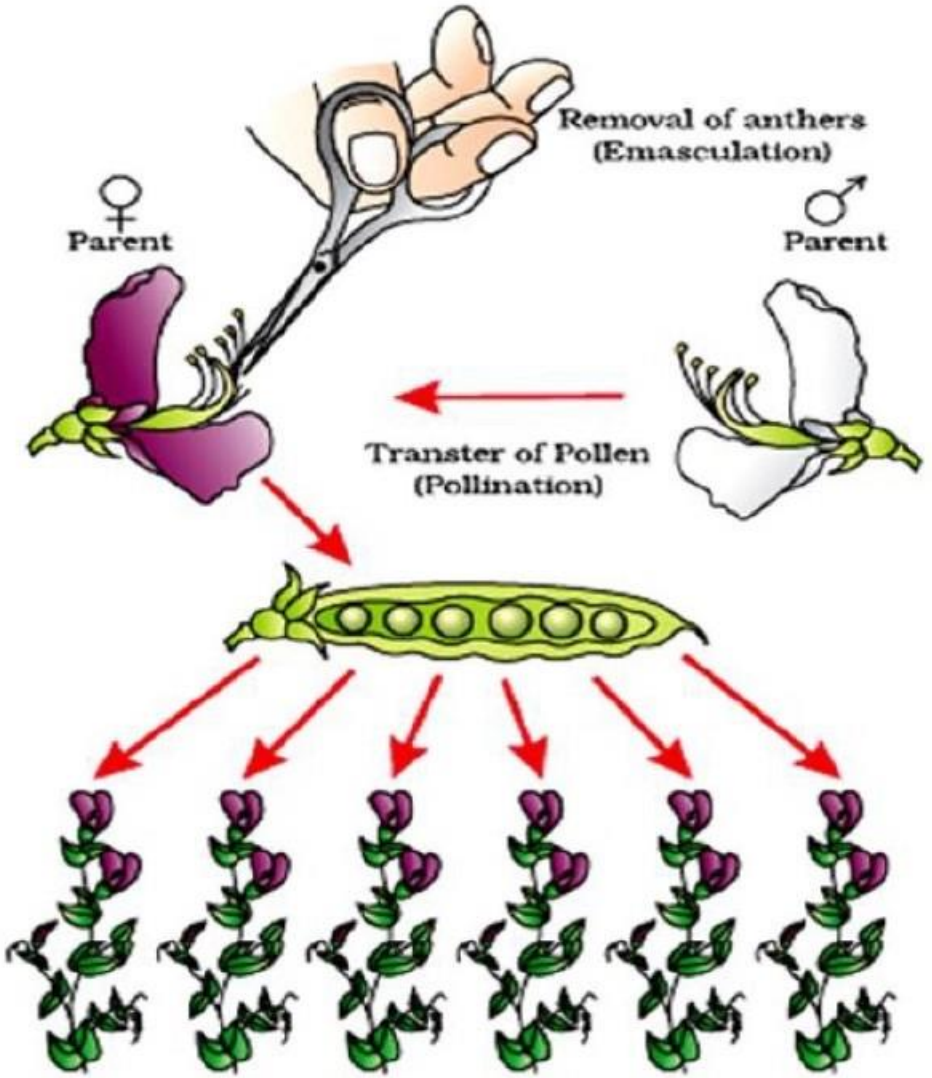
GREGOR MENDEL

MENDEL'S LAWS OF INHERITANCE

STEPS IN MAKING A CROSS IN PEA



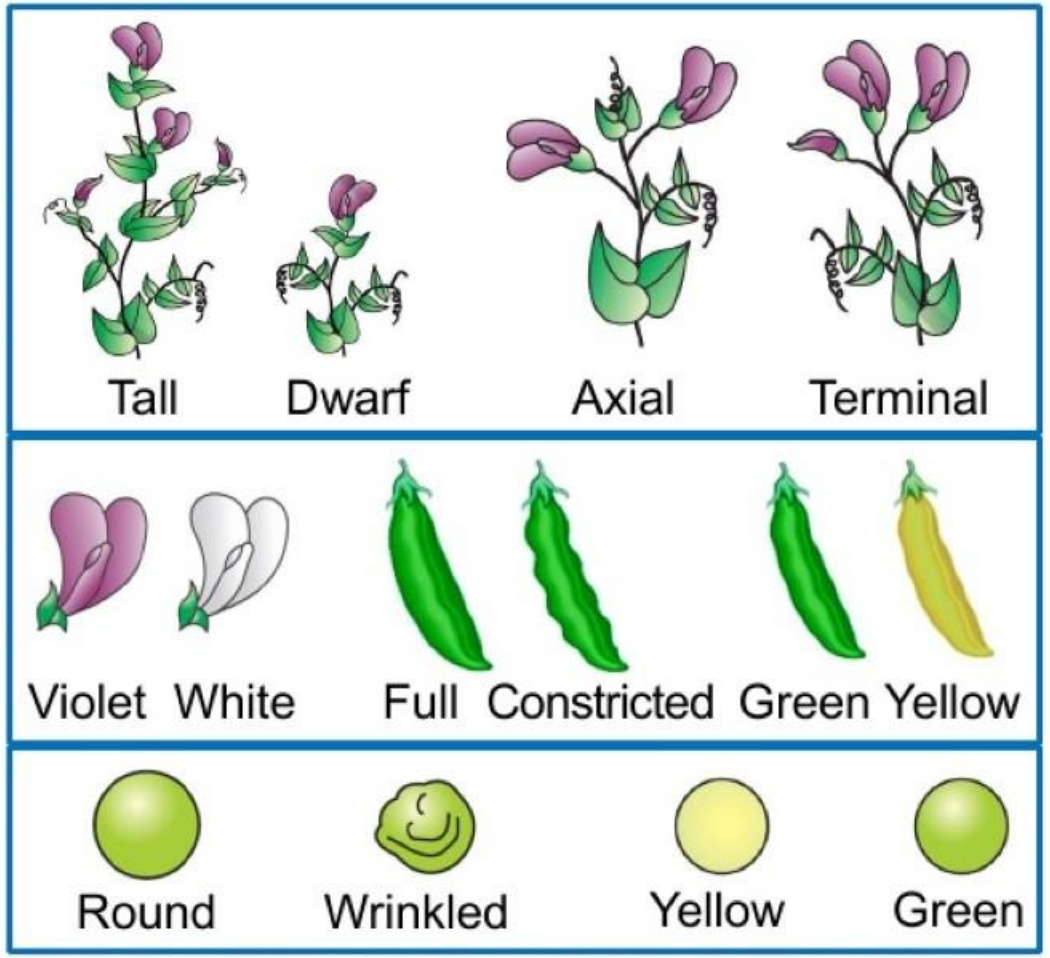
1. **Selection** of 2 pea plants with contrasting characters.
2. **Emasculation:** Removal of anthers of one plant to avoid self-pollination. This is female parent.
3. **Pollination:** Collection of pollen grains from the male parent and transferring to female parent.
4. **Collection & germination** of seeds to produce offspring.



MENDEL'S LAWS OF INHERITANCE

7 TRUE BREEDING VARIETIES SELECTED BY MENDEL

Characters	Contrasting traits	
	Dominant	Recessive
1. Stem height	Tall	Dwarf
2. Flower position	Axial	Terminal
3. Flower colour	Violet	White
4. Pod shape	Inflated	Constricted
5. Pod colour	Green	Yellow
6. Seed shape	Round	Wrinkled
7. Seed colour	Yellow	Green



MENDEL'S LAWS OF INHERITANCE

INHERITANCE OF ONE GENE

Monohybrid cross

- A cross involving 2 plants differing in one character pair.
- E.g. Mendel crossed tall and dwarf pea plants to study the inheritance of one gene.

Tall

X

Dwarf

Cross between tall plant and dwarf plant

Yellow

X

Green

Cross between yellow seeded plant and green seeded plant

MENDEL'S LAWS OF INHERITANCE

INHERITANCE OF ONE GENE

Parents:  Homozygous Tall (TT) **X**  Homozygous Dwarf (tt)

Gametes: T t

Tt

F1 (First filial):  (Heterozygous Tall)

F1 Selfing:  **X** 

Heterozygous Tall (Tt) Heterozygous Tall (Tt)

Gametes: T t T t

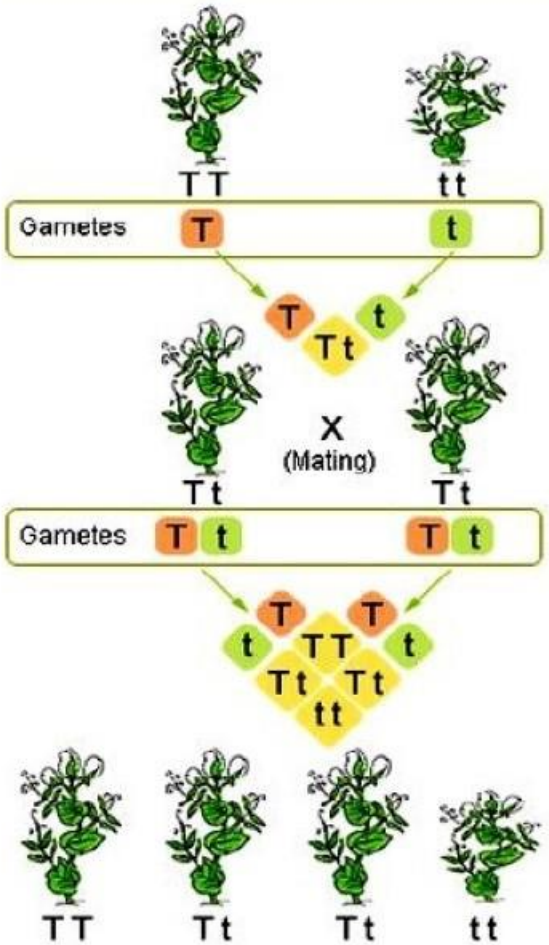
F2:

	T	t
T	TT Tall	Tt Tall
t	Tt Tall	tt Dwarf

Punnett square (checker board)

MENDEL'S LAWS OF INHERITANCE

INHERITANCE OF ONE GENE



	T	t
T	TT Tall	Tt Tall
t	Tt Tall	tt Dwarf

Monohybrid phenotypic ratio

Tall: 3 Dwarf: 1

3:1

Monohybrid genotypic ratio

Homozygous tall (TT): 1

Heterozygous tall (Tt): 2

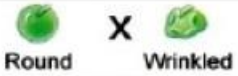
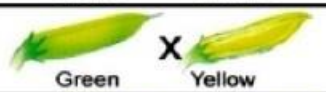
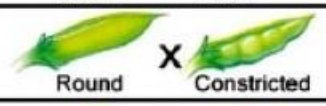
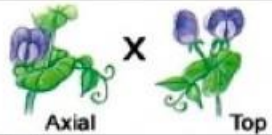
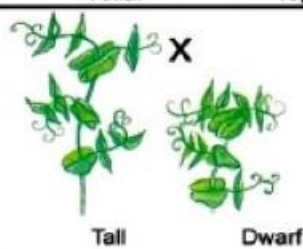
Homozygous dwarf (tt): 1

1:2:1

MENDEL'S LAWS OF INHERITANCE

INHERITANCE OF ONE GENE

- Mendel made similar observations for the other pairs of traits.
- He proposed that some factors were inherited from parent to offspring.
- Factors are now called as genes.

Trait	Dominant vs. recessive	F_2 generations Dominant form	F_2 generations Recessive form	Ratio
Flower color	 Purple X White	705	224	3.15:1
Seed color	 Yellow X Green	6022	2001	3.01:1
Seed shape	 Round X Wrinkled	5474	1850	2.96:1
Pod color	 Green X Yellow	428	152	2.82:1
Pod shape	 Round X Constricted	882	299	2.95:1
Flower position	 Axial X Top	651	207	3.14:1
Plant height	 Tall X Dwarf	787	277	2.84:1

MENDEL'S LAWS OF INHERITANCE

INHERITANCE OF ONE GENE

- The F1 (Tt) when self pollinated, produces gametes T & t in equal proportion.
- During fertilization, pollen grains of T have 50% chance to pollinate eggs of the T and t. Also, pollen grains of genotype t have a 50% chance to pollinate eggs of T and t.

1/4th of the random fertilization leads to TT

1/2 (2/4) of the random fertilization leads to Tt

1/4th of the random fertilization leads to tt.

i.e. ¼ TT, ½ Tt, ¼ tt

MENDEL'S LAWS OF INHERITANCE

INHERITANCE OF ONE GENE

- The F1 (Tt) when self pollinated, produces gametes T & t in equal proportion.
- During fertilization, pollen grains of T have 50% chance to pollinate eggs of the T and t. Also, pollen grains of genotype t have a 50% chance to pollinate eggs of T and t.

Tt x Tt

Binomial expression = $(ax + by)^2$

Hence $(\frac{1}{2} T + \frac{1}{2} t)^2$

$= (\frac{1}{2} T + \frac{1}{2} t)(\frac{1}{2} T + \frac{1}{2} t)$

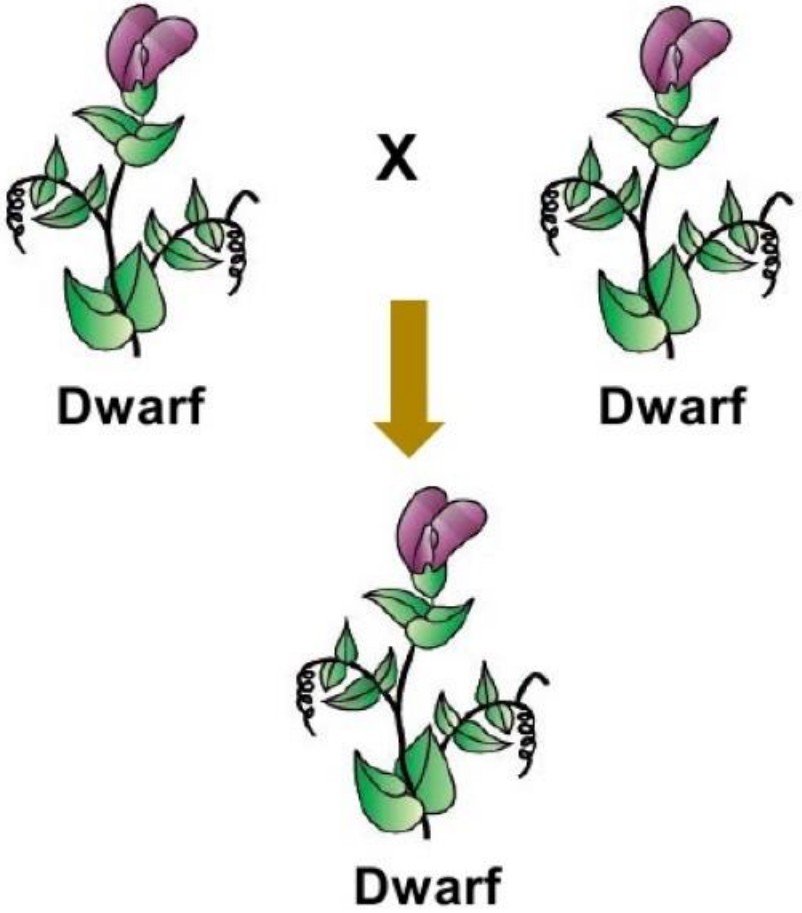
$= \frac{1}{4} TT + \frac{1}{4} Tt + \frac{1}{4} Tt + \frac{1}{4} tt$

$= \frac{1}{4} TT + \frac{1}{2} Tt + \frac{1}{4} tt$

MENDEL'S LAWS OF INHERITANCE

INHERITANCE OF ONE GENE

- Mendel self-pollinated the F2 plants.
- He found that dwarf F2 plants continued to generate dwarf plants in F3 and F4 generations.
- He concluded that genotype of the dwarfs was homozygous – *tt*.



Part 2

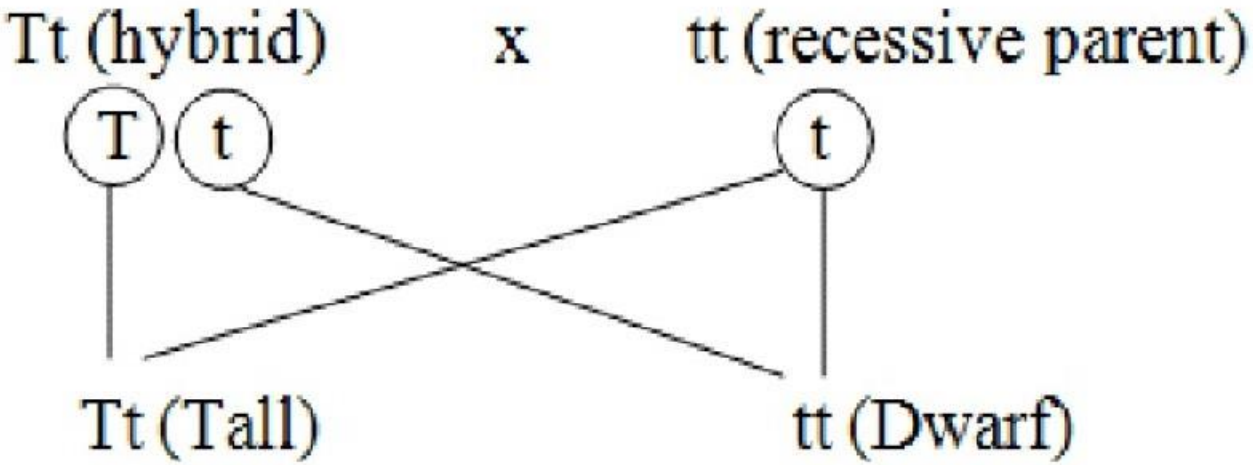
MENDEL'S LAWS OF INHERITANCE-2

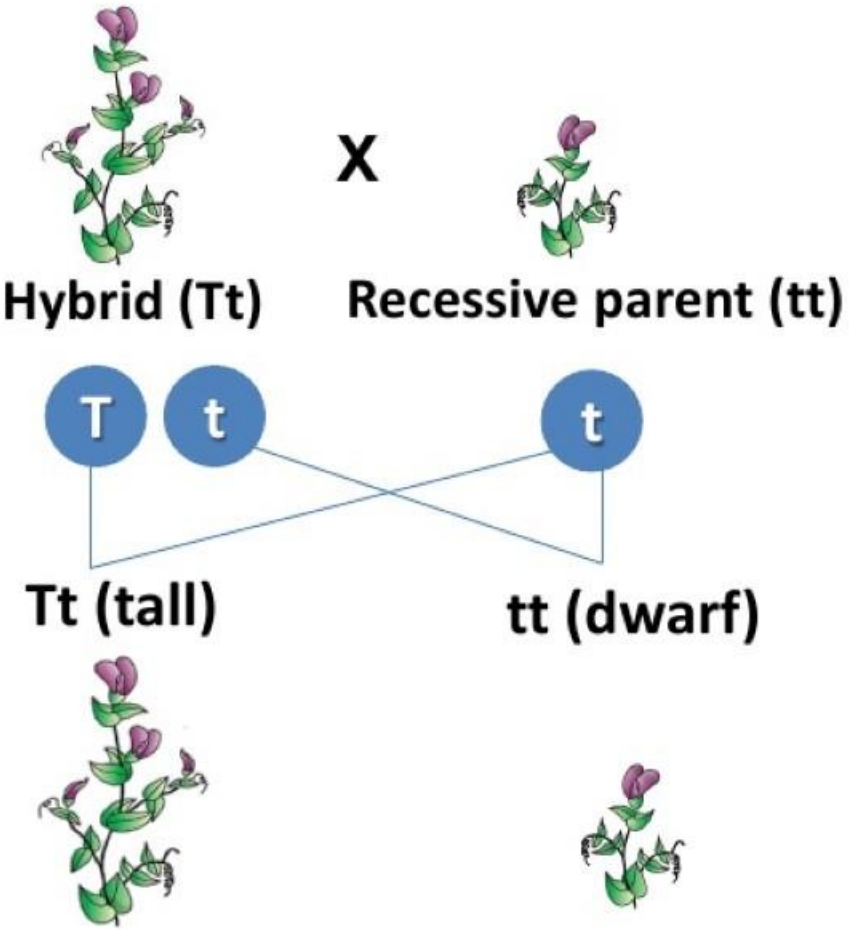
- Back cross
- Test cross
- Dihybrid cross
- Concept of dominance

MENDEL'S LAWS OF INHERITANCE

BACK CROSS AND TEST CROSS

- **Backcross:** Cross between a **hybrid** and its **any parent.**
- **Testcross:** Crossing of an organism with **dominant phenotype** to a **recessive individual.**



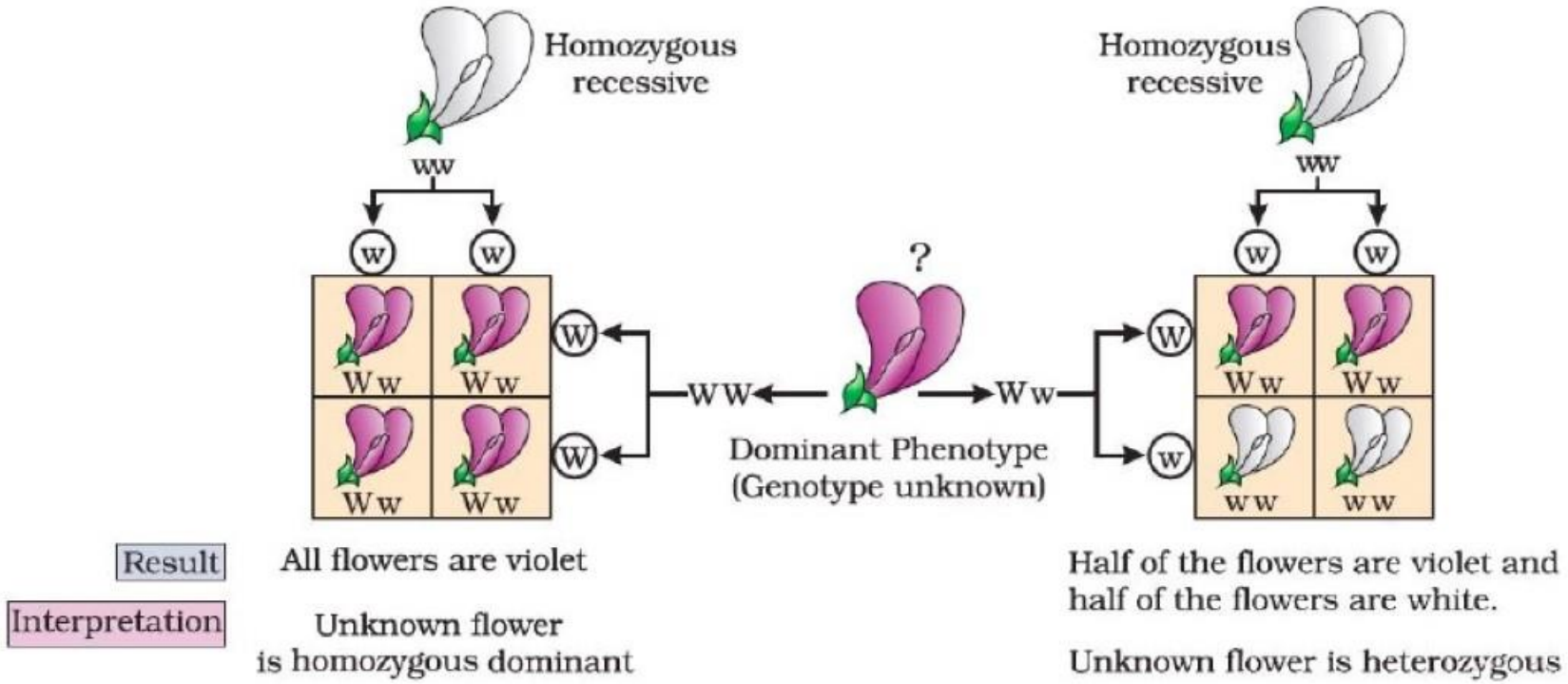


Hence monohybrid test cross ratio= 1:1

MENDEL'S LAWS OF INHERITANCE

BACK CROSS AND TEST CROSS

- **Test cross is used to find out the unknown genotype of a character. E.g.**

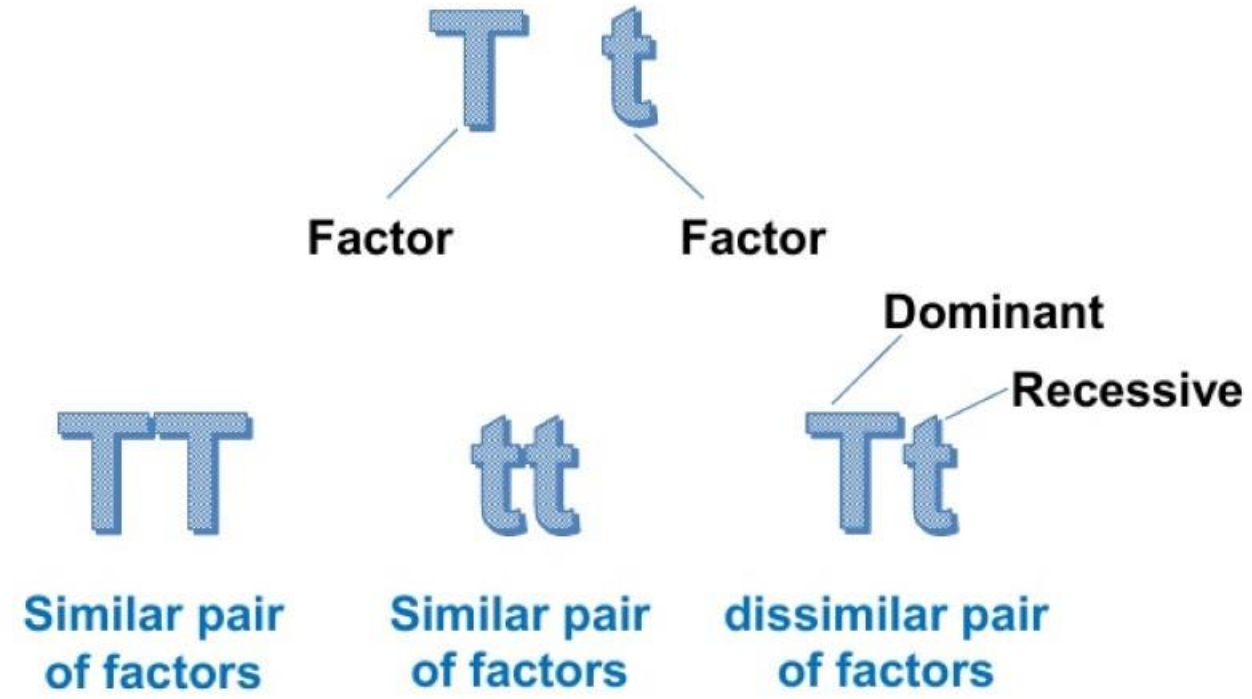


- **Mendel conducted test cross to determine the F2 genotype.**

MENDEL'S LAWS OF INHERITANCE

FIRST LAW: LAW OF DOMINANCE

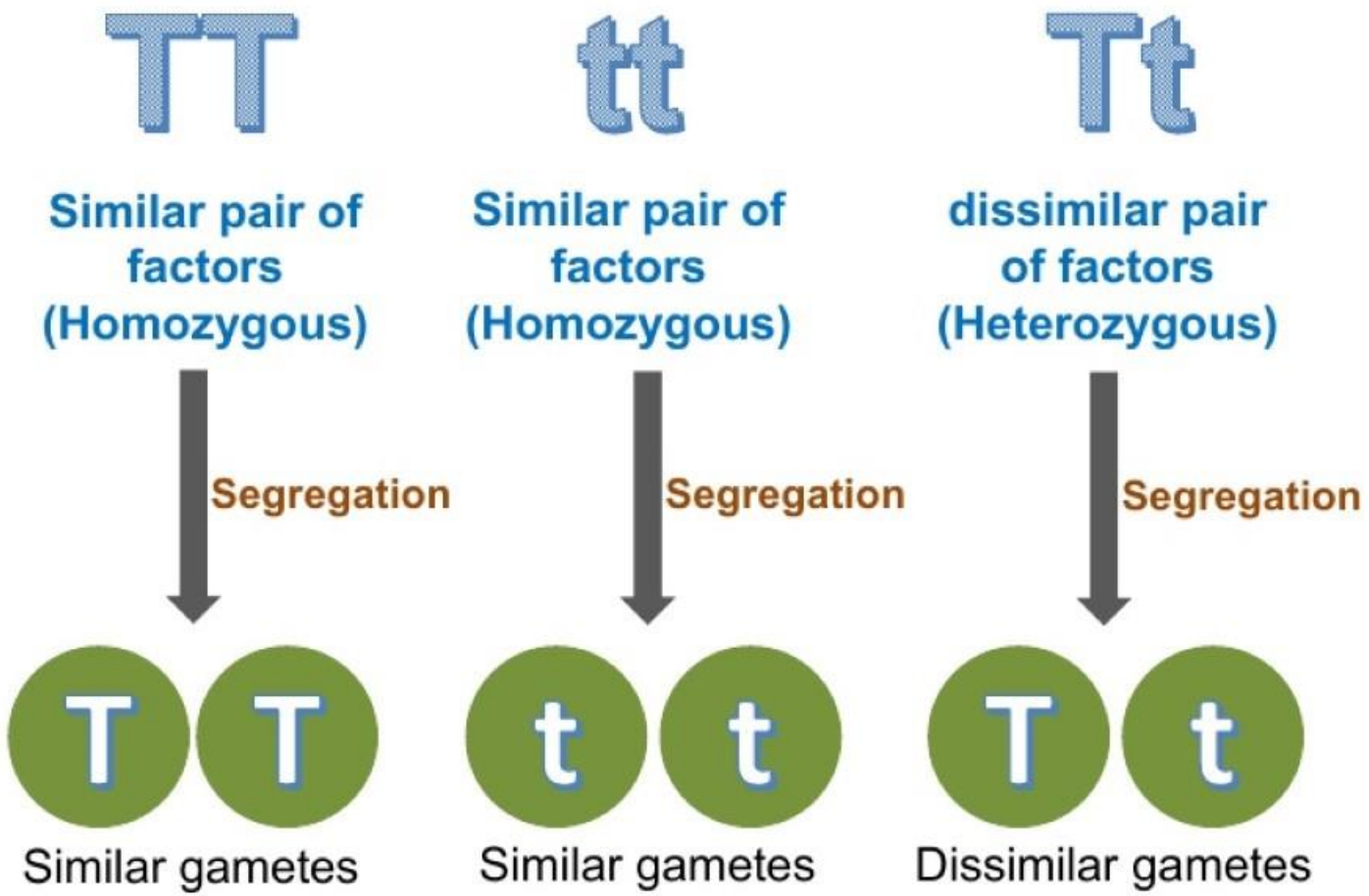
- ✓ *Characters are controlled by discrete units called factors.*
- ✓ *Factors occur in pairs.*
- ✓ *In a dissimilar pair of factors, one member of the pair dominates (dominant) the other (recessive).*



MENDEL'S LAWS OF INHERITANCE

SECOND LAW: LAW OF SEGREGATION

- *"During gamete formation, the factors (alleles) of a character pair present in parents segregate from each other such that a gamete receives only one of the 2 factors".*
- Homozygous parent produces similar gametes.
- Heterozygous parent produces two kinds of gametes each having one allele with equal proportion.



MENDEL'S LAWS OF INHERITANCE

INHERITANCE OF TWO GENES

Dihybrid cross

- It is a cross between two parents differing in 2 pairs of contrasting characters.
- E.g. Cross between pea plant with round shaped & yellow coloured seeds (RRYY) and wrinkled shaped & green coloured seeds (rryy).

Round yellow

X

Wrinkled green

MENDEL'S LAWS OF INHERITANCE

INHERITANCE OF TWO GENES

Dihybrid cross

Parents: Homozygous Round yellow RRYY X Homozygous wrinkled green rryy

Gametes: RY ry

F1: RrYy (Heterozygous Round yellow)

Selfing: RrYy X RrYy

Gametes: RY Ry rY ry RY Ry rY ry

MENDEL'S LAWS OF INHERITANCE

INHERITANCE OF TWO GENES

Dihybrid cross

F2:

	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

Round Yellow

Round Green

Wrinkled Yellow

Wrinkled Green

MENDEL'S LAWS OF INHERITANCE

INHERITANCE OF TWO GENES

Dihybrid cross

On observing F2, Mendel found that the yellow & green colour segregated in a 3:1 ratio.
Round & wrinkled seed shape also segregated in a 3:1 ratio.

	RY	Ry	rY	ry
RY	1	2	3	4
Ry	5	1	6	2
rY	7	8	1	2
ry	9	3	3	1

- 9 Round yellow
  3 Round green
  3 Wrinkled yellow
  1 Wrinkled green

Dihybrid F2 Phenotypic ratio

9:3:3:1

- This ratio can be derived as a combination series of 3 yellow: 1 green, with 3 round: 1 wrinkled.

i.e. (3: 1) (3: 1) = 9:3:3:1

MENDEL'S LAWS OF INHERITANCE

INHERITANCE OF TWO GENES

Dihybrid cross

On observing F2, Mendel found that the yellow & green colour segregated in a 3:1 ratio.
Round & wrinkled seed shape also segregated in a 3:1 ratio.

	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

RRYY = 1
RRYy = 2
RrYY = 2
RrYy = 4
RRyy = 1
Rryy = 2
rrYY = 1
rrYy = 2
rryy = 1

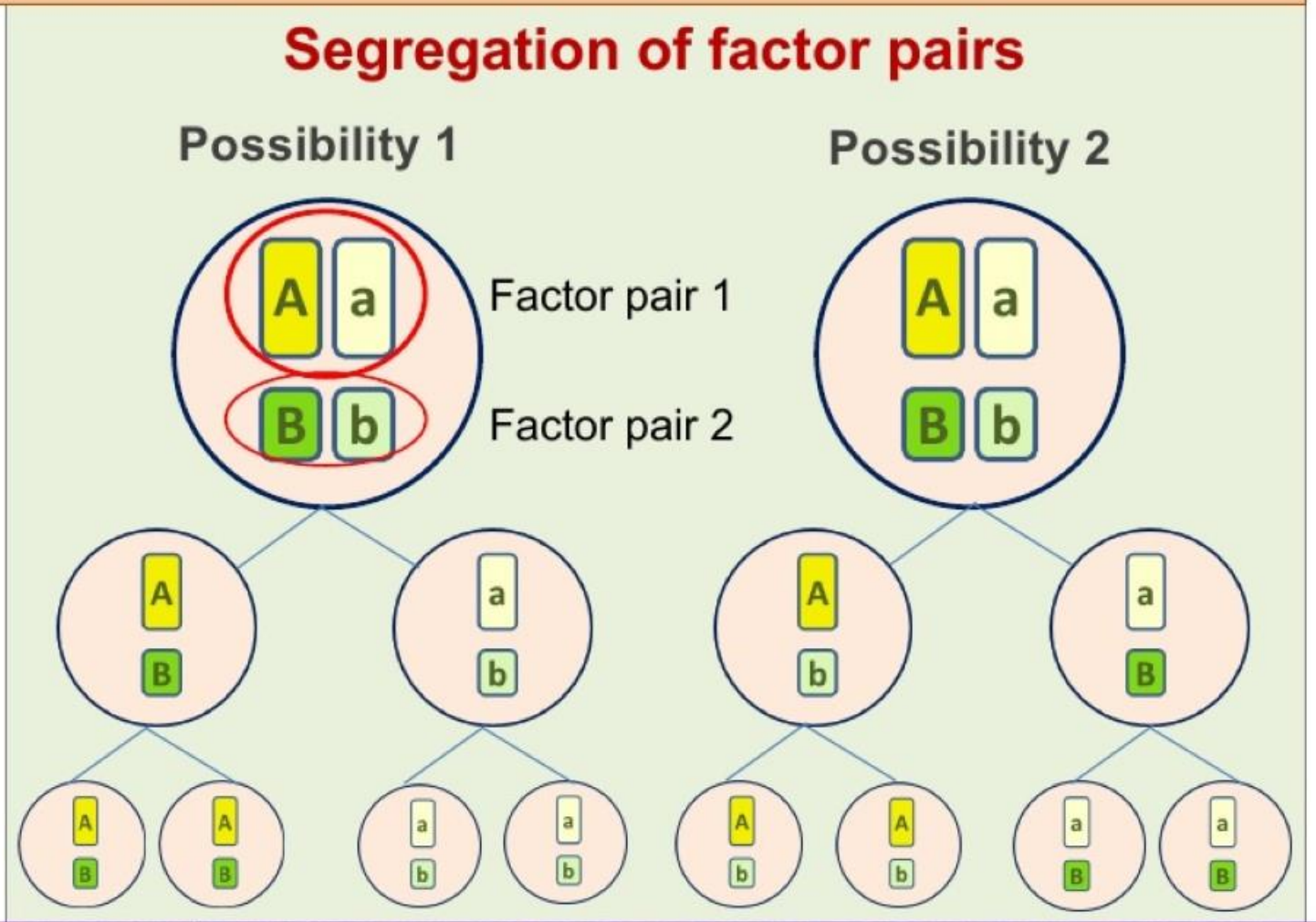
Dihybrid F2 Genotypic ratio

1:2:1:2:4:2:1:2:1

MENDEL'S LAWS OF INHERITANCE

THIRD LAW: LAW OF INDEPENDENT ASSORTMENT

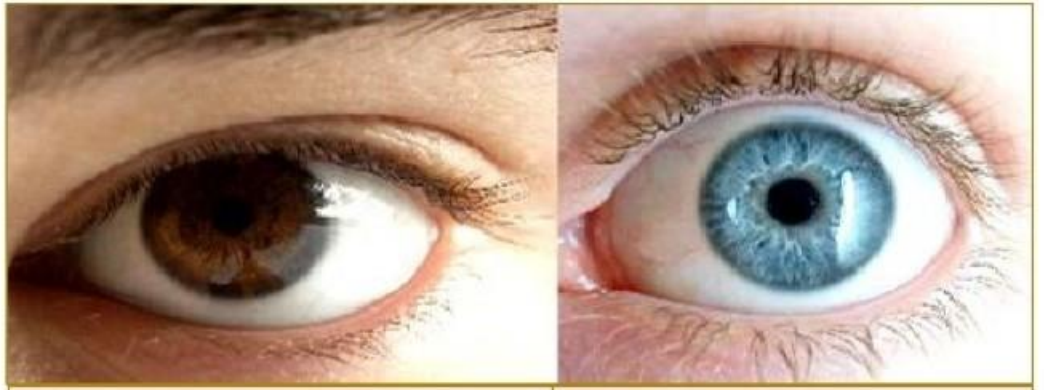
- It is based on the results of dihybrid crosses.
- It states that *'when more than one pair of characters are involved in a cross, factor pairs independently segregate from the other pair of characters'.*



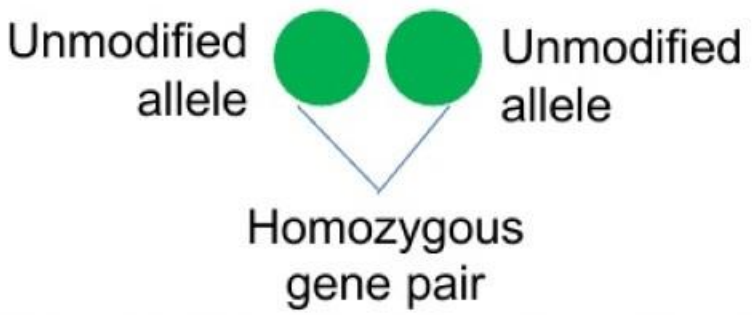
MENDEL'S LAWS OF INHERITANCE

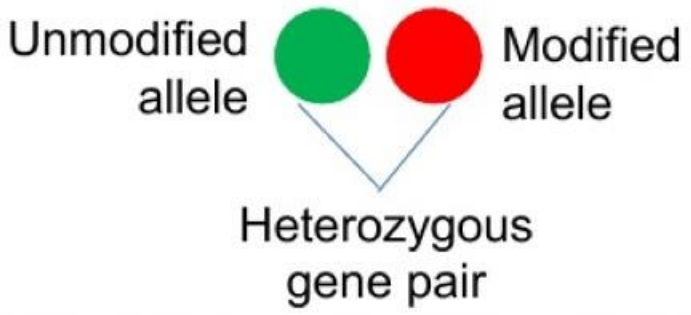
THE CONCEPT OF DOMINANCE

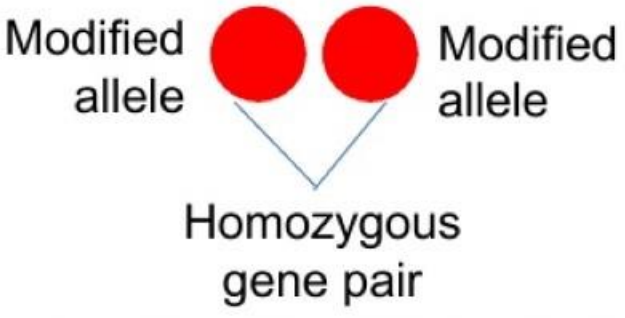
- Every gene contains information to express a particular trait.
- In heterozygotes, there are 2 types of alleles:
  - ✓ **Unmodified (normal or functioning) allele:** It is generally dominant and represents original phenotype.
  - ✓ **Modified allele:** It is generally recessive.



Allele of brown eye colour is unmodified allele	Allele of blue eye colour is modified allele







MENDEL'S LAWS OF INHERITANCE

THE CONCEPT OF DOMINANCE

- E.g. Consider a gene that contains information for producing an enzyme. Normal allele of that gene produces a normal enzyme. Modified allele is responsible for production of

i. Normal/less efficient enzyme or **ii. Non-functional enzyme** or **iii. No enzyme at all**

- In this case, modified allele will produce the same phenotype like unmodified allele.
- Thus, modified allele is equivalent to unmodified allele.

- In these cases, the phenotype will dependent only on the functioning of the unmodified allele.
- Thus the modified allele becomes recessive.