Genetics

INTRODUCTION

Genetics term was given by W. Bateson.

Genetics → Collictive study of heredity and variations.

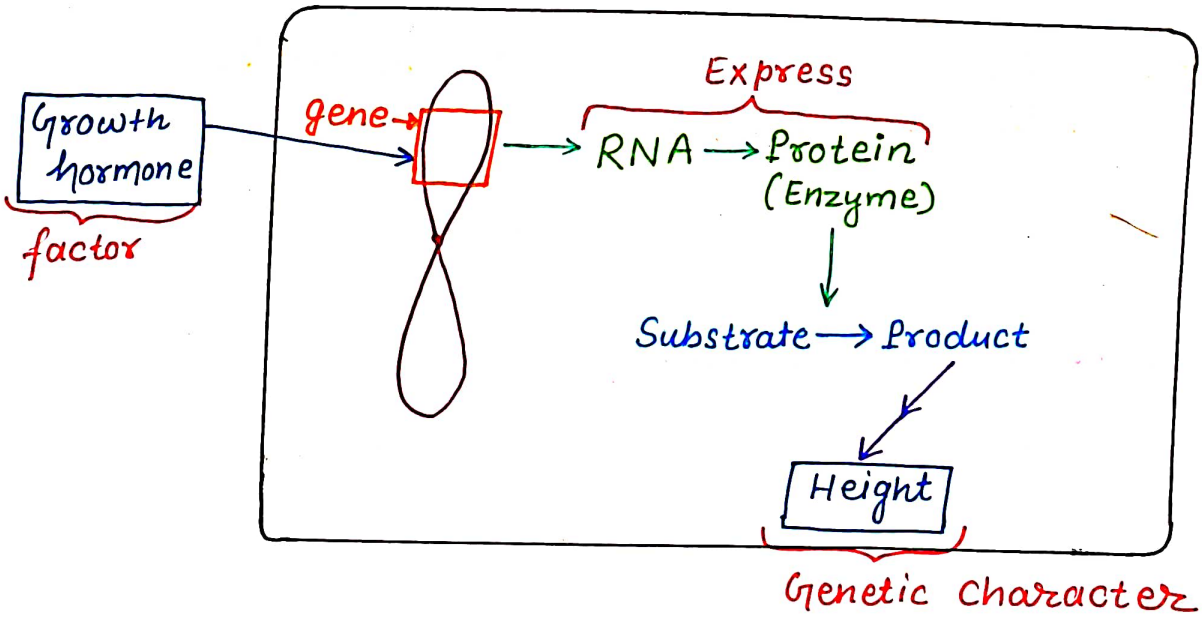
Heredity → Study of transmission of genetic characters from parents to offspring's.

Variations → Differences that are seen among the members of same species.

Inharitance → Process by which genetic characters are transfer from parent to offspring's

For the development of genetic characters following Conditions are required :-

1. Gene should be present.
2. Gene should be express.
3. For expression suitable condition require



HISTORY OF RESEARCHES IN GENETICS ---

Gregor Johan Mendel :- Father of Genetics.

W. Bateson :- Father of Modern Genetics.

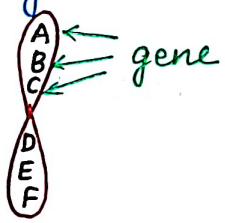
↳ He proposed various term like Genetics, Allele, Homozygous, Heterozygous.

T.H. Morgan :- Father of Experimental genetics.

↳ He performed experiment on Drosophilla.

↳ He proposed various concepts like Linkage, Sex Linkage, Crossing over, Criss-Cross inharitance

↳ He suggested that genes are linearly arranged on chromosome.



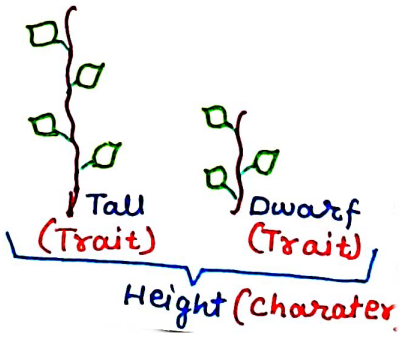
A. Garrod :- Father of human genetics and Biochemical genetics.

↳ He discovered first human metabolic genetic disorder i.e. Alkaptonuria .
[Black urine disease]

SOME GENETICAL TERMS ----

- **Character :-** Any feature of an organism.
  eg: Stem height, Flower colour

- **Trait :-** Variable form of a character.
  eg: Tall/Dwarf

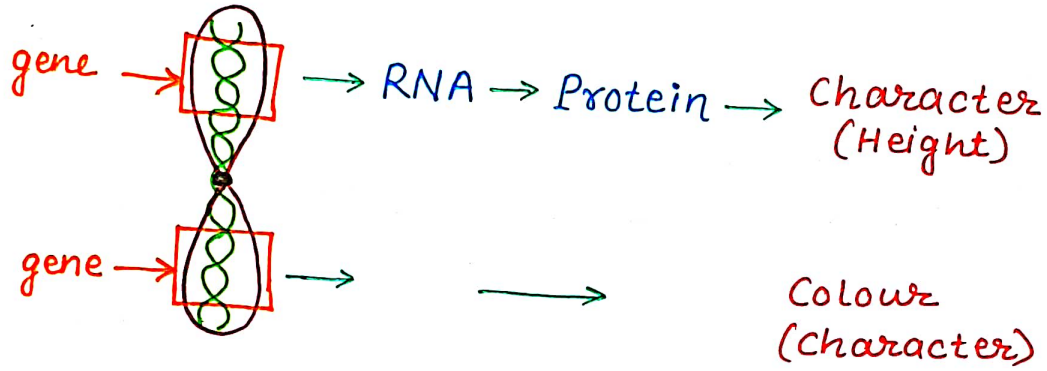


- **Gene (term by Johannsen):-** Mendel used term "Element" or "Factor."
  - ↳ Segment of DNA that is responsible for appearance of Characters.
  - ↳ Segment of DNA that generally synthesizes RNA and protein.

Gene :- Unit of inheritance

Chemically gene is :- DNA

↳ All genes are DNA but all DNAs are not gene.

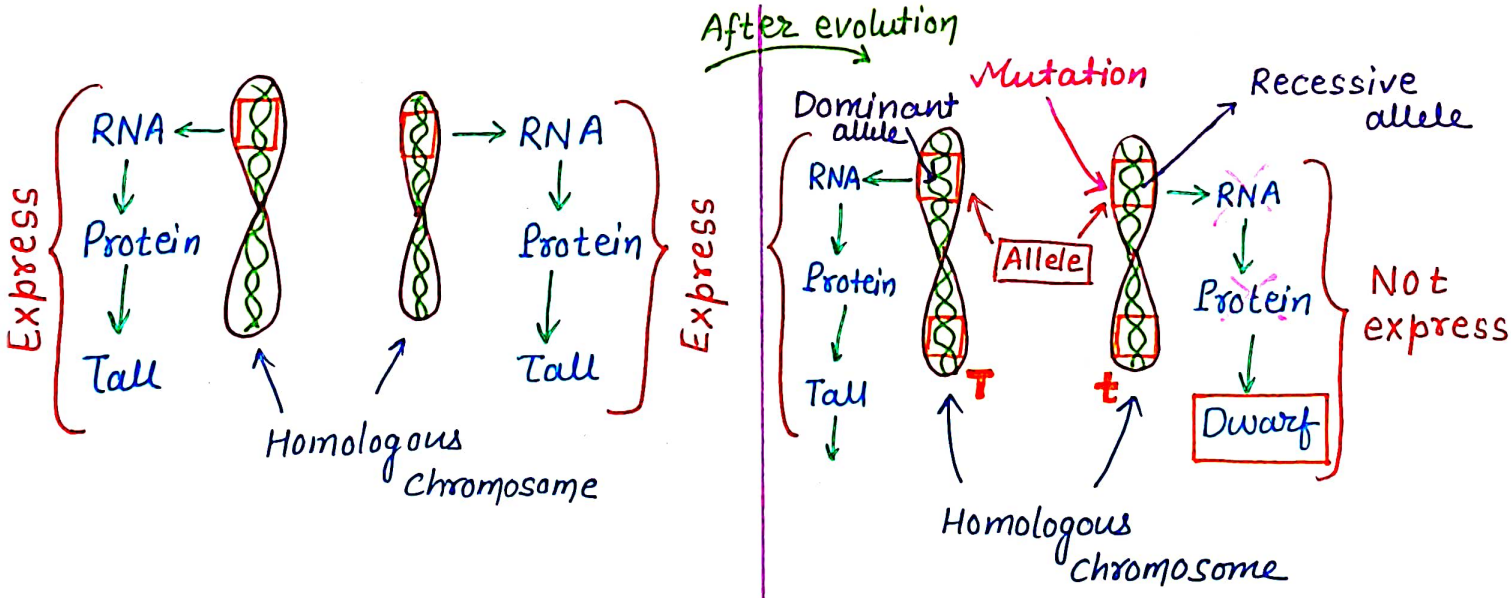


- **Alleles :-**

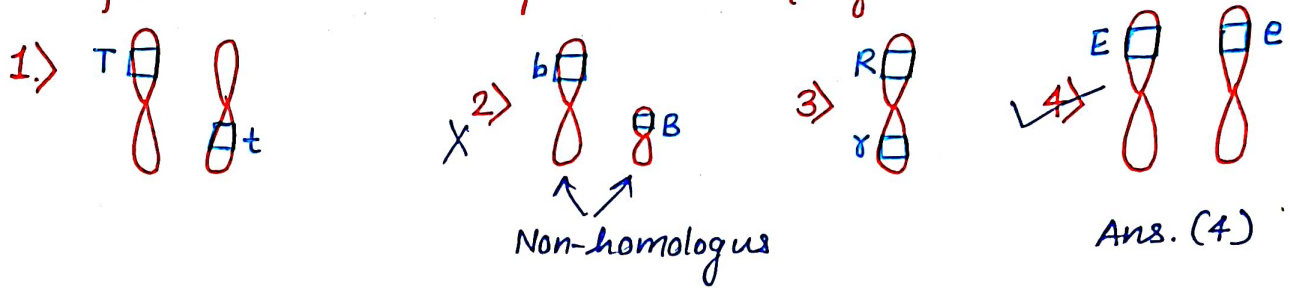
Alternate forms of a gene is called allele.

Allele arise due to mutation.

Allele pr. at same locus on homologous chromosomes.



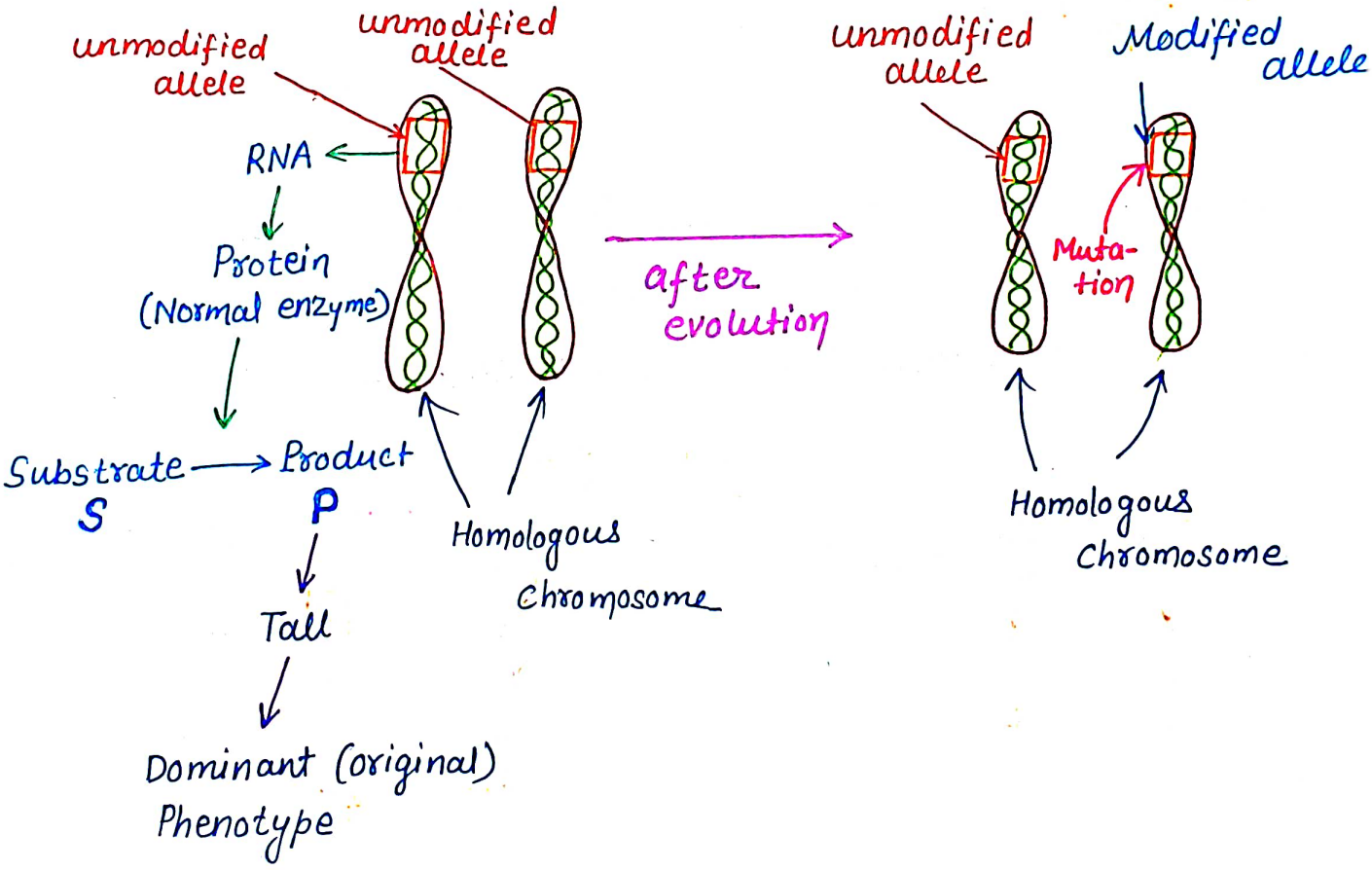
Q. W.O.f is a correct presentation of allele?

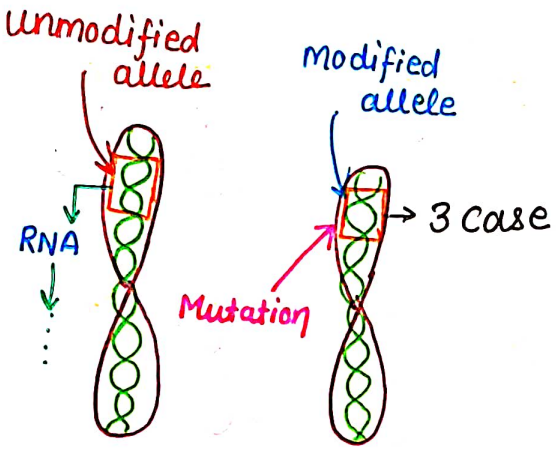


Ans. (4)

- **Unmodified allele/wild allele/original type :-**
  - Allele which is pr. in nature from starting.
  - Generally unmodified allele is dominant allele

- **Modified allele :-**
  - Formed by mutation.
  - Generally modified allele is recessive allele.





RNA → Normal enzyme/less efficient

S → P

Tall ⇒ Dominant

RNA → Non-functional enzyme

S → P

Dwarf ⇒ Recessiv

RNA → No enzyme at all

S → P

Dwarf ⇒ Recessiv

Conclusion :-

① Modified allele = Unmodified allele

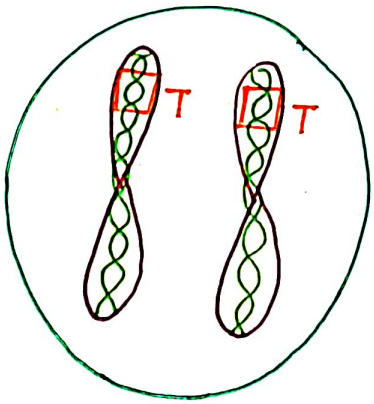
② and ③

Modified allele ≠ Unmodified allele

- **Homozygous / Pure / True-breeding :-**

Presence of two similar alleles of a gene in a diploid organism.

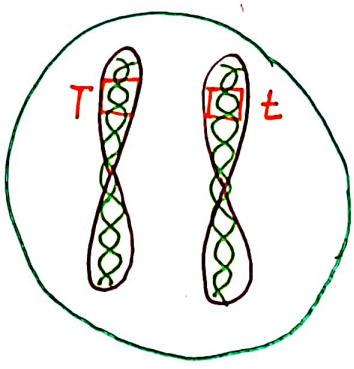
Eg: TT, tt



- **Heterozygous / Impure**

Presence of two dissimi alleles of a gene in a diploid organism.

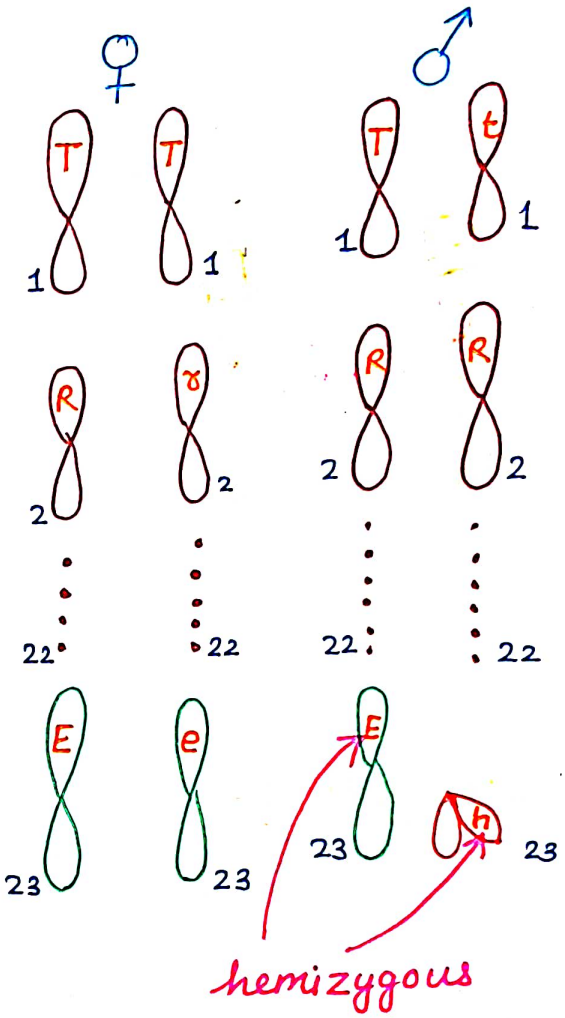
Eg: Tt



• Hemizygous :-

In diploid organism, presence of single allele of a gene.

Eg:- genes pr. on X and Y Chromosomes of human male.



• Dominant Allele

Allele that can be express both in homozygous and heterozygous condition.

Eg: T allele

• Recessive Allele

Allele that can express only in homozygous Condition.

Eg: t allele

Dominant Allele

Homozygous **TT** Tall } Dominant Trait

Heterozygous **Tt** Tall }

Homozygous **tt** Dwarf } Recessive Trait

Recessive Allele

Q. W.o.f is dominant allele and Recessive allele, & if we cross R = Red and R' = yellow ?

Given :-

RR = Red

RR' = yellow

R'R' = yellow

} Dominant trait

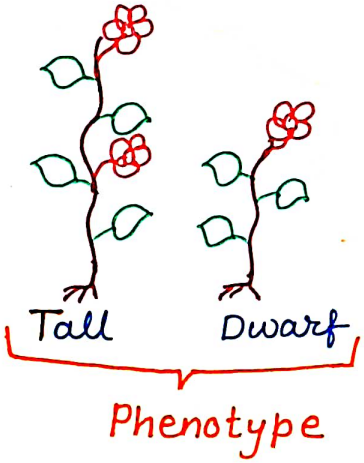
R' → Dominant allele

R → Recessive allele

• Phenotype :-

The external appearance of an organism for a particular character.

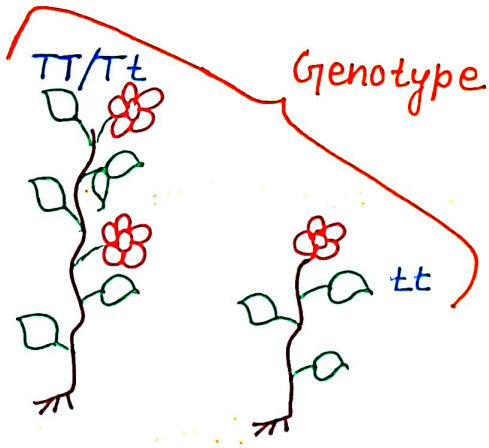
Eg :- Tall / Dwarf



• Genotype :-

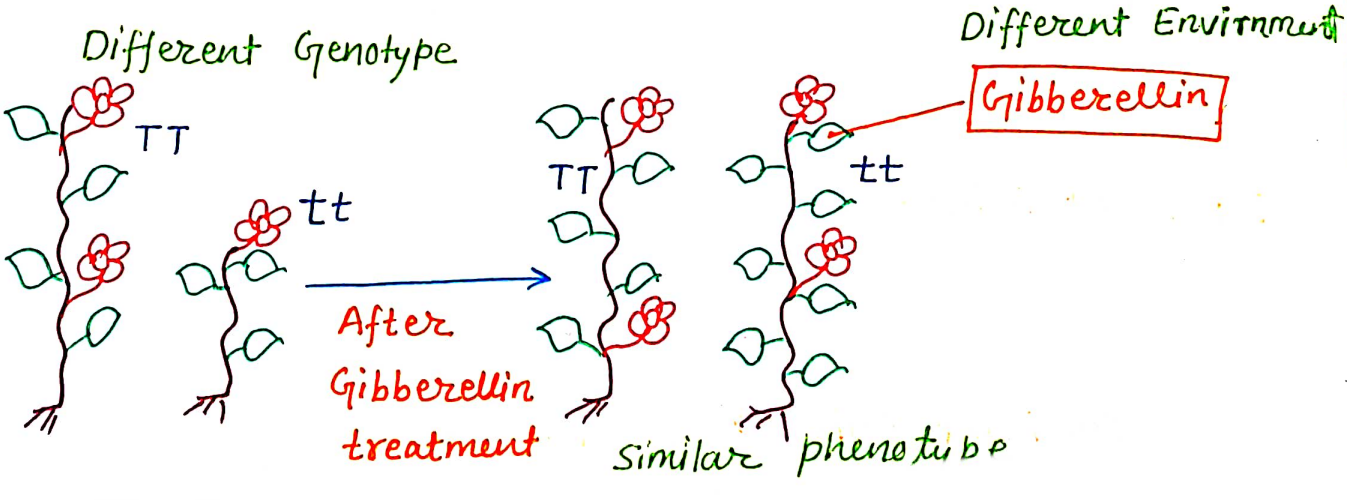
The genetic constitution/ genetic make-up of an organism for a particular character.

Eg :- TT / Tt / tt



• Phenocopy :-

When two different genotype place under different environmental conditions and develop similar phenotype, they are called phenocopy of each other.



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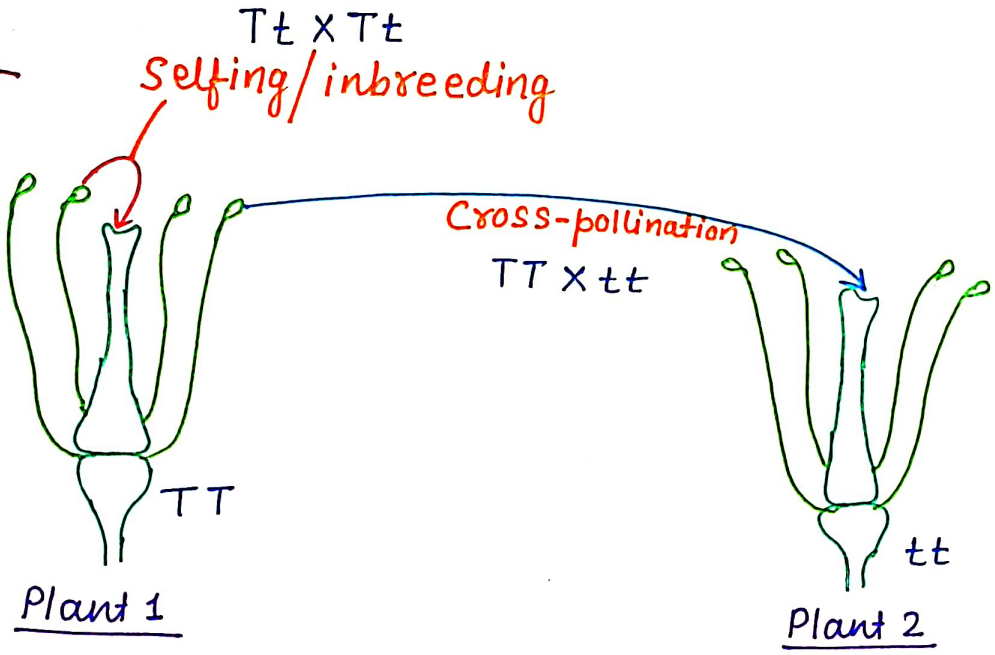
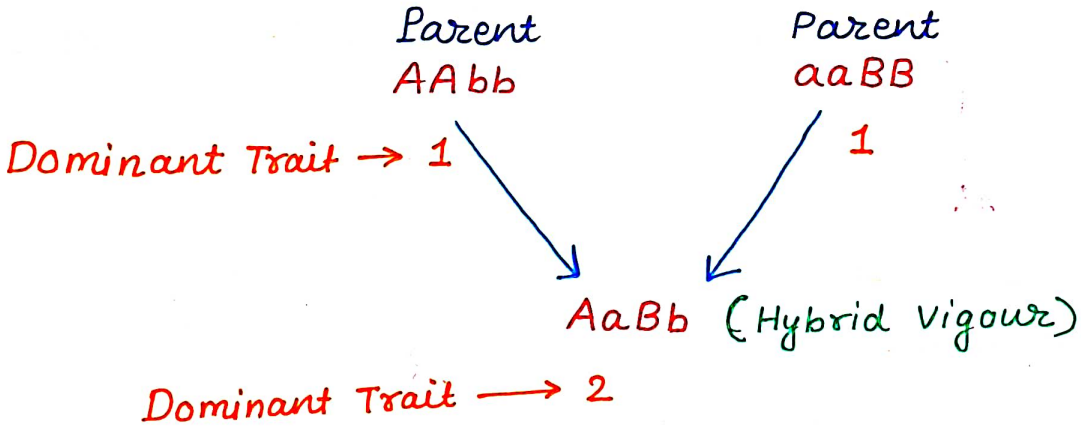
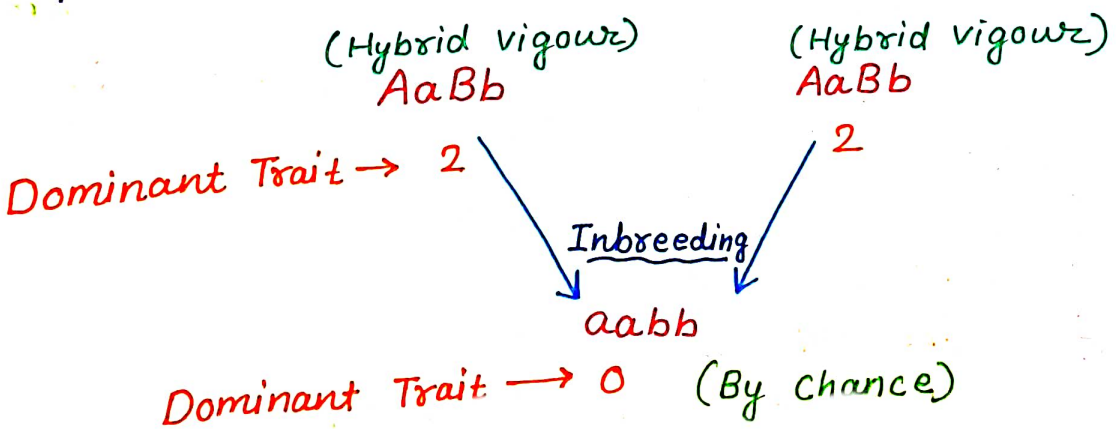


- **Hybrid Vigour/Heterosis :**
  - Superiority of hybrid offspring over both of it's parent
  - This is due to heterozygosity.



- **Inbreeding depression :-**
  - Lost of Hybrid vigour due to inbreeding/self-pollination is called inbreeding depression.

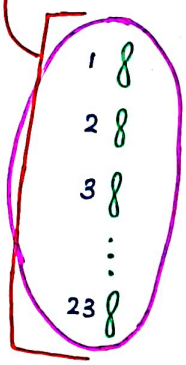


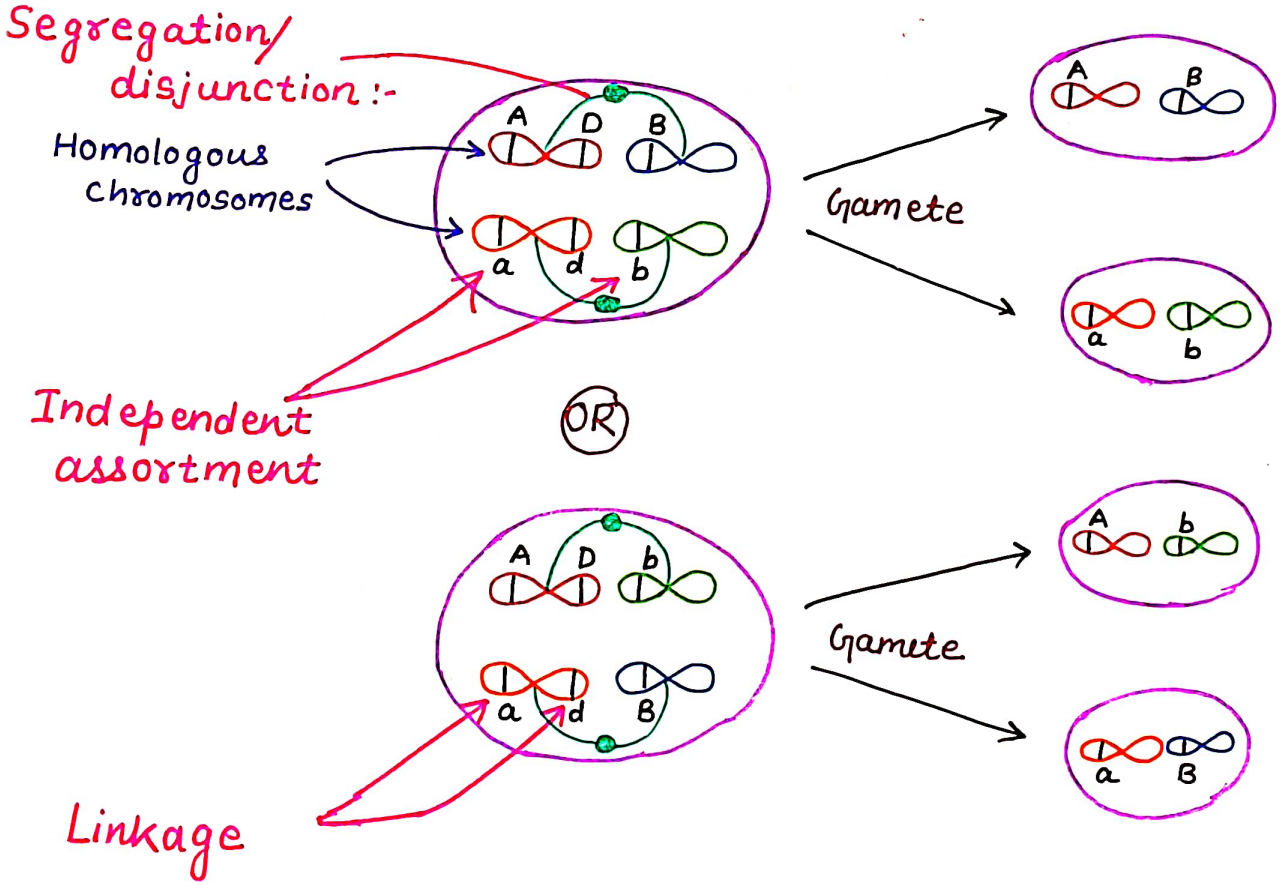
Genome :-

Total genetic material parent in a monoploid (haploid) Cell of an organism.

Genome > Chromosome > Gene > Nucleotide > N. Base

N. base + Sugar + Phosphat





- Independent assortment :-
  Occur when genes present on non-homologus chromosome
  eg: A and B genes

Linkage :-

Occur when genes present on same chromosomes.

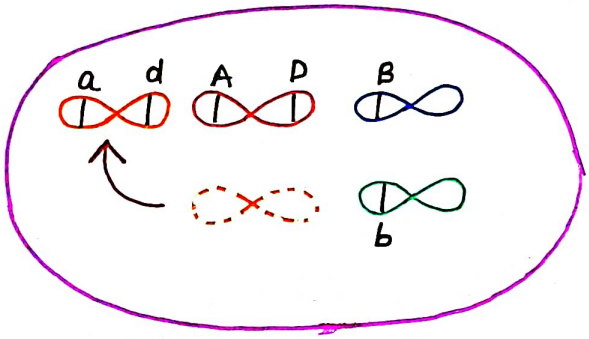
eg: A and D genes

Segregation / disjunction :-

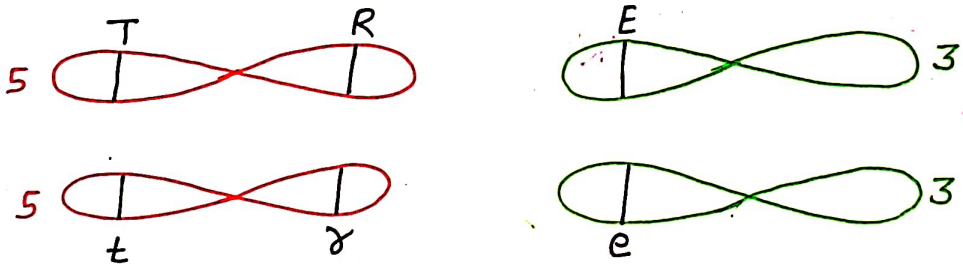
Separation of homologus chromosomes during meiosis is called segregation.

* Non-disjunction :-

▸ Any mistake during separation of chromosomes is called non-disjunction.



?. Find out segregation, Linkage, Independent Assortment,



Tt → segregation

Ee → segregation

tγ → Linkage

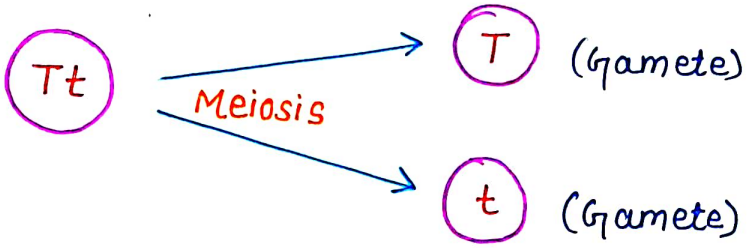
TR → Linkage

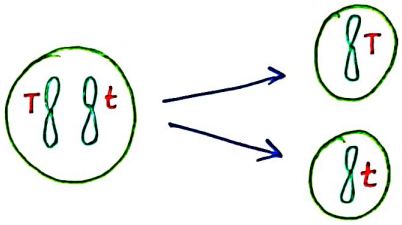
TE → Independent assortment

te → Independent assortment

GAMETE FORMATION

$2n \longrightarrow n$ (Gamete)





Type of gamete = 2^n

n → no. of heterozygous pair

Method :- Fork line method

Homozygous :-

Heterozygous :-

* Example :-

eg: AA

n = 0

Types of gamete = 2^n
= 2^0
= 1

A

eg2 :- Aa

n = 1

↳ $2^1 = 2$

A
a

eg3 :- AA Bb (AA: x, Bb: ✓)

n = 1

↳ $2^1 = 2$

A → B = AB = $\frac{1}{2}$
A → b = Ab = $\frac{1}{2}$

eg4: AA Bb DD (AA: x, Bb: ✓, DD: x)

n = 1

↳ $2^1 = 2$

A → B → AB = $\frac{1}{2}$
A → b → Ab = $\frac{1}{2}$

eg5: Aa Bb

n = 2

↳ $2^n = 4$

A → B = AB = $\frac{1}{4}$
A → b = Ab = $\frac{1}{4}$
a → B = aB = $\frac{1}{4}$
a → b = ab = $\frac{1}{4}$

eg6 :- aa BB Dd

n = 1

↳ $2^1 = 2$

— a — B → D = aBD = ½

B → d = aBd = ½

eg 7 :- AA RR

— A — R = AR

Q. A plant with genotype RR Dd Ee produce gametes. Find out probability of gametes which contain RDE genotype ?

— R → D → E = RDE = ¼

D → e = RDe = ¼

R → d → E = RdE = ¼

d → e = Rde = ¼

TRICK :-

✓ Homozygous = 1/1

RR = — R

✓ Heterozygous = ½

Rr = R / r

RR Dd Ee

R D E

$\frac{1}{1} \times \frac{1}{2} \times \frac{1}{2} = \frac{1}{4}$

Q. A plant with genotype Rr Tt Gg FF produce gametes. Find out probability of gametes which contain following genotype :-

(1) RTgF

(2) rtgf

(3) rTGF

Rr Tt Gg FF

(1) R T g F

$\frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} \times \frac{1}{1} = \frac{1}{8}$

$R\gamma Tt\ Gg\ FF$

(2) $\gamma\ t\ g\ f$

$\frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} \times 0 = 0$

$R\gamma Tt\ Gg\ FF$

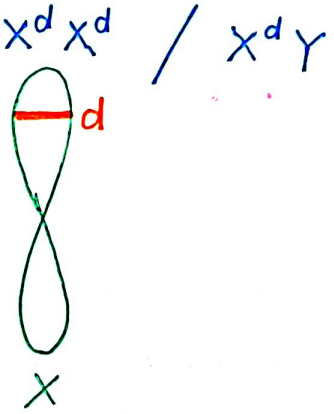
(3) $\gamma\ T\ G\ F$

$\frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} \times \frac{1}{1} = \frac{1}{8}$

Q. In human both male and female have similar autosomal genotype AaBb and both contain a X linked gene 'd'. Find out probablity of gametes produce in :-

(1) Female Contain 'abd' genotype.

(2) Male Contain 'Abd' genotype.



Genotype of female :-

$AaBb + X^dX^d$

(1) $a\ b\ d$

$\frac{1}{2} \times \frac{1}{2} \times \frac{1}{1} = \frac{1}{4}$

Genotype of Male :-

$AaBb + X^dY$

(2) $A\ b\ d$

$\frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} = \frac{1}{8}$

Q. In human both male and female have similar autosomal genotype $\gamma\gamma Tt$ and both contain a X linked gene 'h'. Find out percentage of gametes produce in :-

(1) Female Contain 'γTH' genotype.

(2) Male Contain 'γth' genotype.

$\gamma\gamma Tt + X^hX^h$

(1) $\gamma\ T\ H$

$\frac{1}{2} \times \frac{1}{2} \times 0 = 0$

$\gamma\gamma Tt + X^hY$

(2) $\gamma\ t\ h$

$\frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} = \frac{1}{4} \times 100 = 25\%$

Q. W.o.f is correct presentation of gamete which is formed in diploid organism?

(1) A b H e Rγ

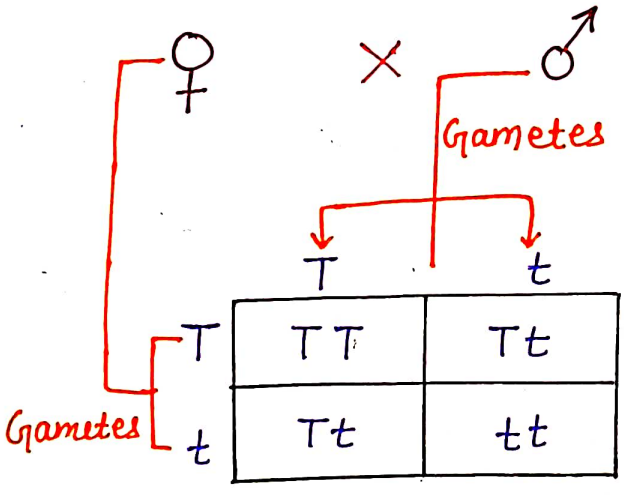
(2) AA Bb Hh Ee γ

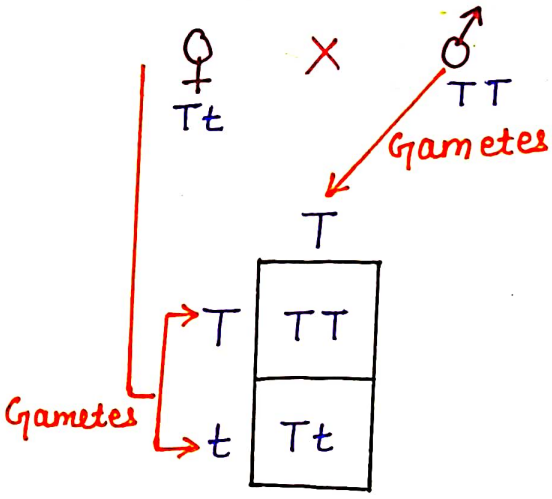
(3) A b H E γ

(4) a bb HH e γ

PUNNET SQUARE/ CHECKER BOARD....

- developed by British geneticist, Reginald C. Punnet.
- It is a graphical representation to calculate the probability of all possible genotypes of offspring in a genetic cross.
- Usually in Punnet square the male gametes lie horizontally and female gametes lie vertically.

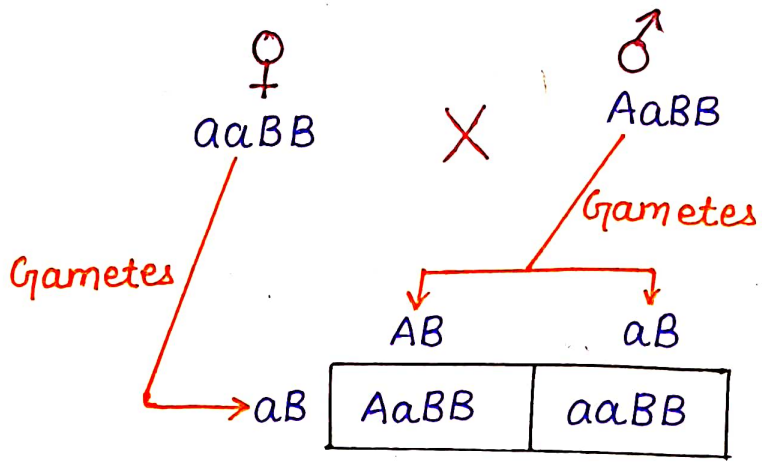




$TT = \frac{1}{4}$

$Tt = \frac{2}{4}$

$tt = \frac{1}{4}$



MENDELISM

- Gregor Johann Mendel (1822-1884) :-
  - → He was born on july 22, 1822 at Silesian village Heinzendorf state in Austria.
  - → Mendel worked in Augustinian Monastery as monk at Brunn City, Austria.
  - → Mendel performed hybridization experiments on garden pea plant (Pisum sativum) for 7 years (1856-1863).
  - → Work started :- 1856
    Work Completed :- 1863 ← 7 yrs
    Work published :- 1865
  - * Without recognition of his work, he died in 188. due to a kidney disease [Bright's disease].
  - → After 16 yrs of Mendel's death, in 1990 his postulates were rediscovered by 3 scientist [working independently].
    1. Carl Correns (Germany) → Maize plants
    2. Hugo de Varies (Holland) → Evening Primerose plants
    3. Erich Von Tschermak (Austria) → diff flowering plant

- Hugo de Vries republished Mendel's result's in journal "Flora" in 1901.

- Carl Correns converted two postulates of Mendel into two laws of heredity/Mendelism :-
  i) Law of segregation
  ii) Law of independent assortment
  ~~Law of dominance~~

REASONS FOR UNRECOGNITION OF MENDEL'S WORK:

Mendel published his work on inharitance of Characters in 1865 but for several reasons, it remained unrecognized till 1900 :-

1. Communication was not easy so his work was not widely publicized.

2. Mendel explained that factors are stable and discrete unit [did not blend] which was not accepted by his contemporaries biologists.

3. Mendel's approach of using mathematics was totally new at that time.

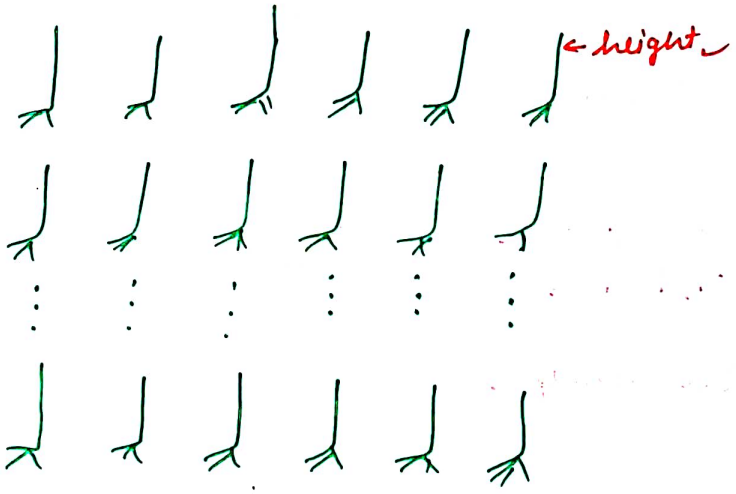
4. He could not provide any physical proof for the existence of factors and what they are made of.

REASONS FOR MENDEL'S SUCCESS

1. Mendel studied the inheritance of one or two characters at a time unlike his predecessors who had considered many characters at a time.

2. Selection of garden Pea plant.
   (i) Pea plant is an annual plant with short life cycle of 2-3 months.
   (ii) Naturally, self pollination occurs in pea plant.
   (iii) Cross-pollination can be performed in it artificially so hybridization can be made possible.
   (iv) It has many constrasting traits.
   (v) Pea plant is easy to cultivate.
   (vi) Pea seeds are large.

3. Mendel quantitatively analysed the inheritance of qualitative characters.
   (His experiments had a large sampling size)



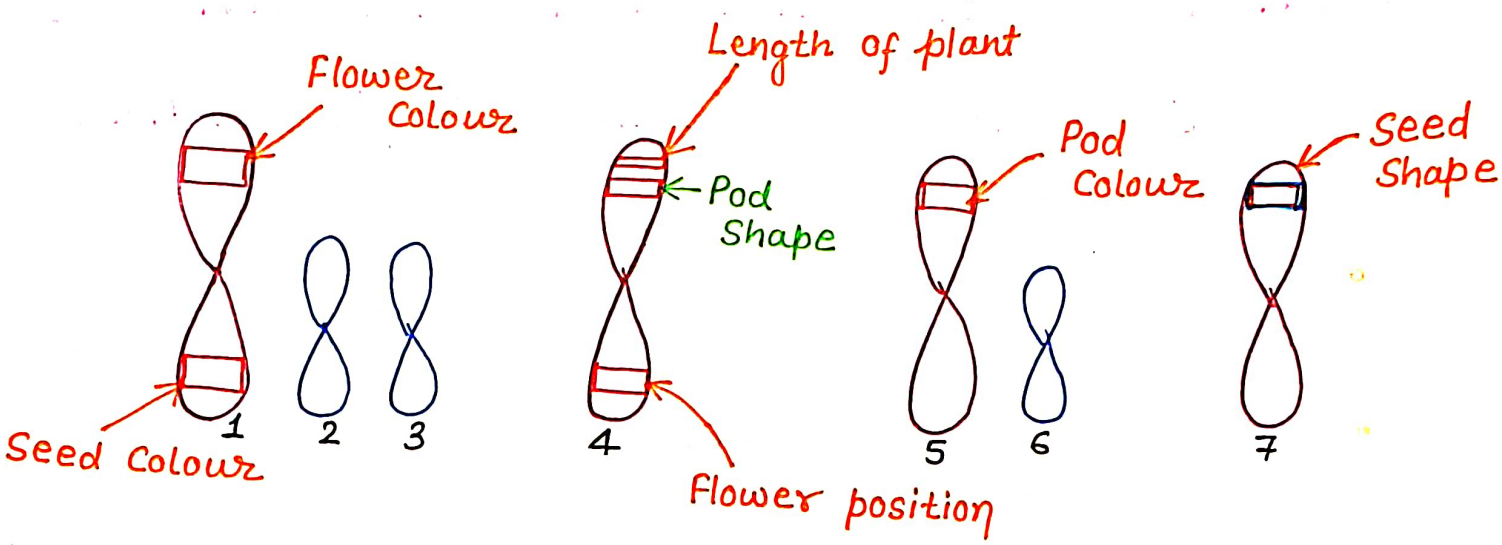
4. He maintained the statistical records of all the experiments.

MENDEL'S WORK

- Mendel studied 7 characters or 14 constrasting traits in Garden Pea plant.

S. No.	Character	Dominant trait	Recessive trait
1.	Stem height [Length of plant]	Tall	Dwarf
2.	Flower position	Axial	Terminal
3.	Flower Colour	Violet	White
4.	Pod Shape	Inflated	Constricted
5.	Pod Colour	Green	Yellow
6.	Seed Colour (Cotyledon)	Yellow	Green
7.	Seed Shape	Round	Wrinkled

• In pea plant Chromosome no. is :- $2n = 14$



Assumption :-

If Mendel had studied pod shape and plant height character simultaneously then :-

** (1) He would not have been able to explain independent assortment.

(2) He might have discovered Linkage.

■ Mendel obtained wrinkled seeds due to absence of Starch Branching Enzyme (SBE).

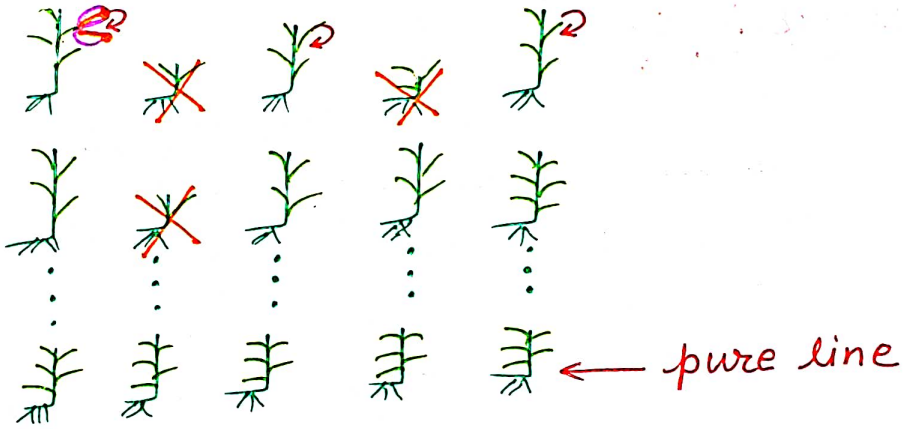
Round Seeds

Wrinkled Seeds

MENDEL'S EXPERIMENTAL TECHNIQUE --

Steps :- 1. Formation of true breeding/pure line (homozygous).

- Mendel selected 14 true breeding varieties of garden pea plant.
- Mendel developed True breeding variety of garden pea plant by continuous self-pollination and selection.

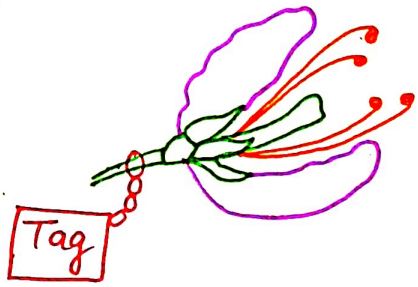


Steps :- 2. Hybridisation between pure parents :-

(a) Emasculation → Removal of anther from bisexua flower before maturity. It is done to prevent self pollination.

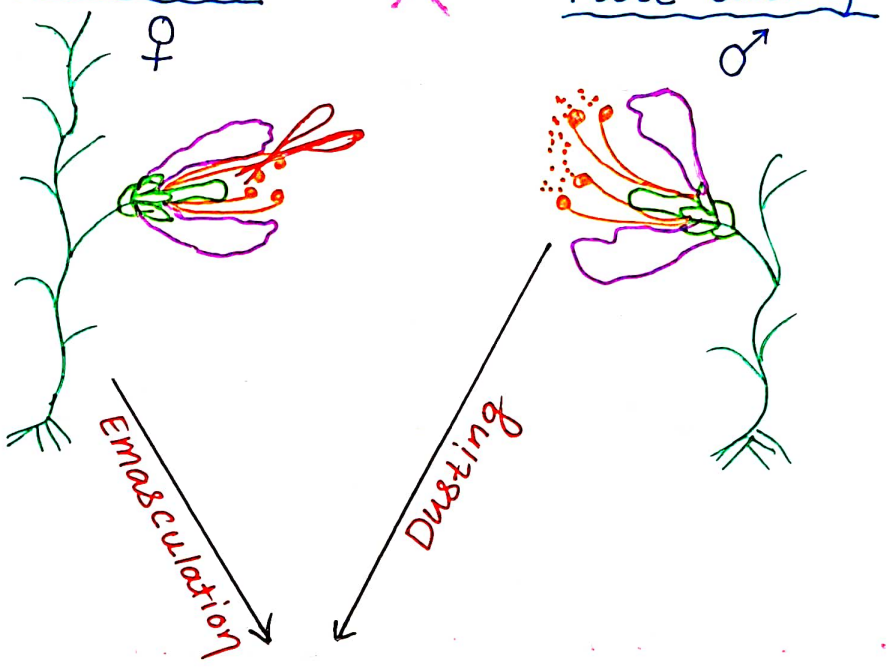
(b) Bagging → with paper bag so as to prevent undesirable Cross pollination.

(c) Tagging → Emasculated and bagged flower are tagged by writing date and time of every steps.

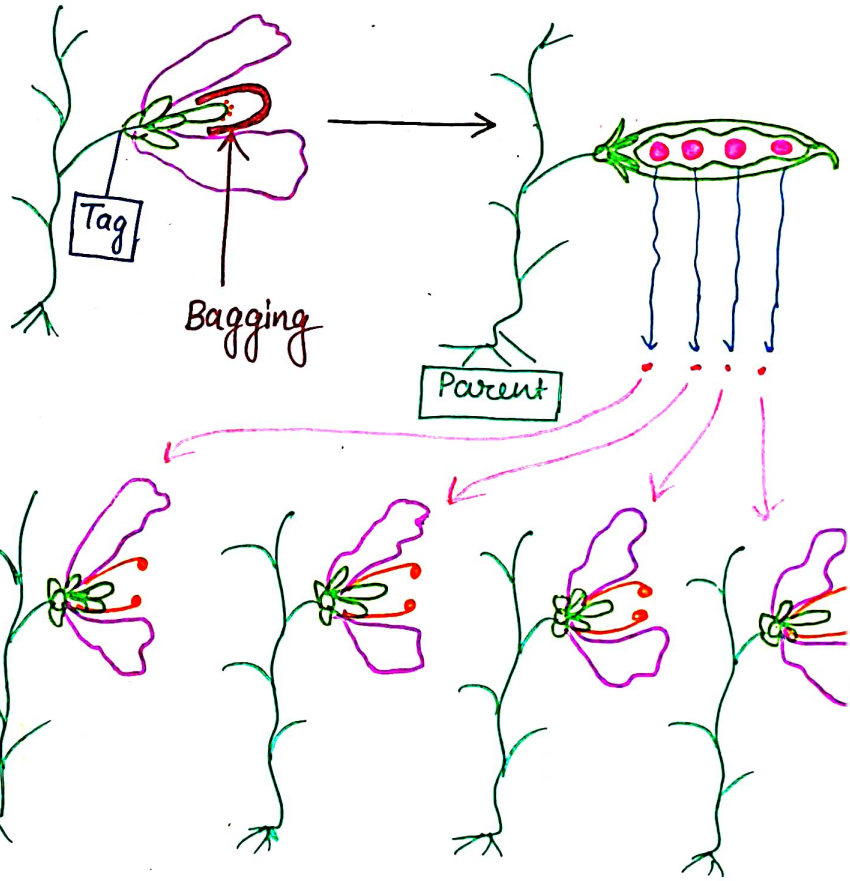


NOTE

Parent ⇒ Pure tall ♀ × Pure dwarf ♂



Cross-



F_1 Generation ⇒

All Tall

Selfing

F_2 - Generation ⇒ Tall, Tall, Dwarf, Tall, Tall, Tall, Dwarf, Tall

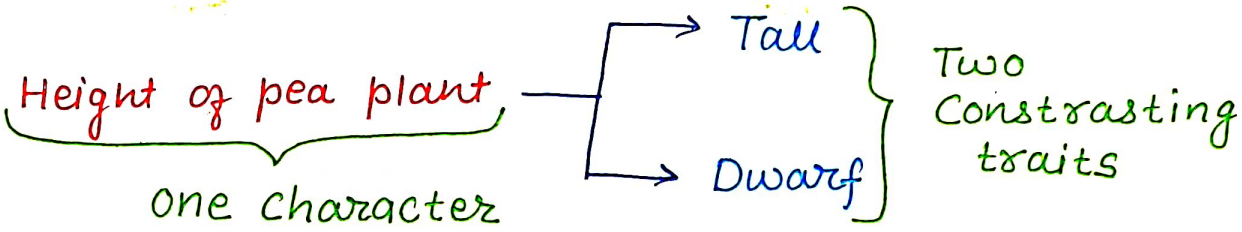
Tall : Dwarf

6 : 2

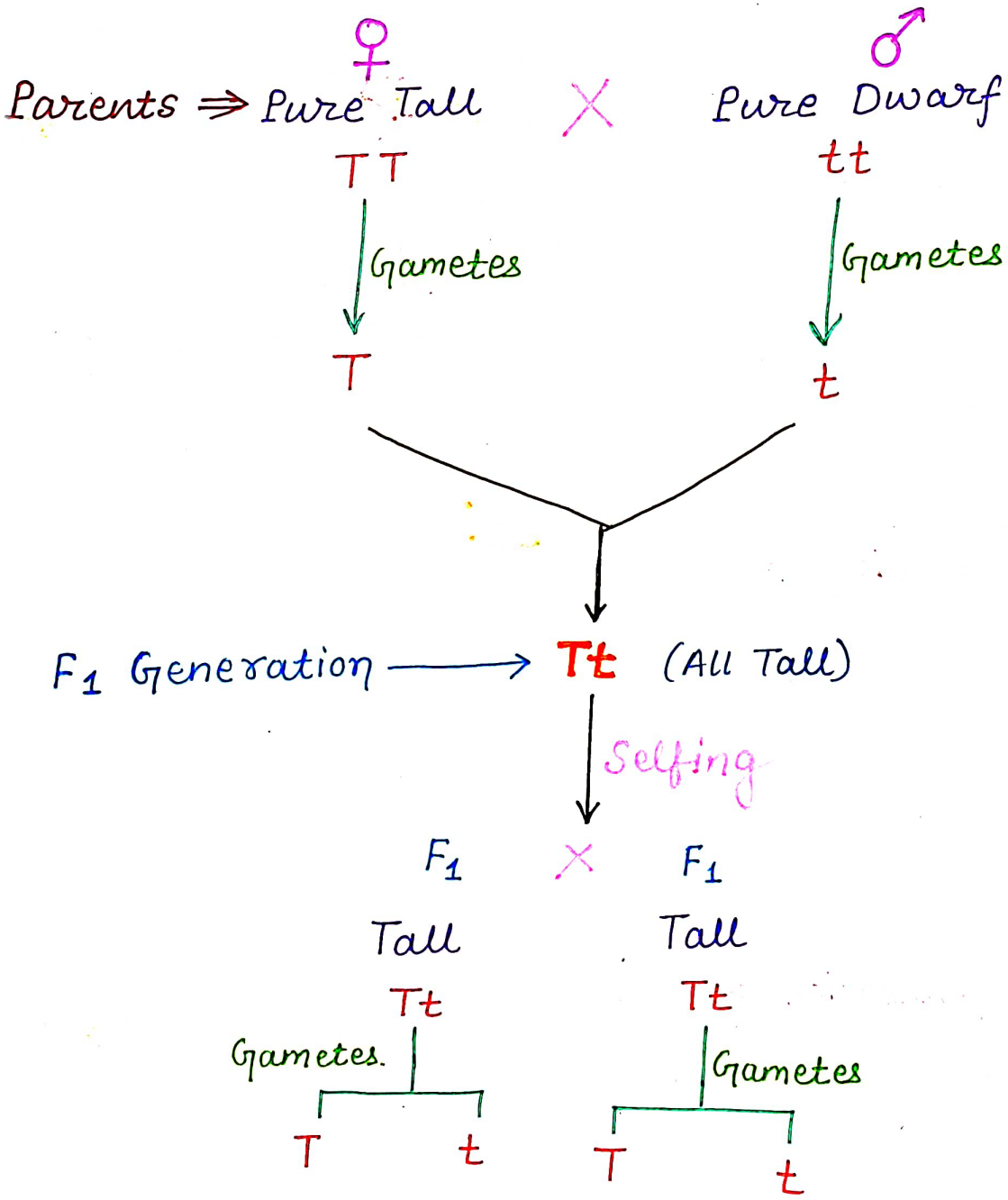
3 : 1

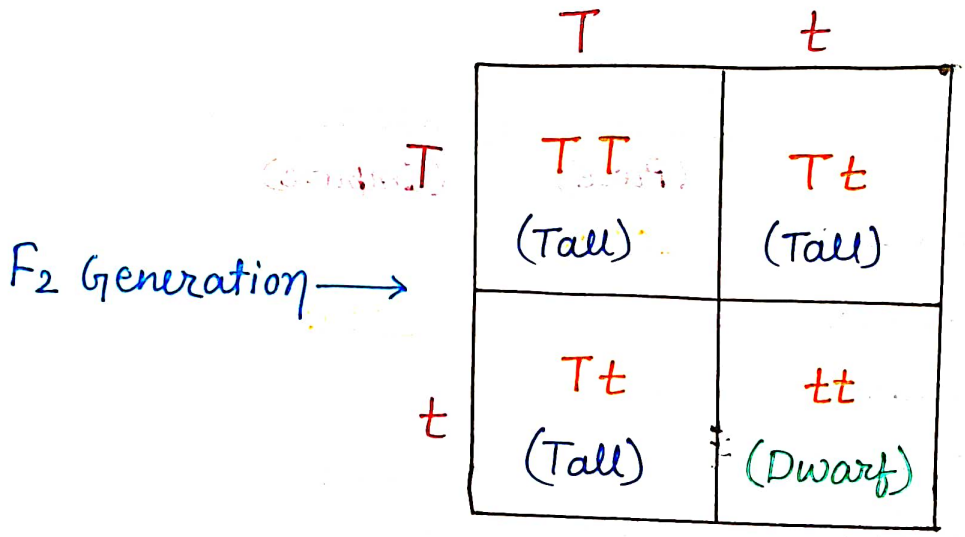
Point to Keep :-

Monohybrid Cross :- A cross done to study inharitance of one character or two Constrasting traits at a time.



MONOHYBRID CROSS





Conclusion of F_2 Generation :-

(1) Phenotype ratio :- Tall : Dwarf
3 : 1

(2) Genotype ratio :- TT : Tt : tt
1 : 2 : 1

(3) Types of Phenotype :- $2^n = 2^1 = 2$

(4) Types of Genotype :- $3^n = 3^1 = 3$

(5) No. of Zygotes/offspring's :- $4^n = 4^1 = 4$

(6) Pure Tall :- $1/4$

(7) Impure Tall :- $2/4$

(8) Pure plants :- $2/4$

$n \rightarrow$ heterozygotic

Generation	Homozygosity (Pure)	Heterozyg.... (Impure)
Parental Generation	100 %	0 %
F_1 (by Cross pollinatn)	0 %	100 %
F_2 (by Self pollinatn)	50 %	50 %
F_3 (by self pollinatn)	75 %	25 %
F_4 (by self pollinatn)	75 %	12.5 %
		6.25 %

NOTE :-

- Self pollination increases homozygosity (Pure line).
- Cross-pollination increases heterozygosity.

CONCLUSIONS OF MONOHYBRID CROSS ----

Conclusions (results) of Monohybrid Cross :-

↳ On the basis of results of Monohybrid Cross, Mendel proposed 3 postulates which have been converted into 2 laws of heredity —

Postulate - I :- Postulate of paired factors
Postulate - II :- Postulate of dominance } Law of dominance

Postulate - III :- Postulate of segregation } Law of segregation

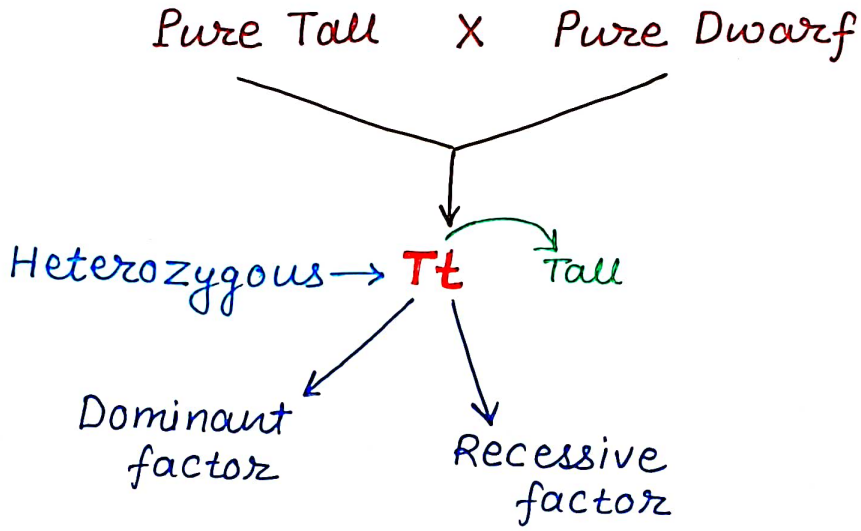
NCERT Law of dominance ——

Postulate-I Postulate of paired factors —

- A/c to Mendel each character is controlled by unit factor.
- Factor occur in the form of pairs.
- Eg :- TT, Tt

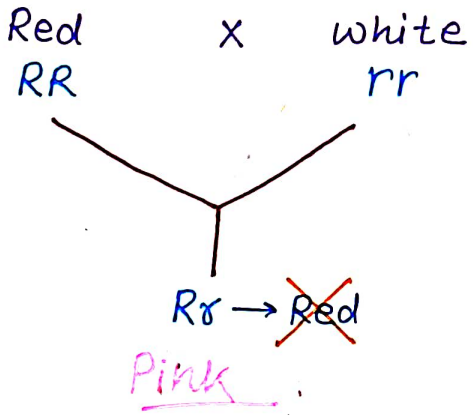
Postulate-II :- Postulate of dominance –

In case of dissimilar unit factors (heterozygous), one unit factor is able to express itself, it is called Dominant unit factor whereas other unit factor fail to express itself it is called recessive unit factor.

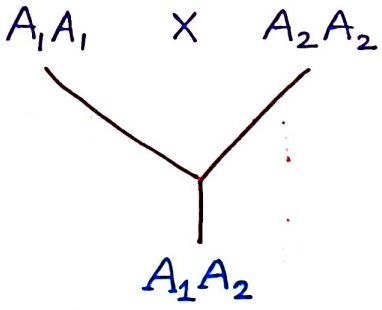


Exceptions of Law of dominance :-

1. Incomplete dominance



2. Co-dominance

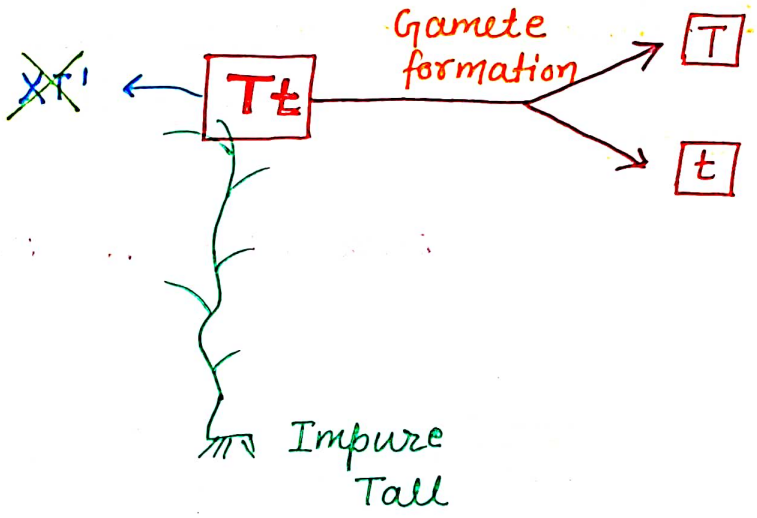


Postulate-III :- Law of segregation/Law of purity of gametes.

When two dissimilar factors pr. in an organism then :-

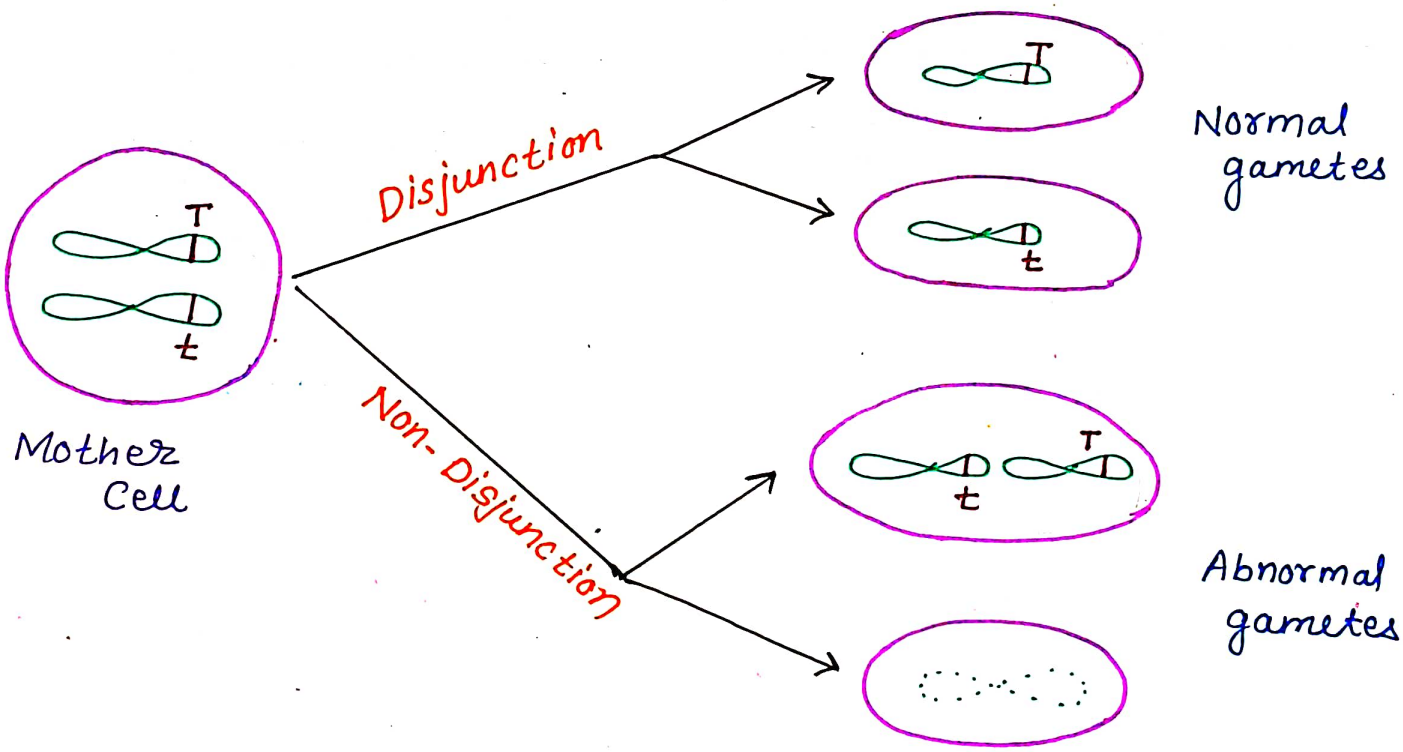
1. Factors never show any blending (mixing) ← merge
2. During gamete formation both factors separate

randomly by this one gamete recessive only one factor of the two factors, so gametes are always pure.



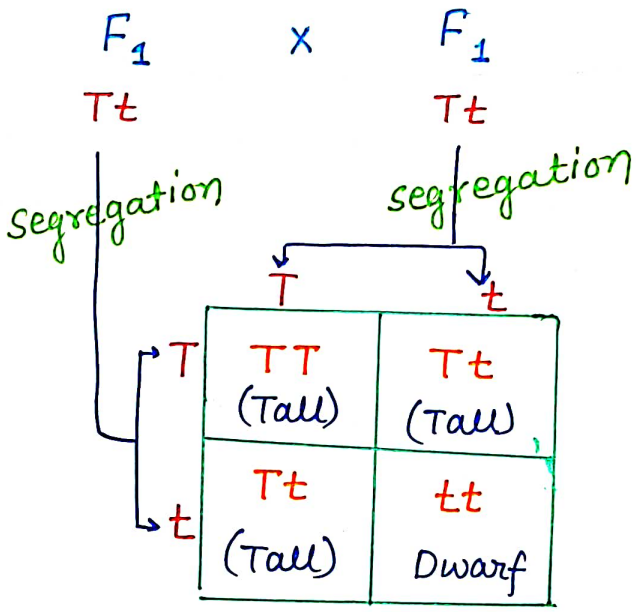
- Under normal condition this law is universally applicable.

Rare exception :- Non-disjunction



■ In F_2 Generation 3:1 ratio is obtained due to :-

(1) Dominance
(2) Segregation



■ In F_2 Generation dwarf plant is obtained due to
(1) Segregation

Q. W.O.f can not be explained on the basis of Mendel's Law of dominance ?

(1) Factors never show blending. → Law of segregation
(2) Factor occur in the form of pairs
(3) Character is controlled by unit factor
(4) Out of one pair of factor one is dominant factor whereas other is recessive factor.

Law o
domina

QUESTION OF MONOHYBRID CROSS---

Q. An impure tea pea plant is crossed with Dwarf plant. This cross produce 200 offspring's. How many of them have pure tall and dwarf plant respectively?

(1) 0, 200
(2) 100, 100
(3) 150, 50
~~(4)~~ 0, 100

Impure tall × Dwarf
Tt tt

	t
T	Tt ← impure tall
t	tt ← Dwarf

↳ Pure tall = 0
↳ Dwarf = $\frac{1}{2}$ × 200 = 100

Q. what will be genotype of parental garden pea plant if they produce 44 tall 15 dwarf offspring's

(1) TT × TT

	T
T	TT

all tall

~~(2)~~ Tt × Tt

	T	t
T	TT	Tt
t	Tt	tt

Tall : Dwarf
3 : 1

(3) TT × tt

	T
t	Tt

(4) Tt × tt

	t
T	Tt Tall
t	tt Dwarf

~~Tall : Dwarf~~
~~1 : 1~~

Tall	Dwarf
45 ≈ 44	15

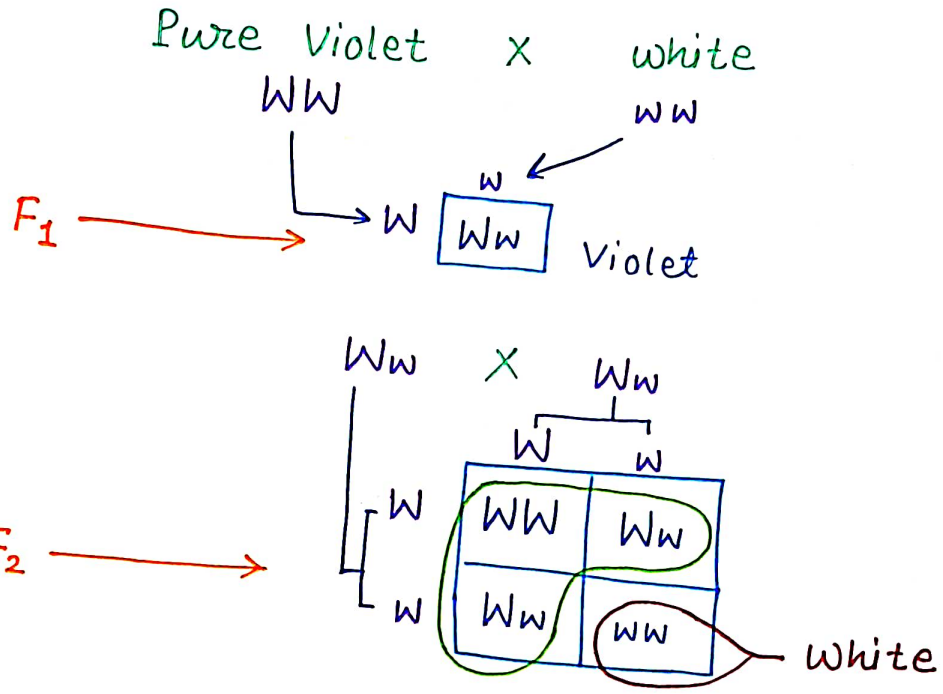
3 : 1

Q. In garden pea plant, a pure violet flower plant is Crossed with white flower plant. In F_2 generation 1000 offspring's are obtained. How many of them have-

(1) Pure flowered plant = $\frac{2}{4}$ × 1000 = 500

(2) Impure violet flower = $\frac{2}{4}$ × 1000 = 500

(3) white flower = $\frac{1}{4}$ × 1000 = 250



Q. In human being brown eye colour is dominant over blue eye colour. what will be the genotype of brown eyed parents, if they have blue eyed child ?

(1) BB x bb

(2) Bb x bb

(3) Bb x Bb

(4) bb x bb

Brown eye (B)
BB, Bb

Blue eye (b)
bb

♀
Brown eyed
~~BB~~, Bb

♂
Brown eyed
~~BB~~, Bb

Blue eyed
bb

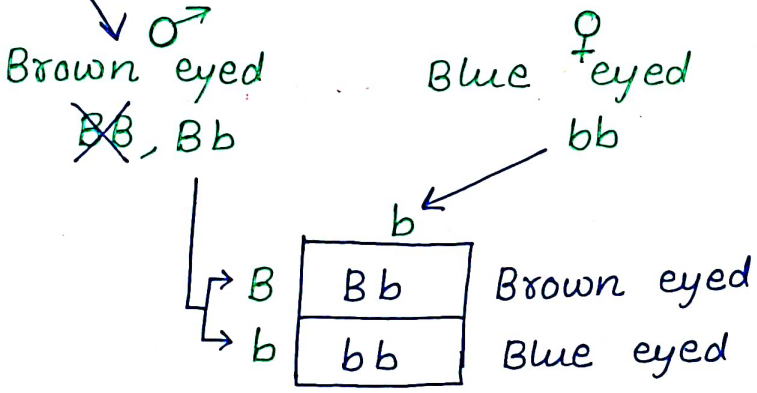
Q. In human being brown eye colour is dominant over blue eye colour. A brown eyed male has blue eyed mother. This male is marry with blue eyed female. Find out probability of their child have brown eyed ?

Mother blue eyed

bb

Brown eye (B) — BB, Bb

Blue eye (b) — bb



⟹ Brown eyed child = $\frac{1}{2}$

Q. In human being albinism is an autosomal recessive disease. The first child of normal parents is albinic. What will be the probability of their second child to be albinic ?

Albinism ⇒ Autosomal recessive disease

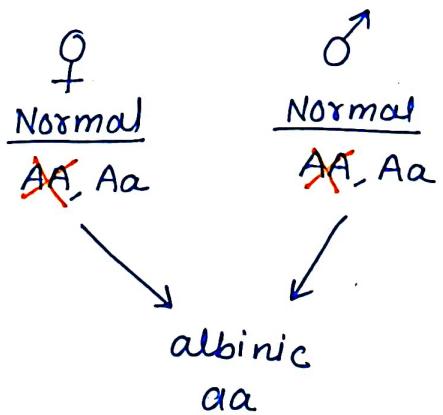
A	a
Dominant	Recessive
(Normal)	(Disease)

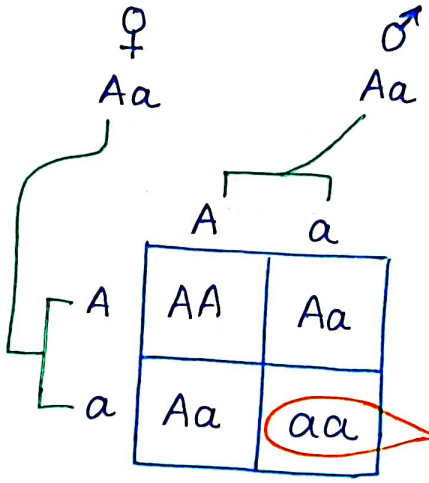
Genotype :-

AA → Normal

Aa → Normal but Carrier

aa → Albinic (affected)





albinic ↳ Albinic child ⇒ 1/4

Q. In human being albinism is an autosomal recessive disease. A normal male has affected father. This male is marry with a female whose father is also affected but mother is homozygous normal. What will be the probability of their child to be Carrier ?

Albinism :- Autosomal recessive disease

AA → Normal
Aa → Normal but carrier
aa → Albinic (affected)

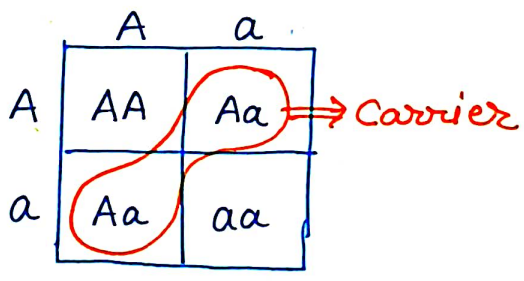
Father affected
aa

Father affected
aa

Mother
Homozygous
Normal
AA

♂
Normal
~~AA~~, Aa

♀
Aa



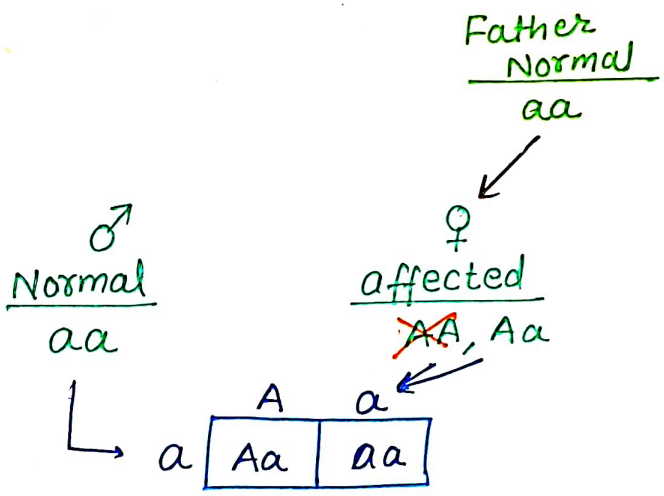
↳ Carrier Child = 2/4

Q. In human being myotonic dystrophy is an autosoma dominant disease. A normal male is marry with a affected female whose father is also normal. What will be the probablity of their child to be homozygous normal?

Myotonic dystrophy :-

A	a
Dominant	Recessive
(Disease)	(Normal)

AA → affected
Aa → affected
aa → Normal



↳ Child to be homozygous normal = $\frac{1}{2}$

SOME IMPORTANT FORMULA FOR SELFING

Formula	Monohybrid Aa X Aa	Dihybrid AaBb X AaBb	Trihybrid AaBbCc X AaBbCc
Types of Phenotype 2^n	$\Rightarrow 2^1 = 2$	$\Rightarrow 2^2 = 4$	$\Rightarrow 2^3 = 8$
Types of Genotype 3^n	$\Rightarrow 3^1 = 3$	$\Rightarrow 3^2 = 9$	$\Rightarrow 3^3 = 27$
Zygote Combination 4^n	$\Rightarrow 4^1 = 4$	$\Rightarrow 4^2 = 16$	$\Rightarrow 4^3 = 64$

where n :- no. of heterozygous pair

DIHYBRID CROSS

- A Cross done to study inharitance of two Characters or four contrasting trait at a time.
- Mendel performed dihybrid Cross to knew the any interaction among the characters during the inharitance.
- Mendel never performed all possible 21 dihybrid Crosses of 7 characters.

Two character of garden pea

Traits

1 - Seed Shape → Round (R) — Dominant
→ wrinkled (r) — Recessive

2 - Seed Colour → Yellow (Y) — Dominant
→ Green (y) — Recessive

Parents ⟹ Round Yellow RRYY × wrinkled green rryy

gamete → RY

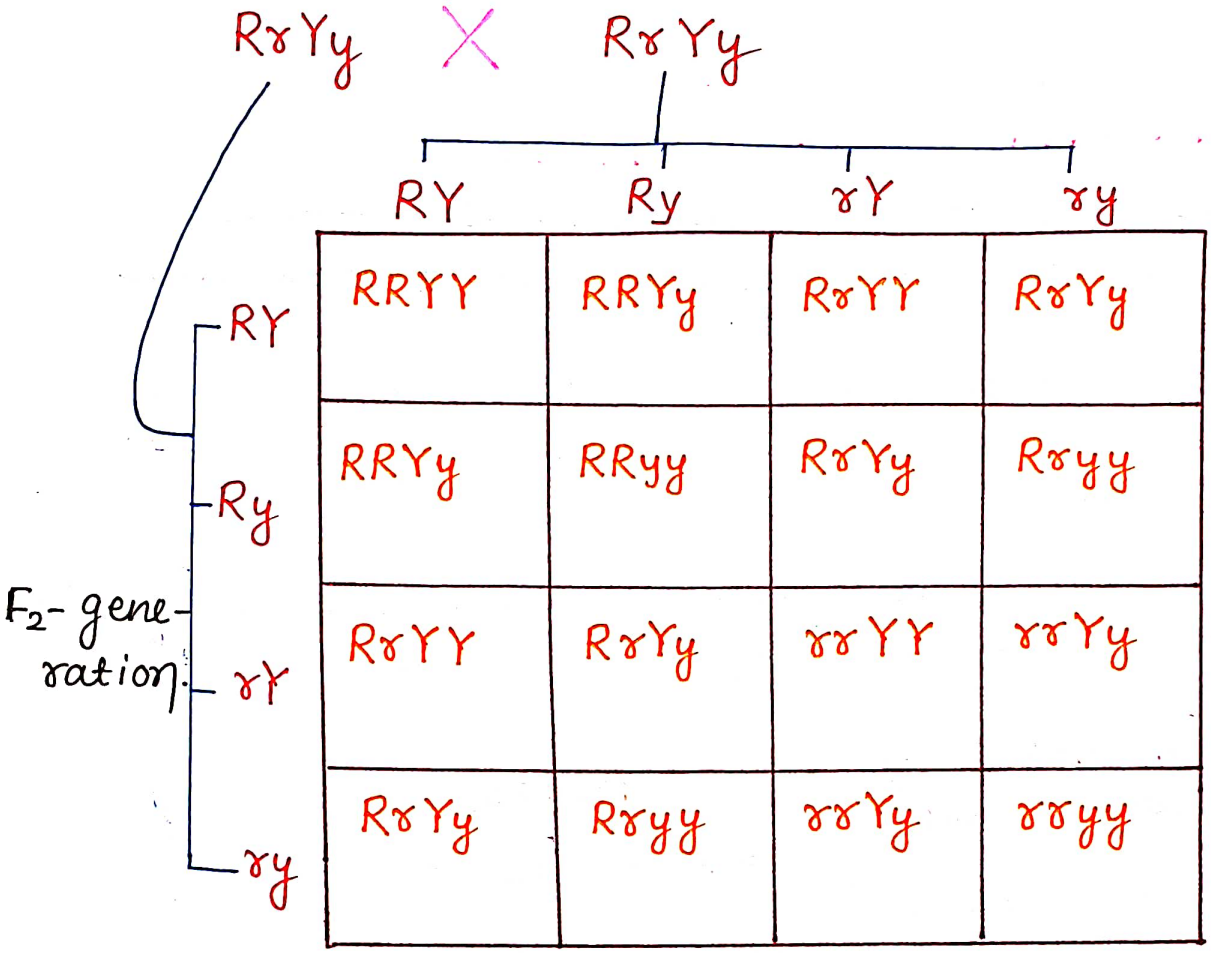
gamete → ry

R–Y = RY

F_1 Generation → RrYy Round yellow

Selfing of F_1

F_1 × F_1



F_2- Generation

RRYY	RRYy	RrYY	RrYy
RRYy	RRyy	RrYy	Rryy
RrYY	RrYy	rrYY	rrYy
RrYy	Rryy	rrYy	rryy

Phenotypic ratio

Round yellow :- 9
R_Y_

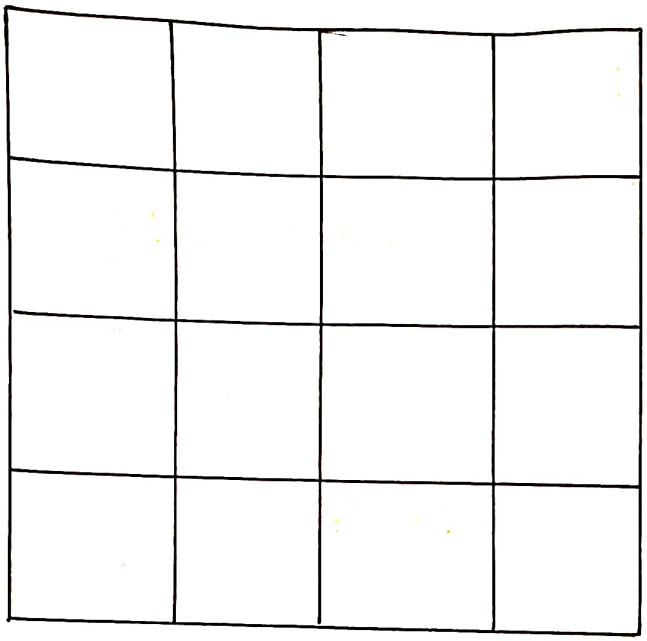
Round green :- 3
R_yy

Wrinkled yellow :- 3
rrY_

New

Wrinkled green :- 1
rryy

parental = 10 , New = 6



Genotypic ratio

In dihybrid cross, in genotype-

- If both pairs are homolog-Zygous :- 1 times
- If one pairs is homozygous and other is heterozygous than :- 2 times
- If both pairs are hetero-Zygous :- 4 times

RRYY → 1
RrYY → 2
RRYy → 2
RrYy → 4

RRyy → 1
Rryy → 2
rrYY → 1
rrYy → 2
rryy → 1

1. Phenotypic ratio :- 9 : 3 : 3 : 1
2. Genotypic ratio :- 1 : 2 : 2 : 4 : 1 : 2 : 1 : 2 : 1
3. Types of Phenotype = $2^n = 2^2 = 4$
4. Types of Genotype = $3^n = 3^2 = 9$
5. No. of Zygotes = $4^n = 4^2 = 16$

Postulate-IV :- Law of Independent Assortment

It is based on F_2 generation of dihybrid cross.

When two or more characters inharitat simultaneously than inharitance of one character independent from other characters, and one character inharitate just like in monohybrid pattern.

Postulate-IV :- Law of Independent Assortment

Dihybrid

Monohybrid

Character 1

Seed Shape

Round (R) wrinkled (r)

Monohybrid

Character 2

Seed Colour

Yellow (Y) Green (y)

Round, Yellow : Round green : Wrinkle, yellow : wrinkled, green

9 : 3 : 3 : 1

Round : wrinkled

12 : 4

3 : 1

Yellow : Green

12 : 4

3 : 1

3:1 x 3:1 ← phenotypic ratio

9:3:3:1

(1:2:1)(1:2:1)(1:2:1)

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

Q. In F_2 generation of dihybrid cross, what is the probability of offspring's which are :-

(i) Homozygous for both characters :- $\frac{4}{16}$

(ii) Heterozygous for both characters :- $\frac{4}{16}$

(iii) Homozygous for one character and heterozygous for another character :- $\frac{8}{16}$

(iv) have phenotype similar to parents :- $\frac{10}{16}$

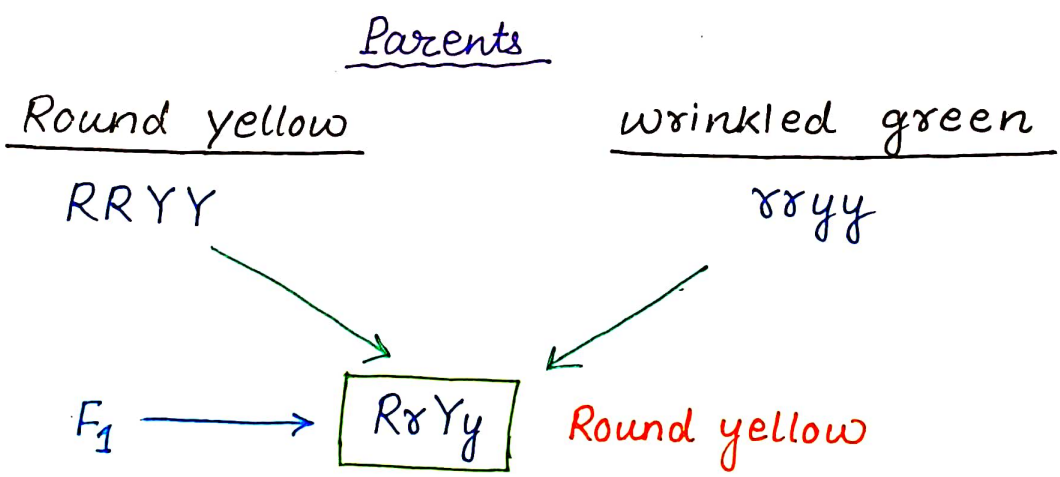
(v) have genotype similar to parents :- $\frac{2}{16}$

(vi) have new genotypic combination :- $\frac{14}{16}$

(vii) have new phenotypic combination :- $\frac{6}{16}$

(viii) have phenotype similar to F_1 :- $\frac{9}{16}$

(ix) have genotype similar to F_1 :- $\frac{4}{16}$



parental
- Round yellow → 9

New
- Round green → 3
- wrinkled yellow → 3

parental
- wrinkled green → 1

RRYY → 1 — Parental.
RrYY → 2
RRYy → 2
RrYy → 4
RRyy → 1
Rryy → 2
rrYY → 1
rrYy → 2
rryy → 1 — Parental.

New

Q. A plant with genotype DdEe is crossed with other plant having genotype Ddee. Find out probability of offspring's which have following genotype :-

(i) Ddee (ii) DDEe (iii) DDEE

DdEe × Ddee

	De	de
DE	DDEe	DdEe
De	DDee	Ddee
dE	DdEe	ddEe
de	Ddee	ddee

Short cut method

DdEe × Ddee

Dd × Dd

	D	d
D	DD	Dd
d	Dd	dd

Ee × ee

	e
E	Ee
e	ee

(i) Ddee $\longrightarrow \frac{2}{4} \times \frac{1}{2} = \frac{2}{8}$

(ii) DDEe $\longrightarrow \frac{1}{4} \times \frac{1}{2} = \frac{1}{8}$

(iii) DDEE $\longrightarrow \frac{1}{4} \times 0 = 0$

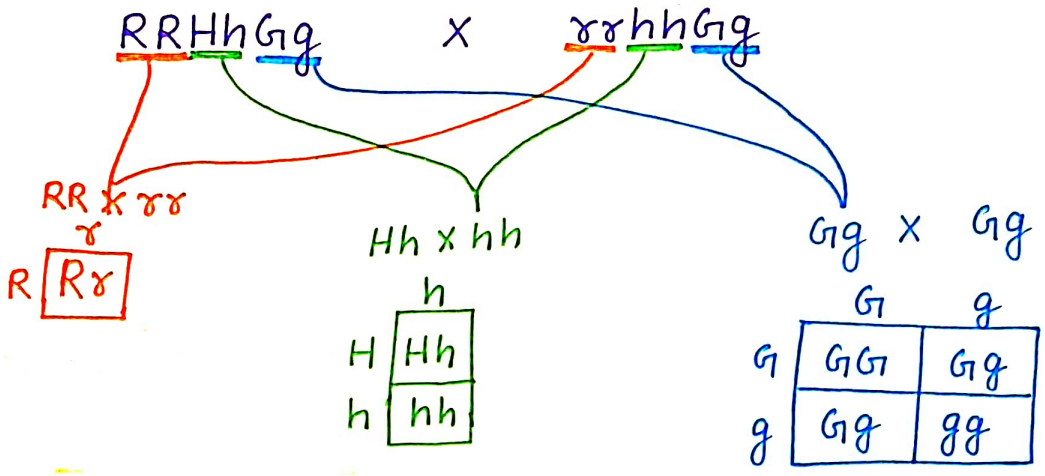
2 : 1 : 0

Q. A plant with genotype RRHhGg is crossed with other plant having genotype rrhhGg and produce 800 offsprings. Find out number of offspring's which have following genotype :-

(1) RrhhGG $\rightarrow \frac{1}{1} \times \frac{1}{2} \times \frac{1}{4} = \frac{1}{8} \times 800 = 100$

(2) RRHhGg $\longrightarrow 0 \times \frac{1}{2} \times \frac{2}{4} = 0$

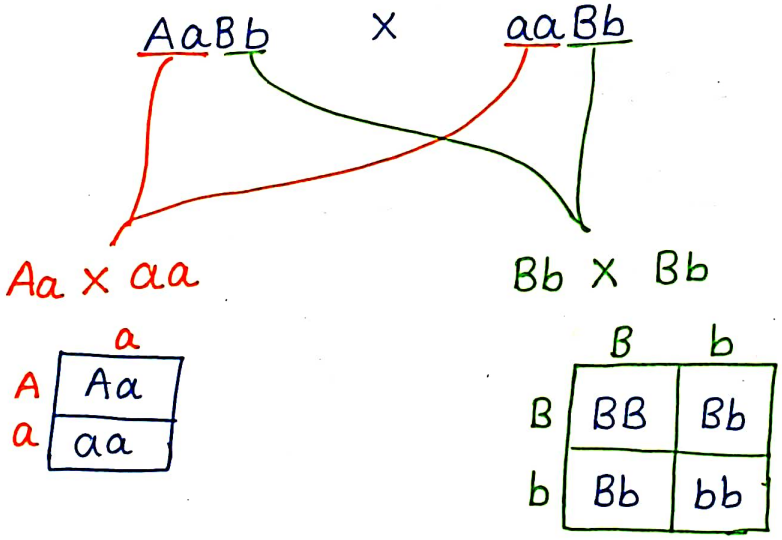
(3) RrHhGg $\longrightarrow \frac{1}{1} \times \frac{1}{2} \times \frac{2}{4} = \frac{2}{8} \times 800 = 200$



Q. In a cross b/w AaBb and aaBb genotypic plant. The ratio of AaBB, AABb, aaBb, aabb in offspring's is is.

(1) 9:3:3:1 (2) 1:1:1:1

(3) 1:0:2:1 (4) 1:1:2:2



AaBB : AABb : aaBb : aabb

$\frac{1}{2} \times \frac{1}{4}$: $0 \times \frac{2}{4}$: $\frac{1}{2} \times \frac{2}{4}$: $\frac{1}{2} \times \frac{1}{4}$

$\frac{1}{8}$: 0 : $\frac{2}{8}$: $\frac{1}{8}$

Ratio → 1 : 0 : 2 : 1

Ans. (3)

Q. In garden pea plant tallness is dominant over dwarfness and round seed shape (R) is dominant over wrinkled (r).

A cross b/w TtRr and Ttrr genotypic plant. Find out probablity of offspring's which have :-

(1) Tallness with round seed shape — $\frac{3}{4} \times \frac{1}{2} = \frac{3}{8}$

(2) Dwarfness with wrinkled seed shape — $\frac{1}{4} \times \frac{1}{2} = \frac{1}{8}$

(3) Phenotypic ratio - Tall : Dwarf (3 : 1) × Round : wrinkled (1 : 1)

3 : 3 : 1 : 1

(4) Types of phenotype. ~~2^n~~ 4 ✓

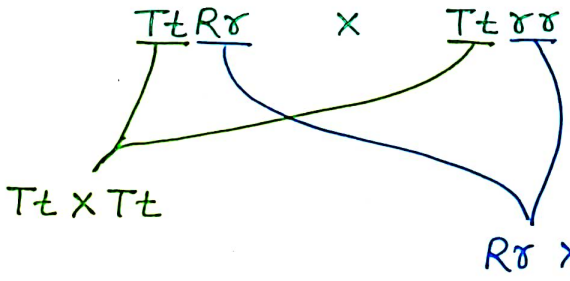
It is for selfing only

(5) Genotyp ic ratio - TT : Tt : tt (1 : 2 : 1) Rr : rr (1 : 1)

1 : 1 : 2 : 2 : 1 : 1

(6) Types of Genotype - ~~3^n~~ 6 ✓

(7) Zygotic Combination - ~~4^n~~ ⇒ 4 × 2 = 8



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

	r
R	Rr Round
r	rr wrinkled

Q. A plant with genotype AaBB is self pollinated. Find out :-

(1) Types of phenotype :- $2^n = 2^1 = 2$

(2) Types of Genotype :- $3^n = 3^1 = 3$

(3) Zygotic Combination :- $4^n = 4^1 = 4$

(4) Phenotypic ratio :- 3 : 1

(5) Genotypic ratio :- 1 : 2 : 1

AaBB × AaBB

This is the case of selfing so, we can use formula → 2^n

n = no. of heterozygous pairs

Here,

n = 1 (monohybrid cross)

Aa × Aa

AA	Aa
Aa	aa

BB × BB

BB

Q. A pea plant with genotype TtRr is crossed with TTRr. Find out :-

(1) Phenotypic ratio :- 1 × 3 : 1

(3 : 1)

(2) Types of phenotype :- 2

(3) Genotypic ratio :- (1 : 1) (1 : 2 : 1)

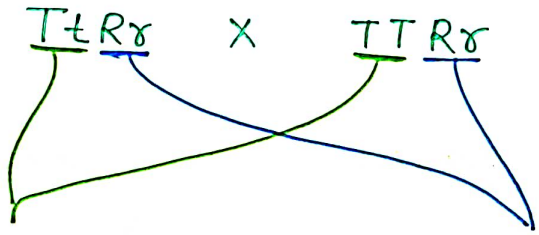
1 : 2 : 1 : 1 : 2 : 1

(4) Types of Genotype :- 6

(5) Zygotic Combination :- $2 \times 4 = 8$

Solution :-

This is not the case of selfing, so we can not use formulae.



Tt X TT

	T	t
T	TT Tall	Tt Tall

Rγ X Rγ

	Rγ	γγ
RR Round	Rγ Round	
Rγ Round		γγ wrinkled

Q. In the given Punnett square A plant of type 'H' will produce seed with the genotype identical to seed produced by the plant of -

(1) Type M
(2) Type J
(3) Type P
(4) Type N

♀ \ ♂	YR	Yγ	yR	yγ
YR	F	J	N	R
Yγ	G	K	O	S
yR	H	L	P	T
yγ	I	M	Q	U

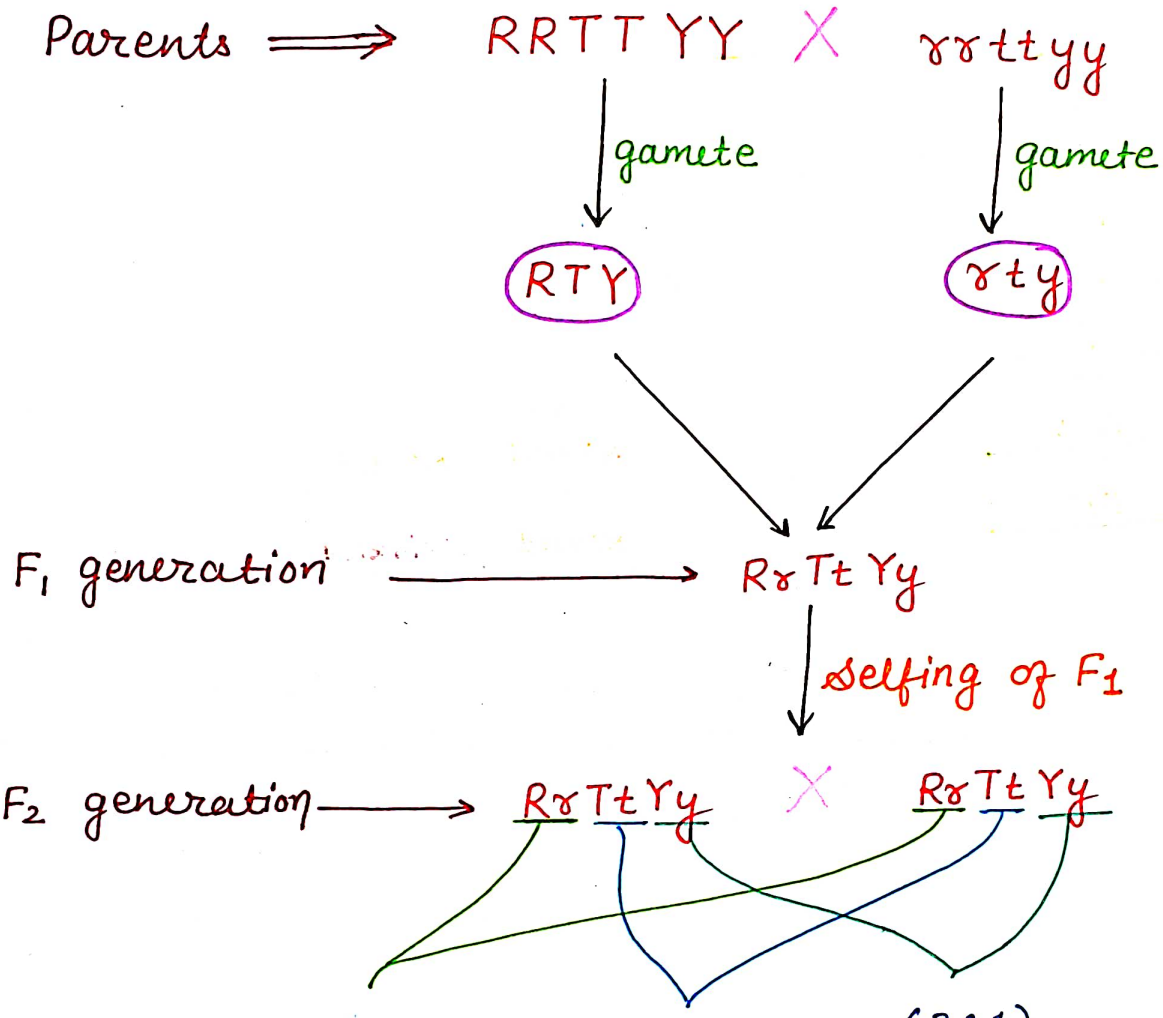
Genotype of 'H' is YyRR

Therefore, it is identical to the genotype of N.

Ans = (4)

TRIHYBRID CROSS ---

- A cross done to study inheritance of three characters or three pairs of contrasting trait at a time.



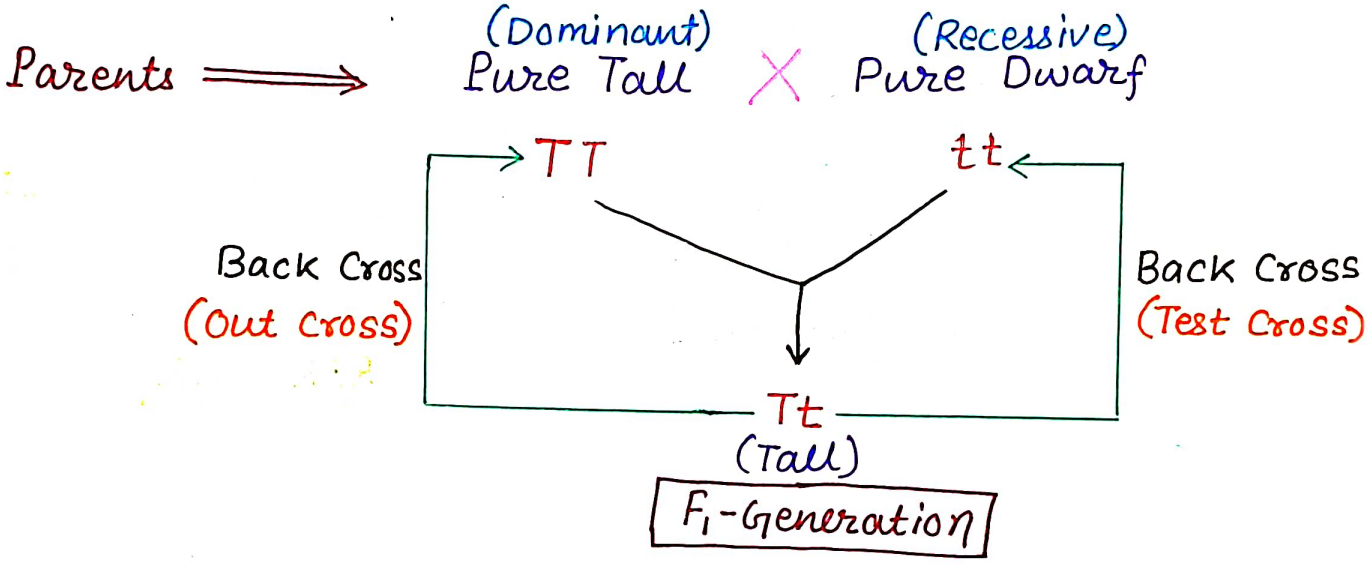
Phenotypic ratio:- (3:1) × (3:1) × (3:1)

Genotypic ratio:- (1:2:1) × (1:2:1) × (1:2:1)

SPECIAL CROSS

1. Back Cross :-
   - 1.1. Out Cross
   - 1.2. Test Cross

F_1 hybrid is crossed with any one of the homozygou parents (either dominant or recessive parents)



Two types of Back Cross :-

(1) Out Cross :-

In this Cross F_1 individual Cross with dominant parents.

In this Cross in next generation only dominant character are appeared so any type of analysis is not possible.

F_1 hybrid (Tall) Tt × Homozygous dominant parent TT (Tall)

	T	t
T	TT Tall	
t	Tt Tall	

Phenotypic ratio :- 1

Genotypic ratio :- 1 : 1

~~RR~~ PR ≠ GR

(2) Test Cross :-

In this cross F_1 individual cross with recessive parents.

This cross very significant.

a) Monohybrid Test Cross :-

F_1 hybrid (Tt) × Recessive parent (tt)

	t
T	Tt Tall
t	tt Dwarf

Phenotypic ratio (PR) :- 1:1

Genotypic ratio (GR) :- 1:1

PR = GR

b) Dihybrid Test Cross :-

F_1 hybrid (RrYy) × Recessive parent (rryy)

	ry
RY	RrYy Round yellow
Ry	Rryy Round green
rY	rrYy wrinkled yellow
ry	rryy wrinkled green

Phenotypic ratio :- 1:1:1:1

Genotypic ratio :- 1:1:1:1

PR = GR

C) Trihybrid Test Cross :- [3 Monohybrid Test cross]

(1 : 1) x (1 : 1) x (1 : 1)

(1 : 1 : 1 : 1) x (1 : 1)

Phenotypic ratio :- 1 : 1 : 1 : 1 : 1 : 1 : 1 : 1

Genotypic ratio :- 1 : 1 : 1 : 1 : 1 : 1 : 1 : 1

Uses of test Cross :-

1. To know the genotype of unknown dominant individual.
2. To know the types of gametes formed in unknowr dominant individual.

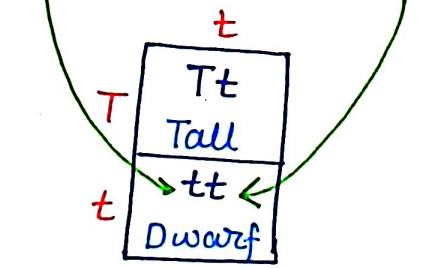
Unknown Tall (dominant)
TT, Tt

Unknown Dwarf
tt

Unknown Tall (TT) X Dwarf (tt)

Tt
Tall

Unknown Tall (Tt) X Dwarf (tt)



3. Example :- Flower colour in garden pea plant.

Flower Colour in garden pea plant

Violet (dominant), white (recessive)

Unknown violet X white

Result :- All flowers are violet.

Interpretation :- unknown flower is homozygous

Unknown violet X white

Result :- Half of the flowers are violet and half of the flowers are white.

Interpretation :- Unknown flower is heterozygous.

2. Reciprocal Cross :-

- It is a set of two crosses in which in second cross sex of the parents are reversed.
- Mendel conducted reciprocal cross to knew the inharitance of characters is dependent on parental sex or not.

Cross 1

♀ Pure Tall TT × ♂ Dwarf tt

Tt (All Tall)

Cross 2

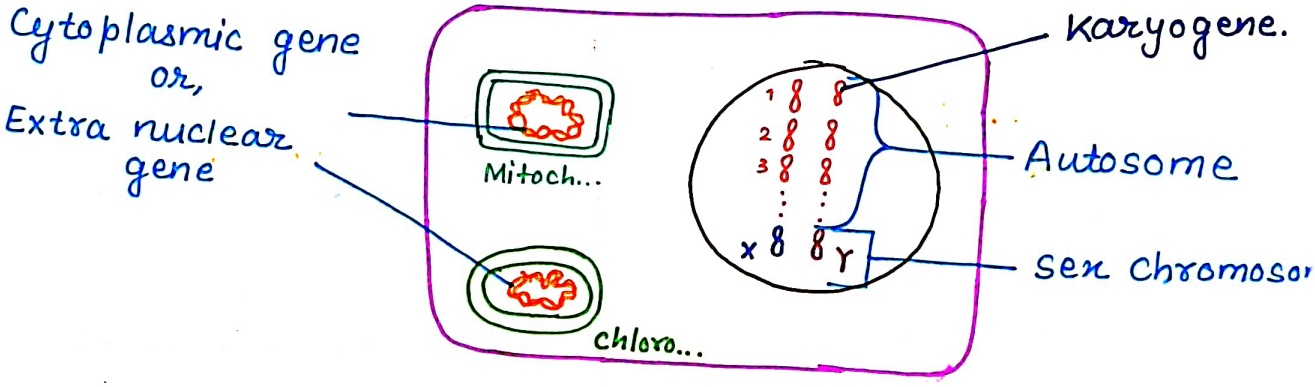
♀ Dwarf tt × ♂ Pure Tall TT

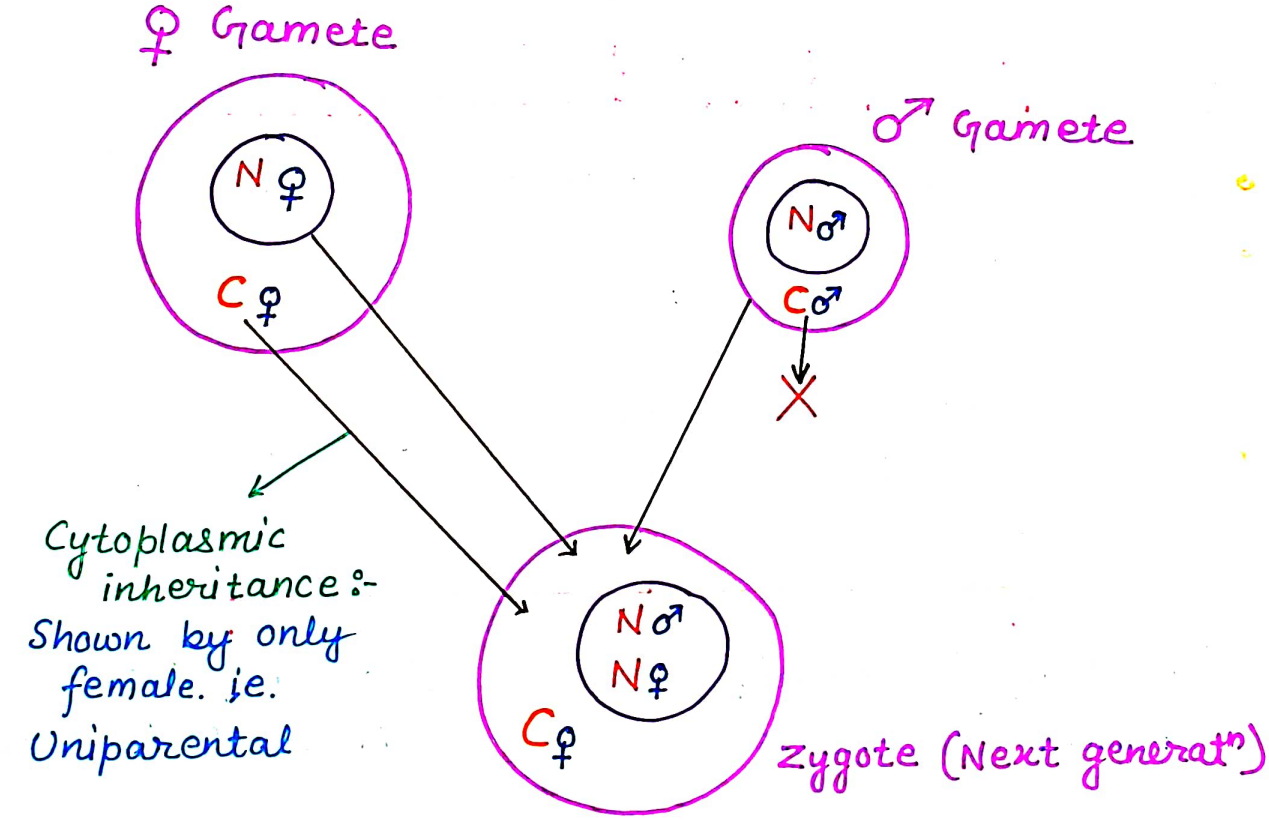
Tt (All tall)

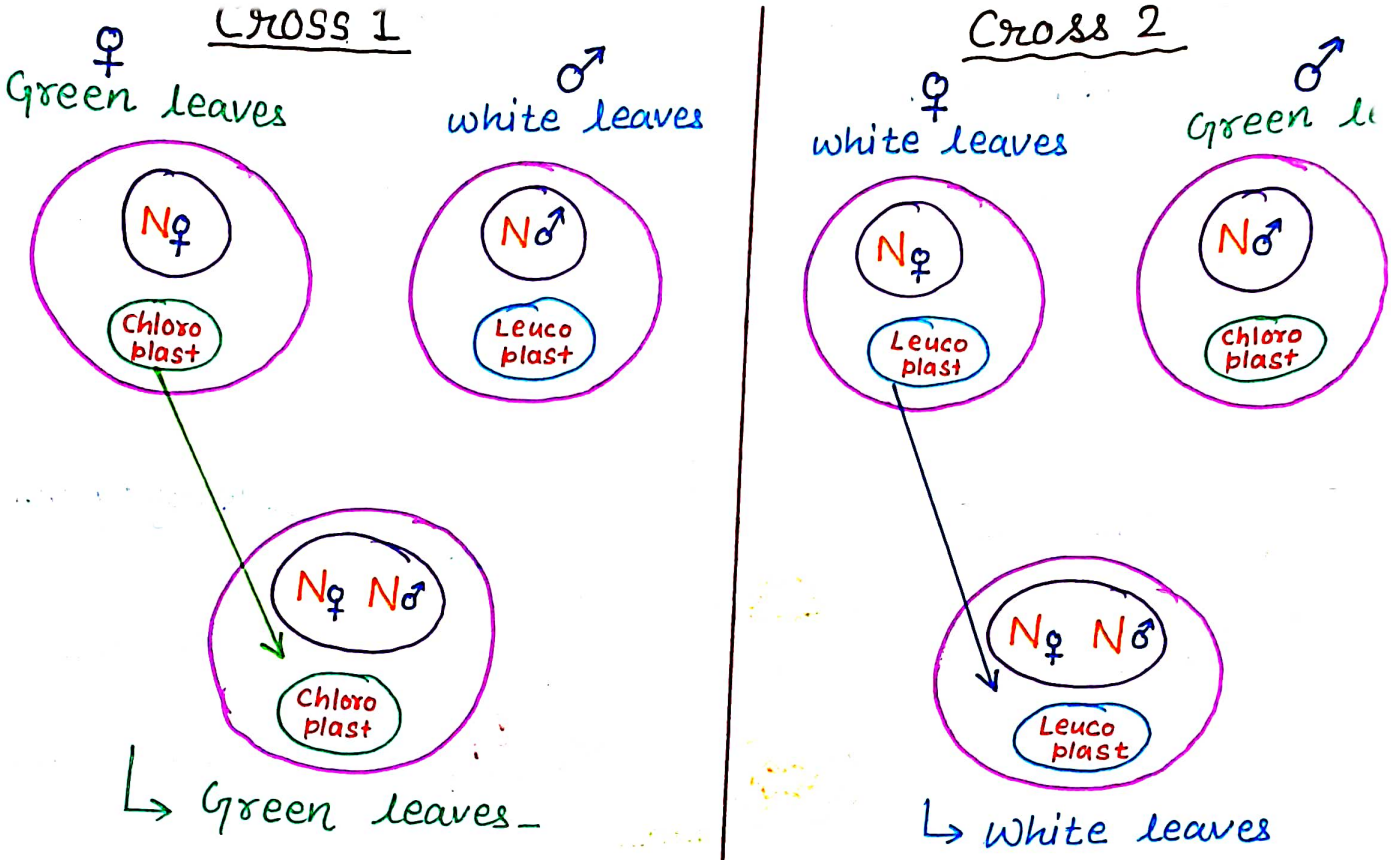
Result :- Mendel obtained similar result in both Cross

Conclusion :- Inharitance of character is not dependent on parental sex.

- Characters studied by Mendel were controlled by karyogene (Nucleus).
- Results of reciprocal cross will change in 2 cases.
  1) Genes pr. in cytoplasm (Cytoplasmic inheritance).
  2) Genes pr. on sex chromosomes (sex linkage).







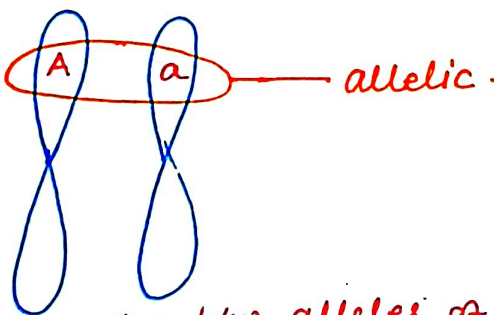
POST MENDELISM

- After rediscovery of Mendel's work
- 1900 onwards

GENE INTERACTION

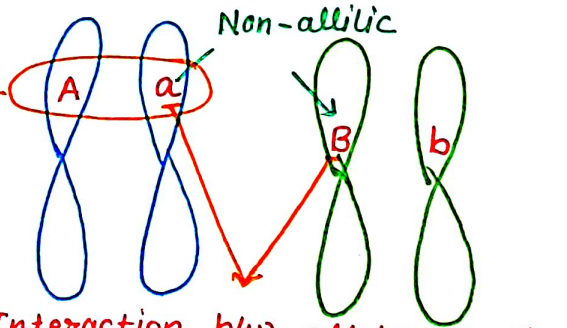
- Gene interact to modify the phenotype.

One gene/Intragenic/ Allelic interaction



Interaction b/w alleles of the same gene

Two gene/Intergenic/ Non-allelic interacti



Interaction b/w alleles of the 2 diff genes or non-alleles

Examples :-

1. Incomplete dominance
2. Co-dominance
3. Multiple alleles
4. Pleiotropic gene

Examples :-

1. Complementary gene
2. Epistatic gene

QUALITATIVE AND QUANTITATIVE CHARACTE

Qualitative Character

This character is not dependent on number of dominant alleles.

Genotype	Dominant alleles	Height
TT	2	10 cm
Tt	1	10 cm
tt	0	5 cm

Quantitative Character

This Character is dependent on number of dominant alleles.

Genotype	Dominant alleles	Height
TT	2	10 cm
Tt	1	7.5 cm
tt	0	5 cm

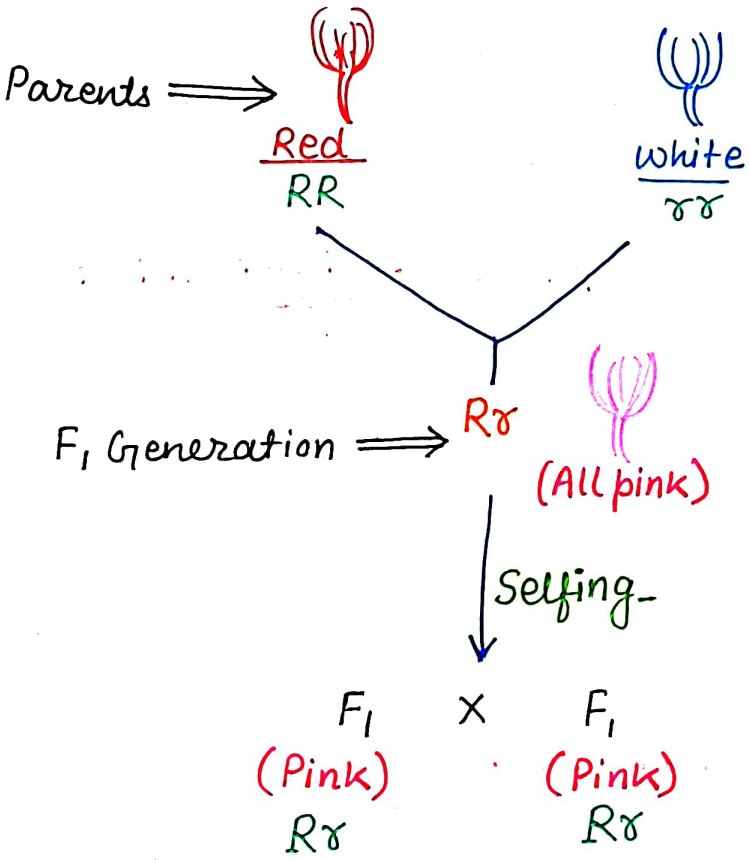
INCOMPLETE DOMINANCE

- Also called monogenic quantitative inheritance/ PHENOTYPIC BLENDING.
- Exception of Mendel's law of dominance.
- In this interaction dominant allele is not fully dominant over recessive allele.
- So, in heterozygous condition an intermediate phenotype appears.
- Thus, F_1 hybrid does not resemble to any of the parent.

- In this inheritance Phenotypic and genotypic ratio are obtained same.
- It was discovered by Carl Correns in flower Colour of Mirabilis jalapa/ 4 o' clock plant/ Gul-e-B

Example :-

(a) flower Colour in Mirabilis/4 o' clock plant/ Gul-e- Bans.



	R	r
R	RR Red	Rr Pink
r	Rr Pink	rr white

Phenotype ratio :-

Red : Pink : white

1 : 2 : 1

Genotype ratio :-

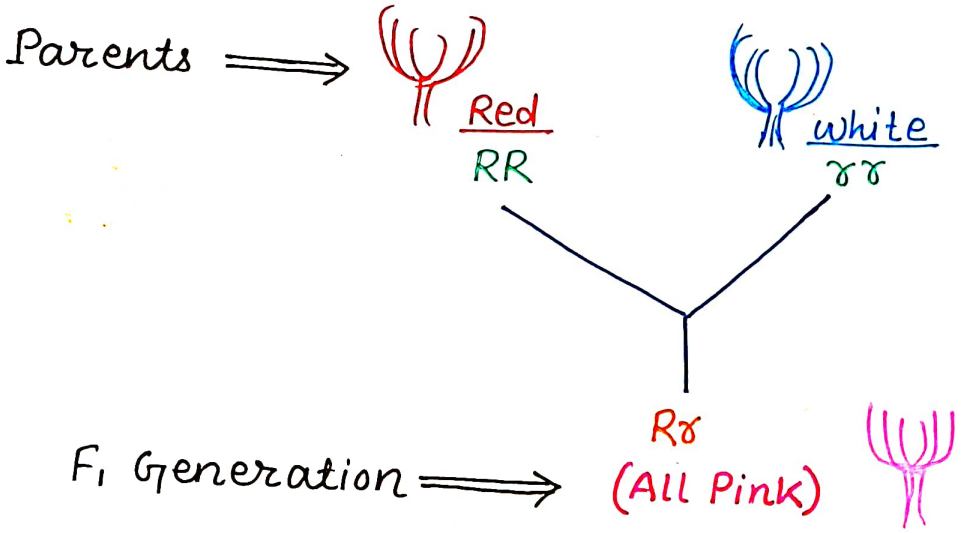
RR : Rr : rr

1 : 1 : 1

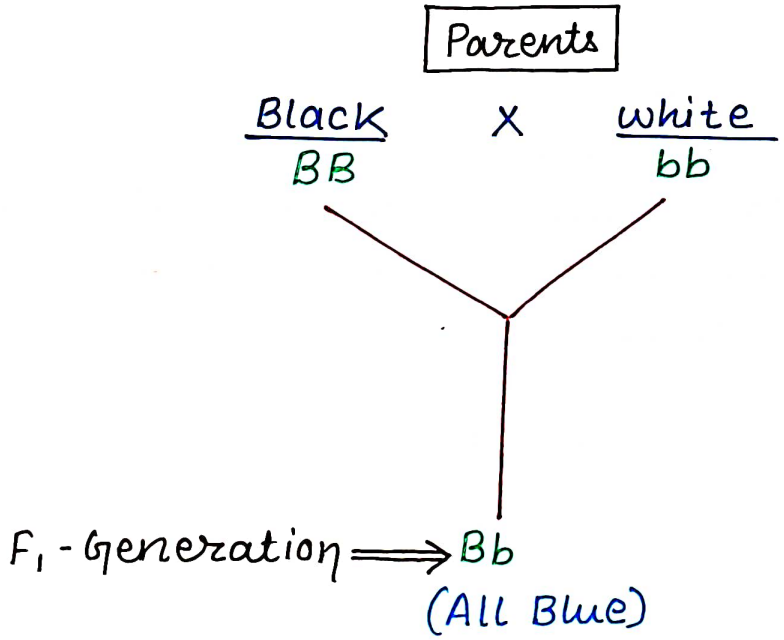
PR = GR

★NCERT

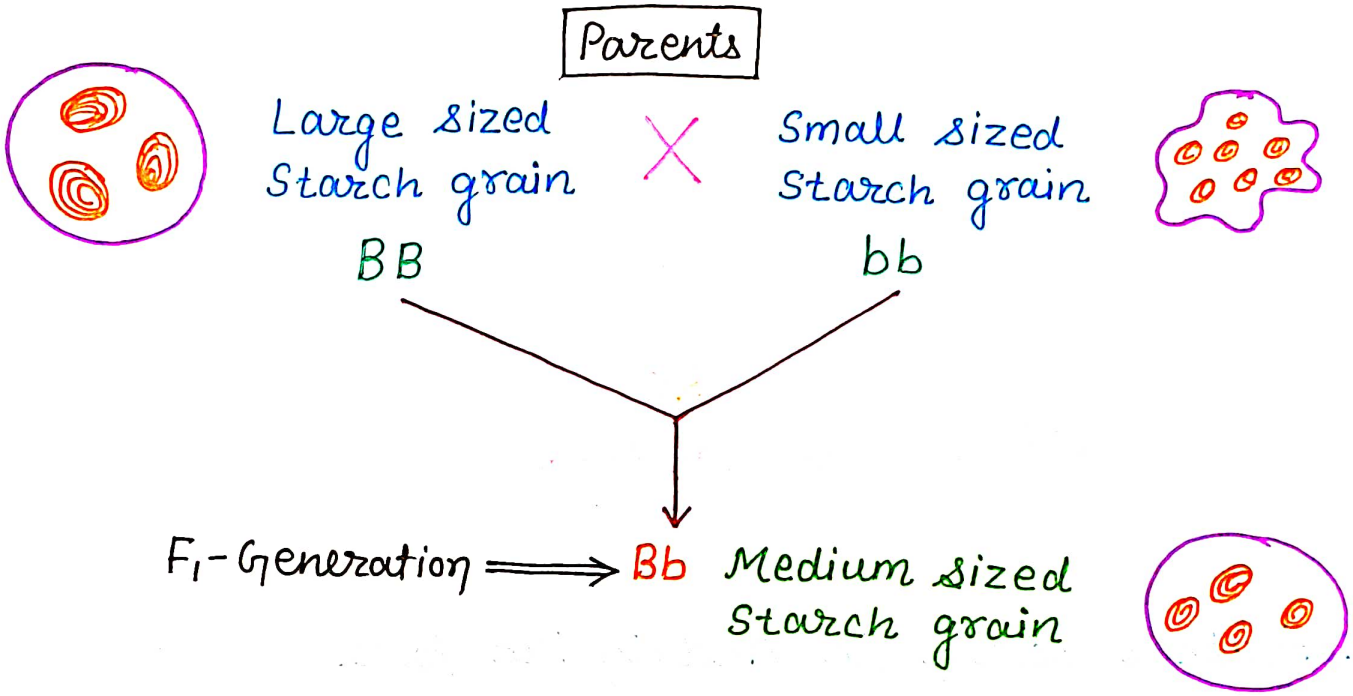
b) Flower Colour in Antirrhinum majus / Snapdragon / Dog flower.



(C) Feather Colour in Andalusian fowl.



(d) Size of starch grain in seeds of garden pea plant.



Q. With respect to size of starch grain in pea plant large sized starch garin plant is crossed with medium sized starch grain and produce 100 offspring's. Find out number of large, medium and small sized respectively?

$$\underset{BB}{\text{Large}} \times \underset{Bb}{\text{Medium}}$$

	B	b
B	BB large	Bb medium

Large $\longrightarrow \frac{1}{2} \times 100 = 50$

Medium $\longrightarrow \frac{1}{2} \times 100 = 50$

Small $\longrightarrow 0$

In Mirabilis red (RR) and white (rr) flower produces F_1 generation. Now F_1 generation is test crossed and produce 200 offspring's, how many of them are red, pink, and white flowered respectively :-

Red × white

RR × rr

Rr (Pink)

F_1 × Test crossed

Rr × rr

	r	r
R	Rr Pink	
r		rr white

Red = 0

Pink = $\frac{1}{2}$ x 200 = 100

white = $\frac{1}{2}$ x 200 = 100

2. CO-DOMINANCE

- Exception of Mendel's law of dominance.
- In this interaction in heterozygous condition both alleles are equally dominant and show their independent expression.
- So in heterozygous condition an intermediate phenotypes are not appears.

Thus, F_1 hybrid resemble to both of the parents.

- In this inheritance Phenotypic and genotypic ratios are obtained here same.

Example :-

(a) Coat Colour in Cattle's :-

♂ Black B_1B_1 X ♀ white B_2B_2

F_1-Gen. ⟹ B_1B_2 (Roan)

Sib-mating

F_1 (Roan) B_1B_2 X F_1 (Roan) B_1B_2

Mosaic form.

F_2- Gen... ⟹

	B_1	B_2
B_1	B_1B_1 Black	B_1B_2 Roan
B_2	B_1B_2 Roan	B_2B_2 white

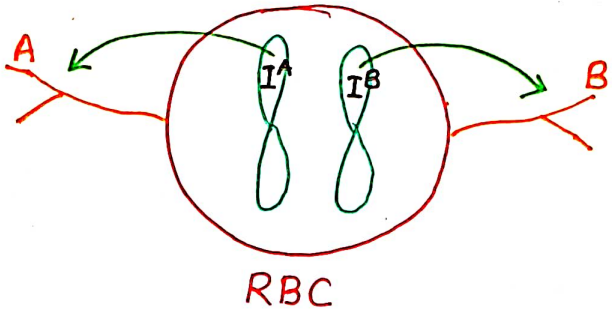
Phenotypic ratio :- Black : Roan : white
1 : 2 : 1

Genotypic ratio :- B_1B_1 : B_1B_2 : B_2B_2
1 : 2 : 1

PR = G.R

★★NCERT

(b) AB blood group in human (I^AI^B) :-



★★NCERT

(C) Carrier (Trait) of sickle cell anaemia (Hb^AHb^S) :-

POINT TO KEEP :-

Co-Dominance

Parents: Red × white

F_1-Gen.: Red + white

Selfing

F_2-Gen.: P.R = 1:2:1

G.R = 1:2:1

Complete-Dominance

Red × white

All Red

Selfing

PR = 3:1

GR = 1:2:1

Incomplete-Dominance

Red × white

Pink

Selfing

PR = 1:2:1

GR = 1:2:1

Q. In a dihybrid cross, when one pair of alleles show incomplete dominance and other pair show complete dominance, the phenotypic ratio comes in F_2 generation is —

(1) 3:1:6:2:3:1
(2) 1:2:2:4:1:2:1:2:1
(3) 9:3:3:1
(4) 1:2:1

↳ Phenotypic ratio of gene showing
i) Incomplete dominance (1:2:1)
ii) Complete dominance (3:1)

So, phenotypic ratio considering both the genes together will be—

(1:2:1) × (3:1)
3:1:6:2:3:1

Q. F_2 generation in a Mendelian cross showed that both genotypic and phenotypic ratios are same as 1:2:1. It represents a case of :-

(1) Monohybrid cross with complete dominance (3:1) X
(2) Monohybrid cross with incomplete dominance
(3) Co-dominance
(4) Dihybrid cross X

3. MULTIPLE ALLELES ----

- Presence of more than two alleles of a gene.
- Multiple alleles are located at same locus on homologous chromosome.
- Multiple alleles arise due to mutation.
- For the study of multiple alleles population study is essential.
- In a diploid individual study of multiple allele is not possible because a diploid individual have only maximum two allele of a gene.
- In case of multiple alleles number of alleles in _

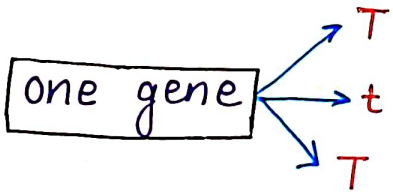
Diploid individual → 2

Gamete → 1

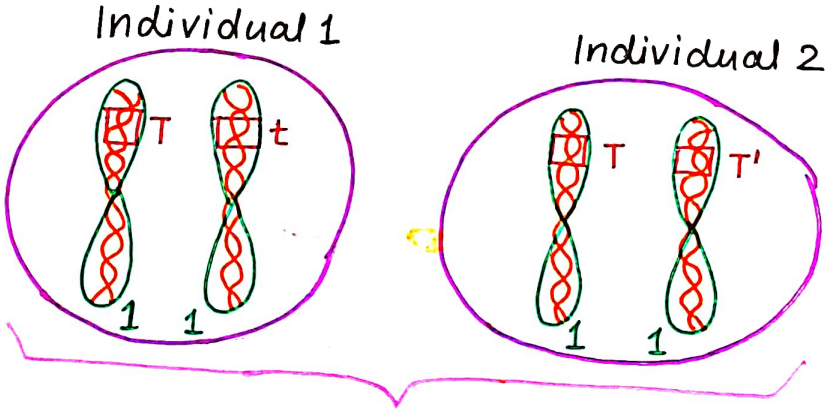
Population → All posible

$$\text{Types of genotype} = \frac{n(n+1)}{2}$$

∴ n → number of alleles



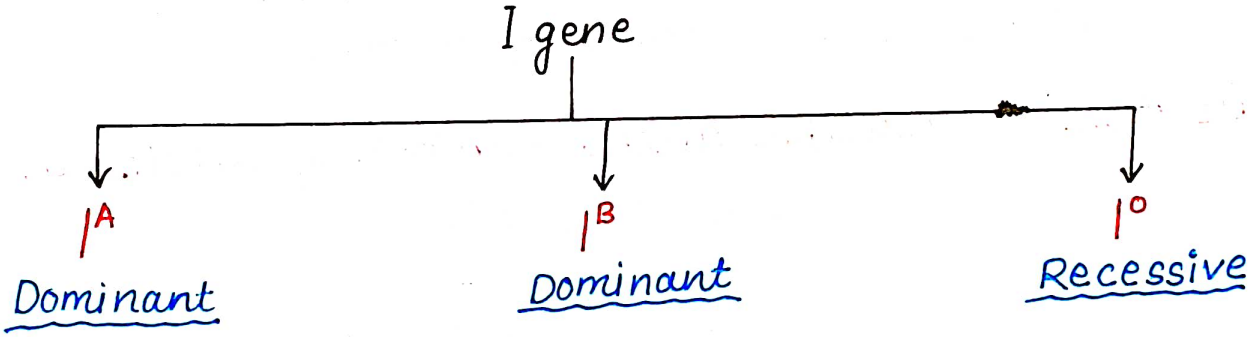
2 alleles genotype	3 alleles genotype
TT	TT
Tt	Tt
tt	tt
	TT'
	T'T'
	T't



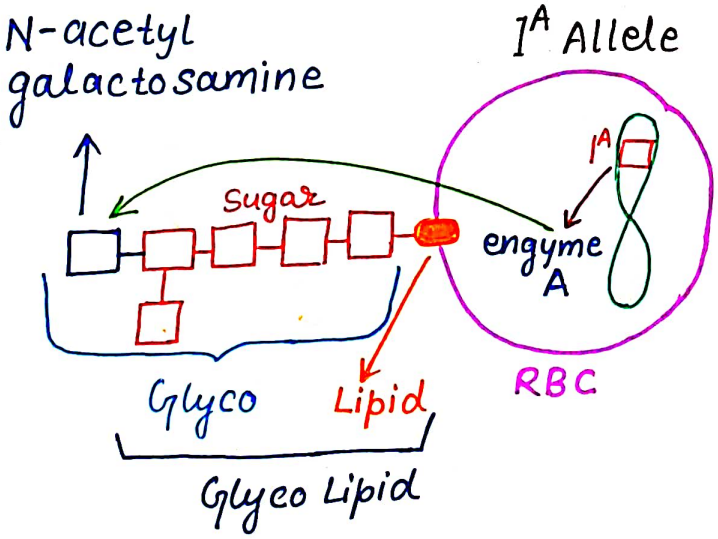
Example :-

ABO blood group in human :- 3 alleles.

- ABO blood group is discovered by Land Steiner
- Blood group is controlled by I gene, and this gene located on chromosome no. 9.
- I gene regulate attachment of sugar molecule on the surface of RBC.
- This gene has three alleles :- I^A, I^B, I^o

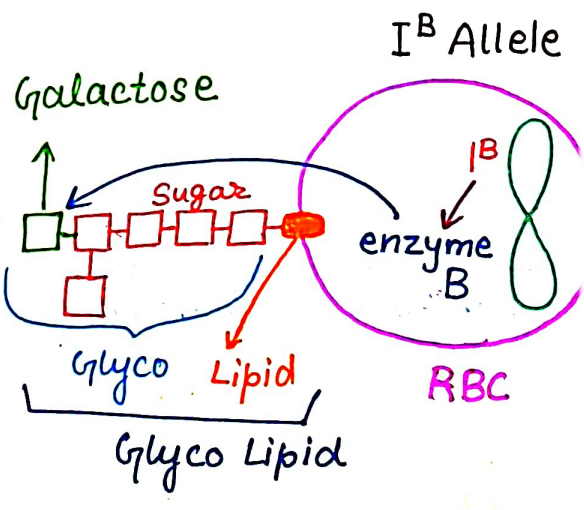


Consepts to understand :-



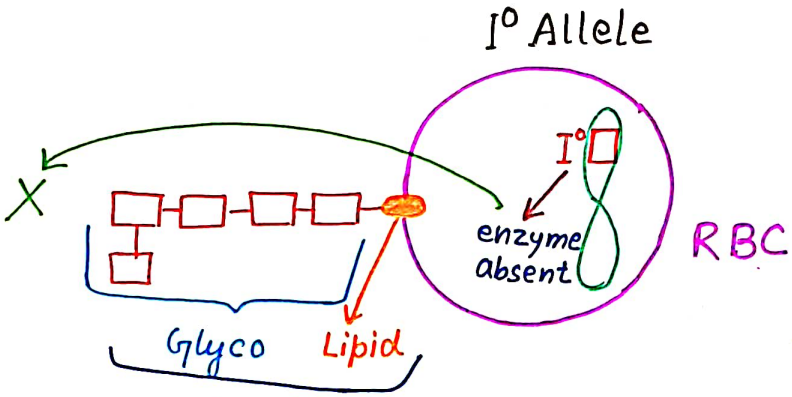
→ Antigen 'A'

→ Blood group 'A'



→ Antigen B

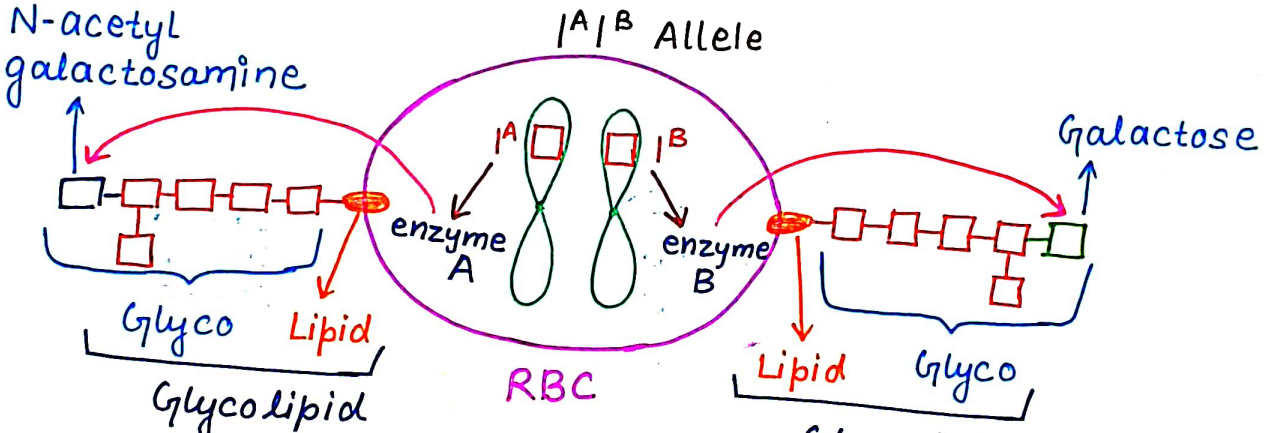
→ Blood group B



Glyco lipid

Antigen 'absent'

Blood group 'O'



Glycolipid

Antigen 'A'

Glycolipid

Antigen 'B'

Blood group AB

Phenotype

Blood Group	Genotype	Antigen	Antibody
A	I^AI^A, I^AI^O	A	b
B	I^BI^B, I^BI^O	B	a
AB	I^AI^B	A & B	Neither a nor b
O	I^OI^O	Neither A nor B	a & b

In ABO blood Group

Gene → 1

Allele → 3

Genotype → 6

Phenotype → 4

Dominance → Apply

Co-Dominance → Apply

Multiple allele → Apply

Incomplete Dominance → Not apply

Q. Father is heterozygous for A blood group and blood group of mother is AB. How many types of genotype and phenotypes are possible in this cross.

♂ Heterozygous
~~I^AI^A~~, I^AI^O

♀ AB
I^AI^B

Gametes ⟹	I^A	I^B
I^A	I^AI^A 'A'	I^AI^B 'AB'
I^O	I^AI^O 'A'	I^BI^O 'B'

Phenotype → 3
Genotype → 4

Q. A Child's blood group is 'O'. His parents blood group can't be_

(1) B & O
(2) A & O
~~(3)~~ AB
(4) A & B

♂ I^O (A – I^A, B – I^B, O – I^O)
♀ I^O (I^A – A, I^B – B, I^O – O)
Child 'O'

Q. What will be the phenotype and genotype of parental blood group of a family in which all four types of blood group are present in their children?

♂ I^AI^O
♀ I^BI^O

Child
'A' 'B' 'AB' 'O'
I^AI^B I^OI^O

Phenotype → A, B
Genotype → I^AI^O, I^BI^O

3. A man of 'A' blood group marries a woman of 'AB' blood group, which type of blood group in the child would indicate that the man is hetero zygous for A

♂ I^AI^A, I^AI^O ♀ I^AI^B

Case 1

♂ I^AI^A ♀ AB I^AI^B

	I^A	I^B
I^A	I^AI^A A	I^AI^B AB

♂ 'Homozygous' :- A, AB

Case 2

♂ I^AI^O ♀ AB I^AI^B

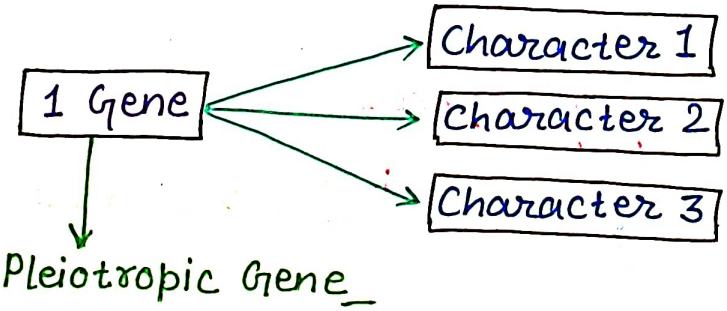
	I^A	I^B
I^A	I^AI^A A	I^AI^B AB
I^O	I^AI^O A	I^BI^O B

♂ 'Heterozygous :- A, AB, B

Ans

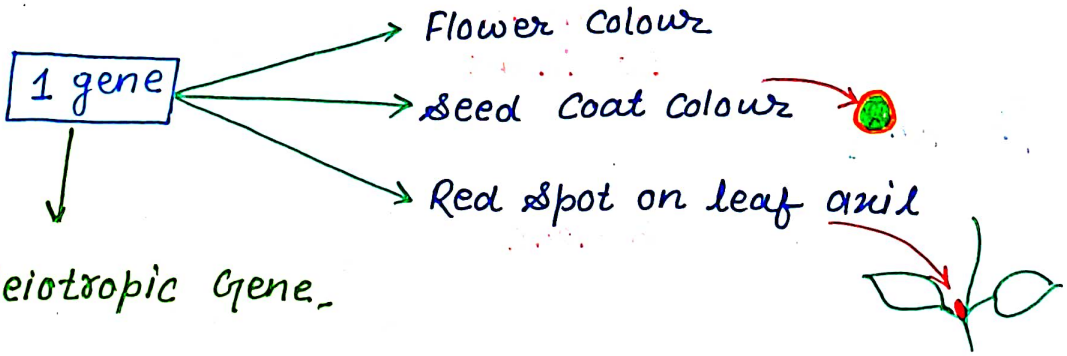
4. PLEIOTROPIC GENE

- A gene which controls more than one character.
- Pleiotropic gene produce multiple phenotypic effects.

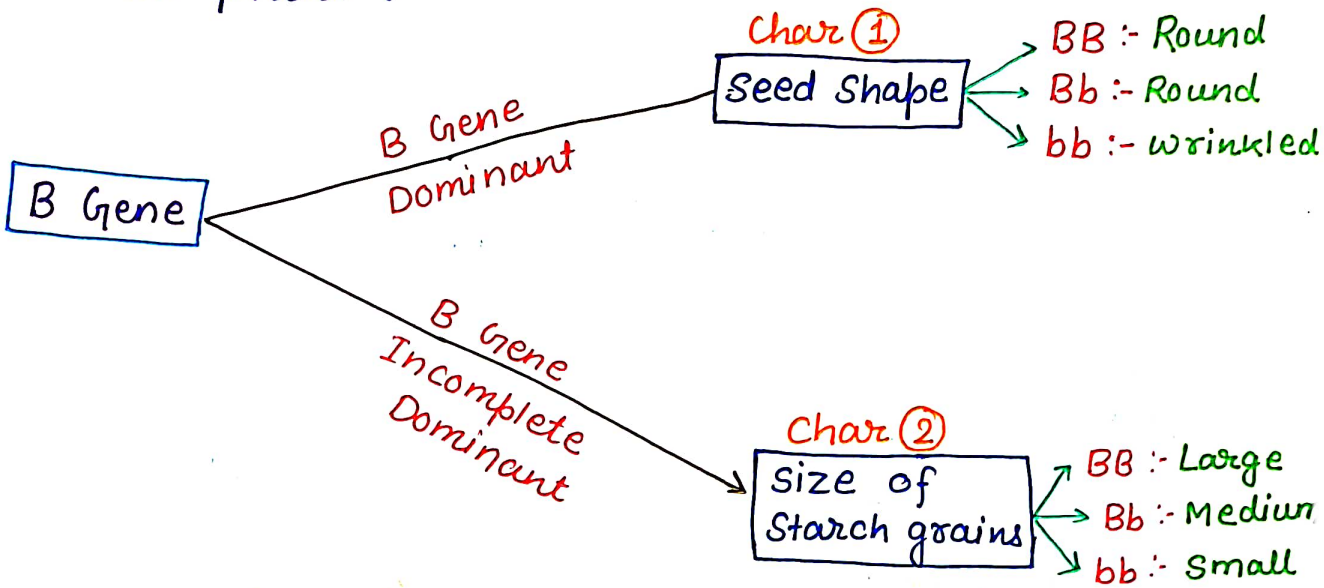


Example :-

(a) In Pea plant :-



(b) In Pea plant :-



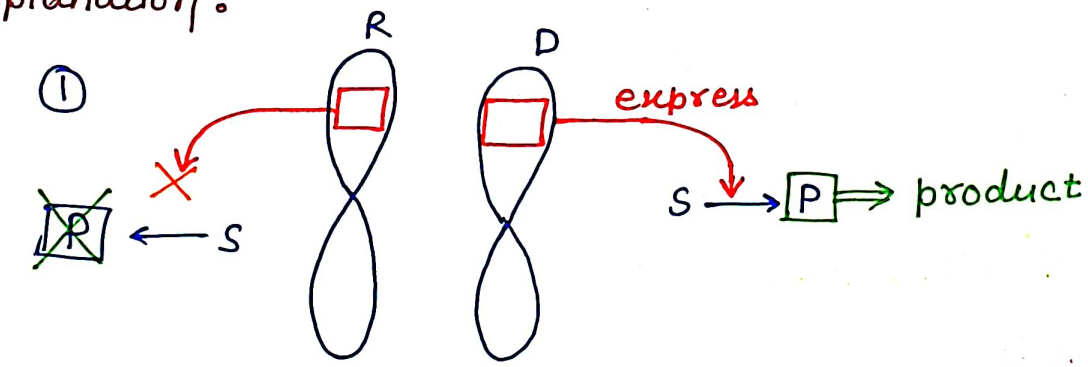
Conclusion of above example :-

Dominance is not an autonomous (self) feature of a gene, It dependent on :-

(1) Product of gene

(2) Partipular phenotype (character) that we choose to examine (study) in case of pleiotropic gene.

Explanation :-



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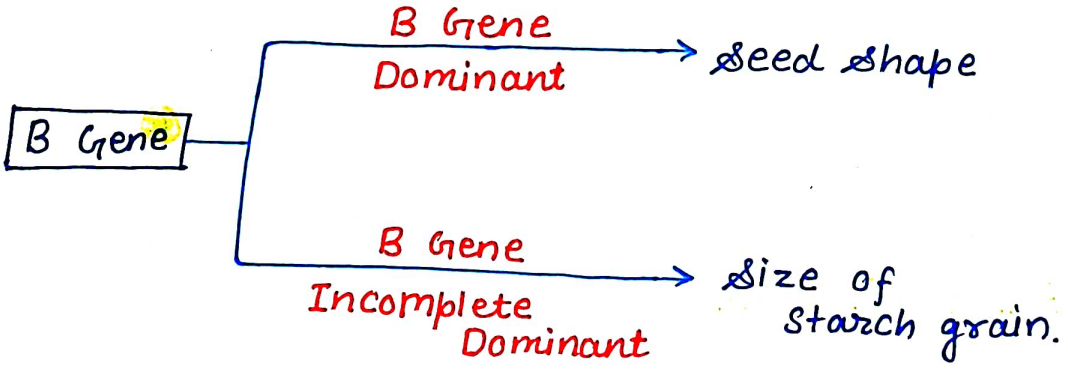


Q. A pure round seed shape pea plant is cross with wrinkled seed shape plant and produce F_1 generation. In F_1 generation :-

(1) Wrinkled seeds are obtained

(2) Large sized starch grains are obtained

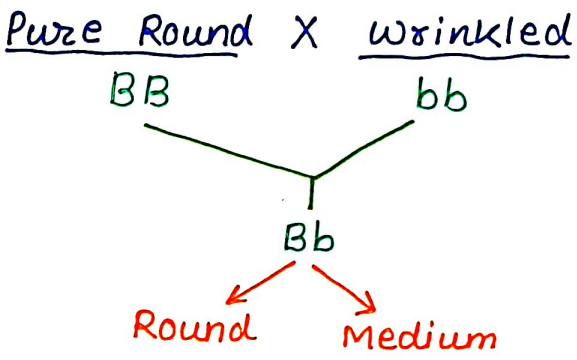
(3) Medium sized starch grains are obtained

(4) Small sized starch grains are obtained

B Gene

BB – Round
Bb – Round
bb – wrinkled

BB – Large
Bb – Medium
bb – Small



(C) Most of genetic disease :-

I. Phenylketonuria ⟶ Study in Human Health & diseas

II. Sickle cell anaemia

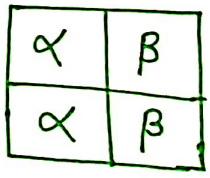
Sickle Cell anaemia :-

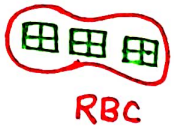
- Autosomal recessive disorder
- In this disease 6th amino acid of beta chain of haemoglobin is changed (Glutamic acid to Valine) due to point (Gene) mutation / Substitution / Transversion.
- Gene of beta chain is located on chromosome number 11.

Hb^A wild allele ⟶ (Point mutation) ⟶ Hb^S Mutant allele

Normal Hb.

Abnormal Hb. [Mutant Hb.





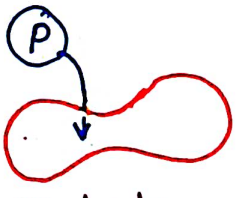
Sickle Shape RBC

→ Hard and rigid RBC → Slow blood Circulation → organ disfunctioni

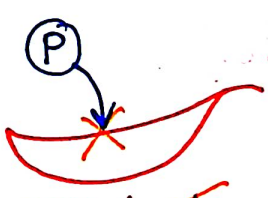
→ Short life Span of RBC 80-100 days → RBC death ↑ → Anaemeia

→ Jaundice

→ Resistance to malaria



Malaria



~~Malaria~~

Genotype :- Hb^A / Hb^S

Hb^AHb^A :- Normal

Hb^AHb^S :- Normal but Carrier/trait of sickle cell anaemia (co-dominance)

Hb^SHb^S :- Sickle cell anaemia

♂ Trait Hb^AHb^S X ♀ Trait Hb^AHb^S

	Hb^A	Hb^S
Hb^A	Hb^AHb^A Normal	Hb^AHb^S Carrier
Hb^S	Hb^AHb^S Carrier	Hb^SHb^S Sickle cell anaemia

Non-Allelic Interaction:-

1. COMPLEMENTARY GENE

- In this interaction two non-allelic gene regulate one character.

For the development of dominant trait the dominant alleles of both genes must be pr. together.

Absence of both dominant alleles of any genes will result in recessive expresion.

Example:-

Flower Colour of lathyrous odoratus (Sweet pea)

Flower Colour is Controlled by two genes 'C' and 'P'.

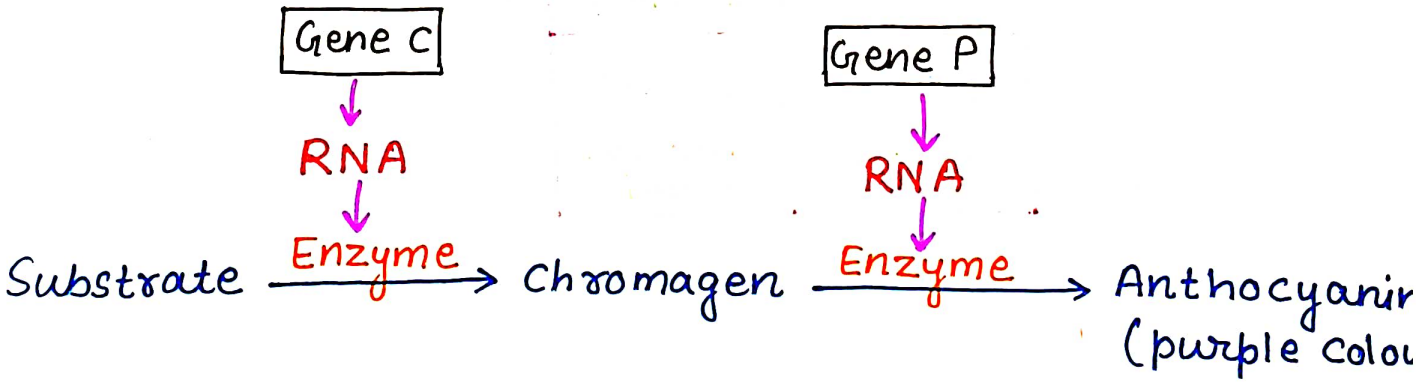
C_P_ :- purple Coloured

C_pp :- Colourless (white)

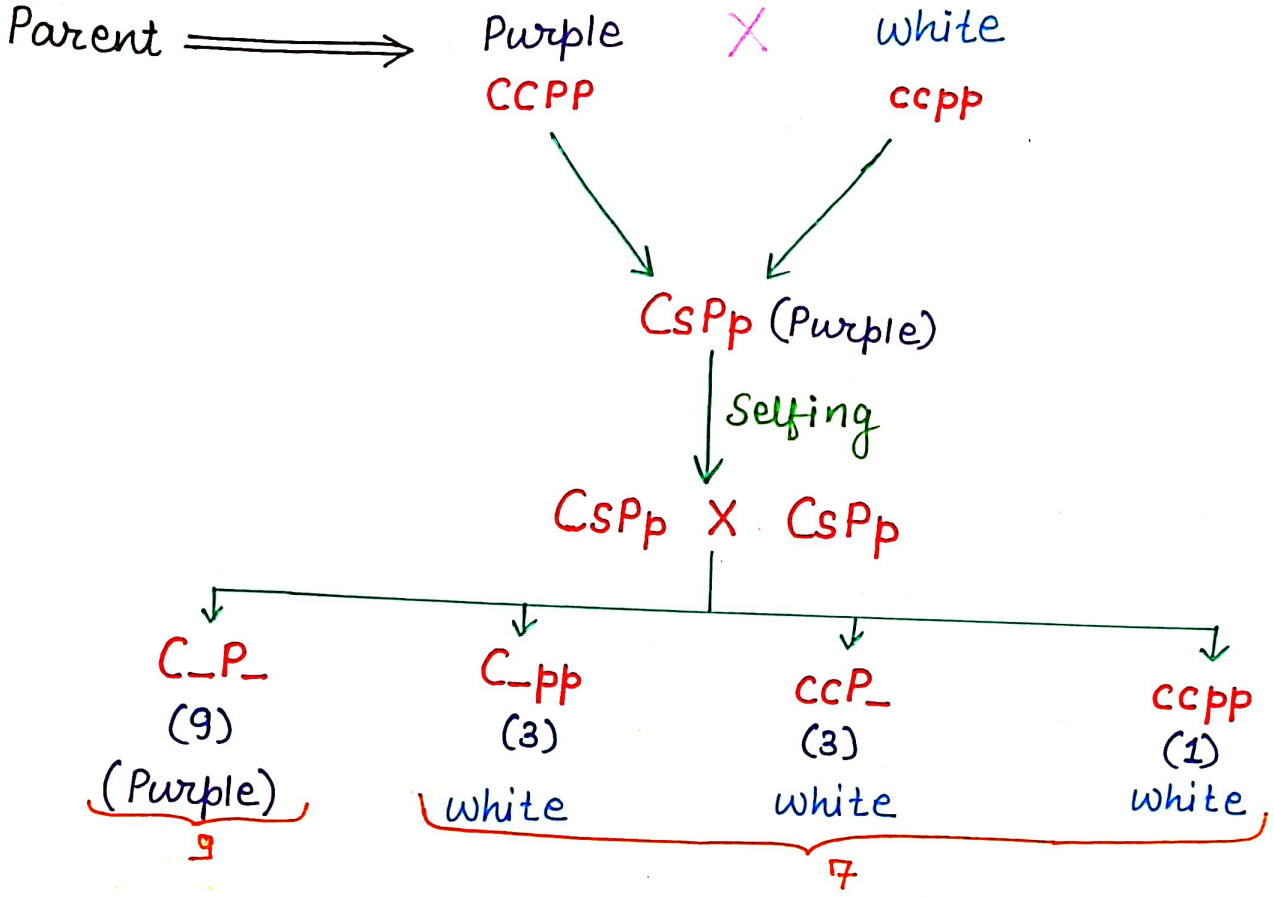
ccP_ :- Colourless (white)

ccpp :- Colourless (white)

Biochemical basis of Colour production:-



CROSS :-

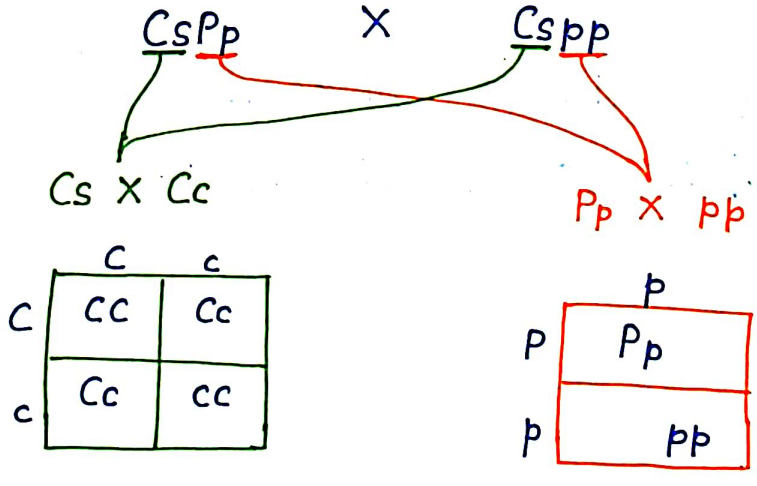


- Phenotypic ratio :- 9:7
- Genotypic ratio :- 1:2:2:4:1:2:1:2:1

Q. with respect to flower colour of Lathyrous odoratous genotype of a plant is CcPp. This plant is crossed with Ccpp genotype plant. Find out probablity of purple and white flower respectively in offspring.

CsPp X Ccpp

	Cp	cp
CP	CCPp	CcPp
Cp	CCpp	Ccpp
cP	CcPp	ccPp
cp	Ccpp	ccpp



Purple Colour :- C_P_

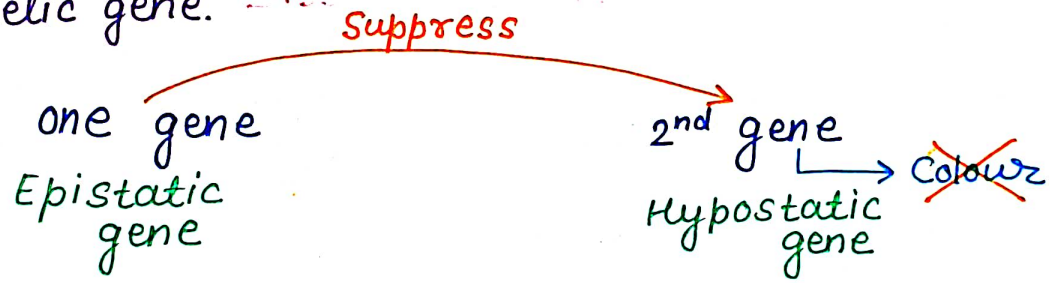
↳ $\frac{3}{4} \times \frac{1}{2} = \frac{3}{8}$

White Colour :- 1 - Coloured

↳ $1 - \frac{3}{8} = \frac{5}{8}$

2. EPISTASIS

In this interaction one non-allelic gene suppresses or prevents the phenotypic expression of the other non-allelic gene.



(a) Epistatic gene :-
Gene which inhibit the expression of another gene.

(b) Hypostatic gene :-
Gene whose expression is suppressed.

Epistasis is of 2 types :-

i) Dominant epistasis :-

ii) Recessive epistasis :-

i) Dominant Epistasis :-

In this interaction dominant allele of epistatic gene suppresses the expression of other non-allelic gene.

Eg :- Fruit Colour in Summer Squash (Cucurbita pepo)

Epistatic gene → W Dominant
→ w Recessive

yellow Y green y

Dominant epistasis

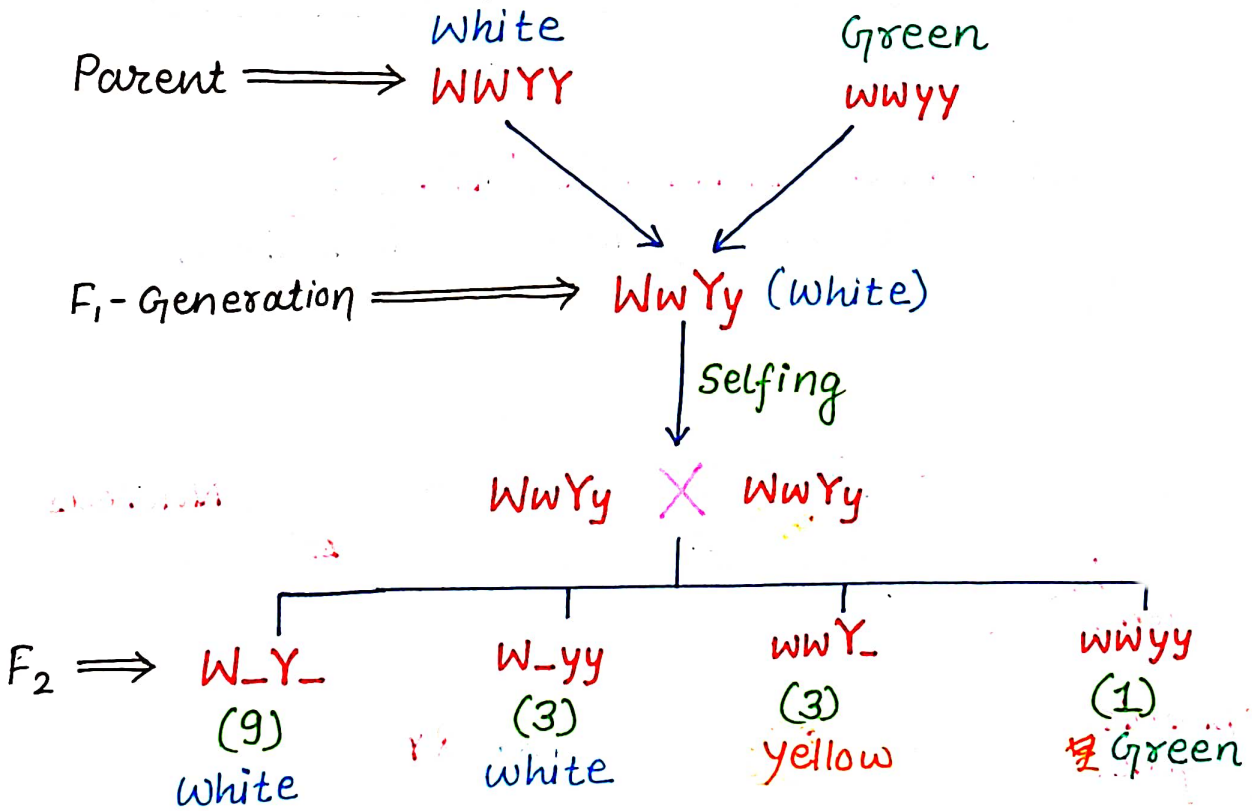
W_Y_ :- ~~Yellow~~ white (Supresses)

wwY_ :- yellow

W_yy :- ~~green~~ white (Supresses)

wwyy :- green

CROSS :-



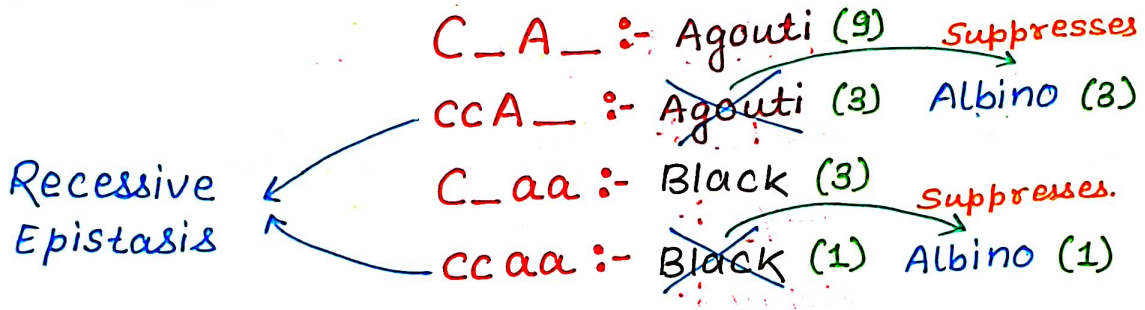
Phenotypic Ratio :- 12 : 3 : 1

Genotypic Ratio :- 1 : 2 : 2 : 4 : 1 : 2 : 1 : 2 : 1

ii) Recessive Epistasis :-

In this interaction recessive allele of epistatic gene, suppresses the expression of other non-allelic gene.

eg: Coat colour in mice

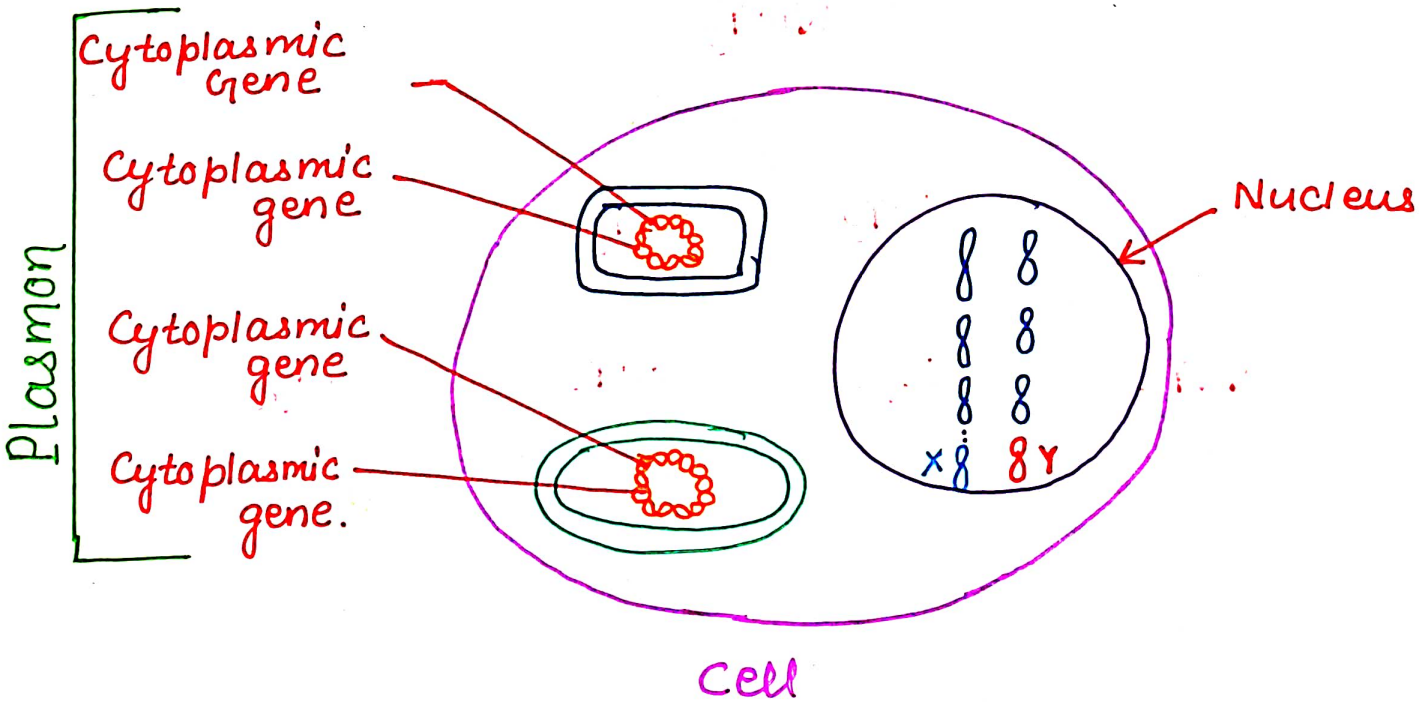


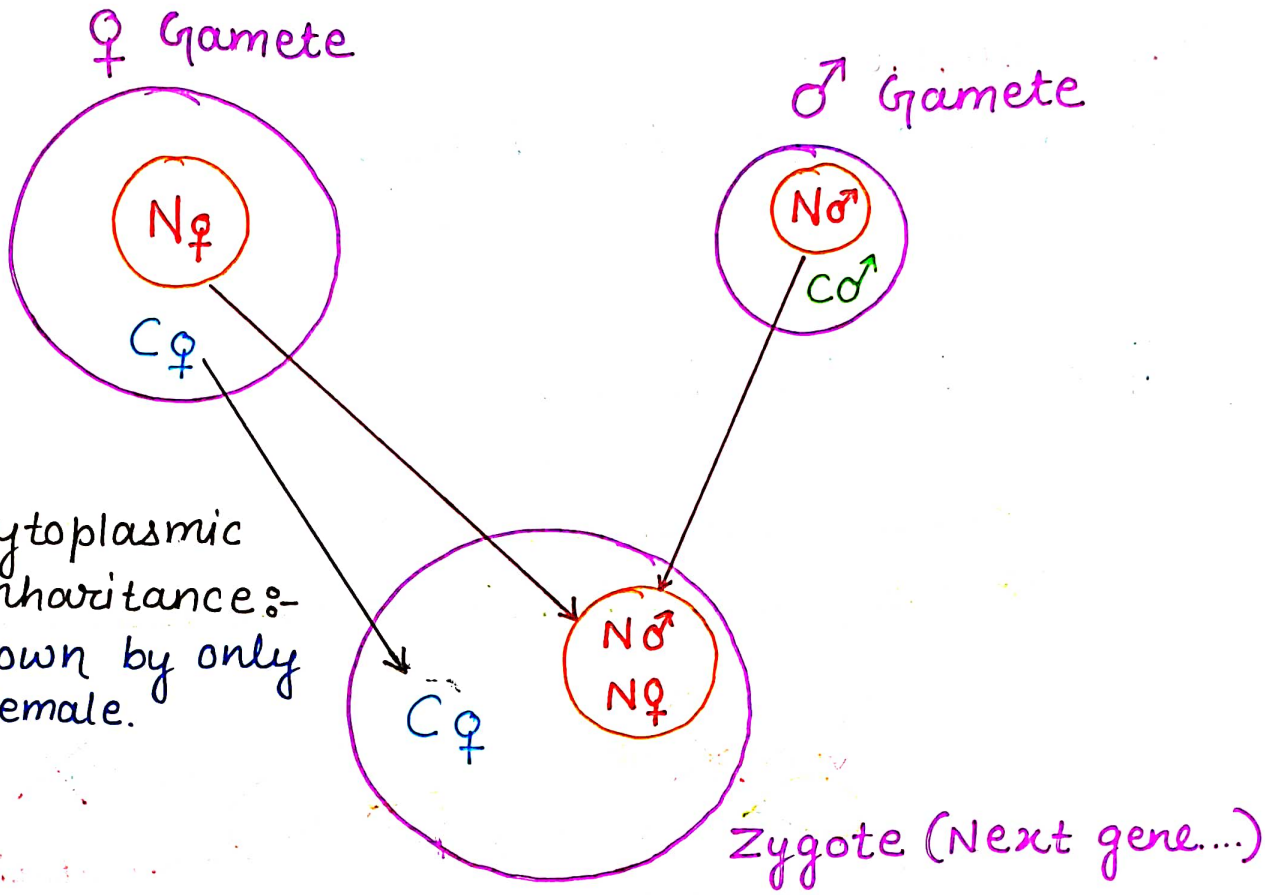
Phenotypic Ratio :- 9:3:4

Genotypic Ratio :- 1:2:2:4:1:2:1:2:1

CYTOPLASMIC INHARITANCE

- Also called extranuclear/maternal inharitance.





Discovered by Carl Correns in Mirabilis jalapa.

Inharitance of those characters which are Controlled by cytoplasmic genes is called cytoplasmic inharitance.

Gene pr. in cytoplasm is called Cytogene/ extranuclear gene.

Cytogenes are pr. in cell organelles like mitochondria (mitogene) and plastid (plastogene).

Sum total of all the cytogenes pr. in a cell is called Plasmon.

Since zygote receives most of the cytoplasm from female gamete, so cytoplasmic inheritance is also called as maternal Inharitance.

Some Example :-

i) Mitochondrial inheritance

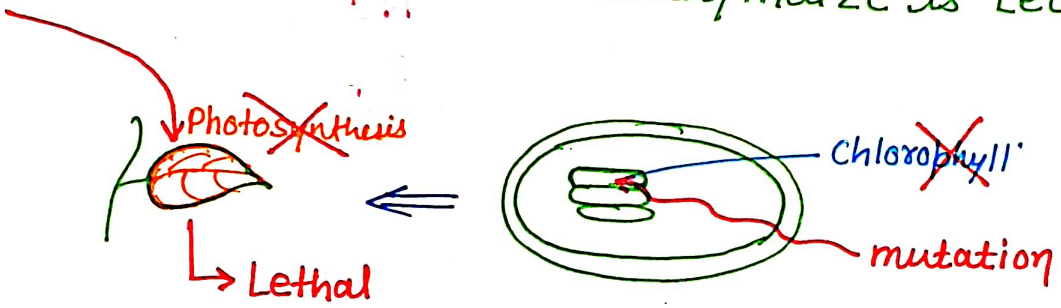
↳ Male sterility in maize plant.

ii) Plastid inheritance

a) Albinism (Colourless Cond^{n}) in certain plants

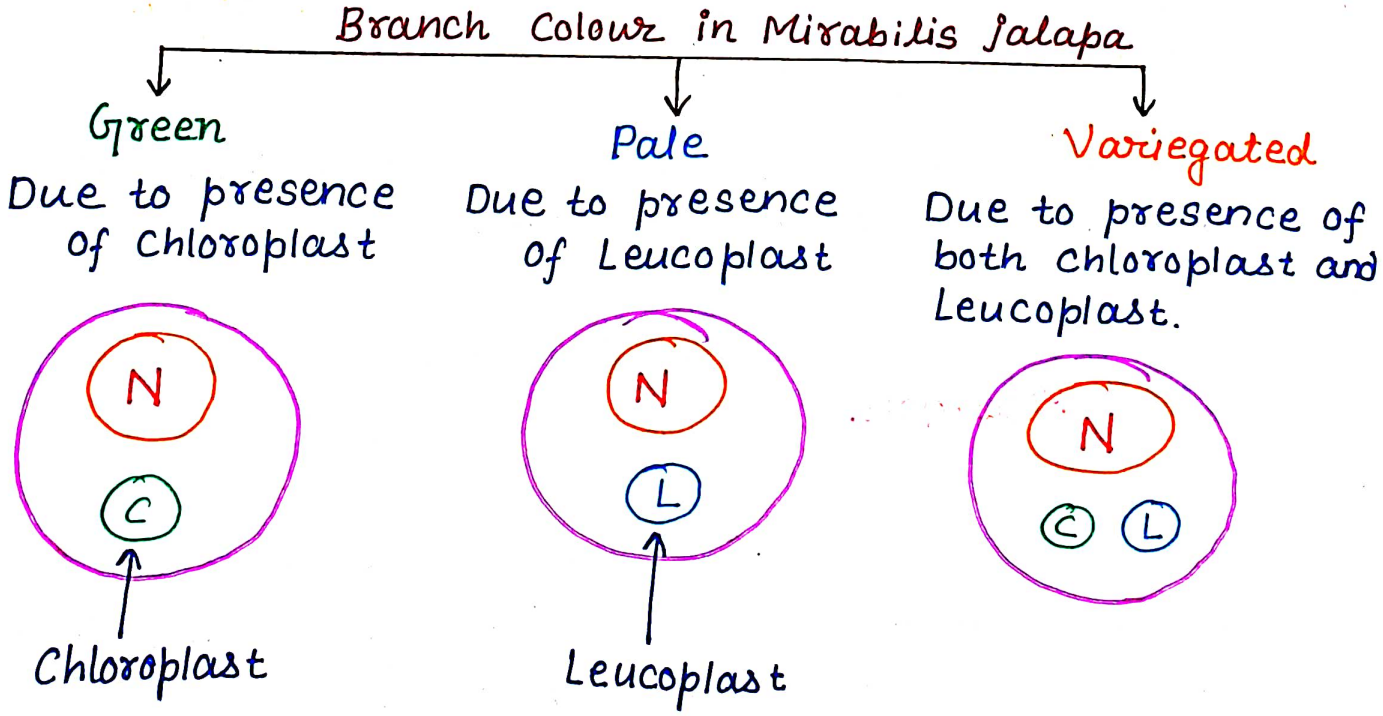
→ Gene for albinism is found in Chloroplast.

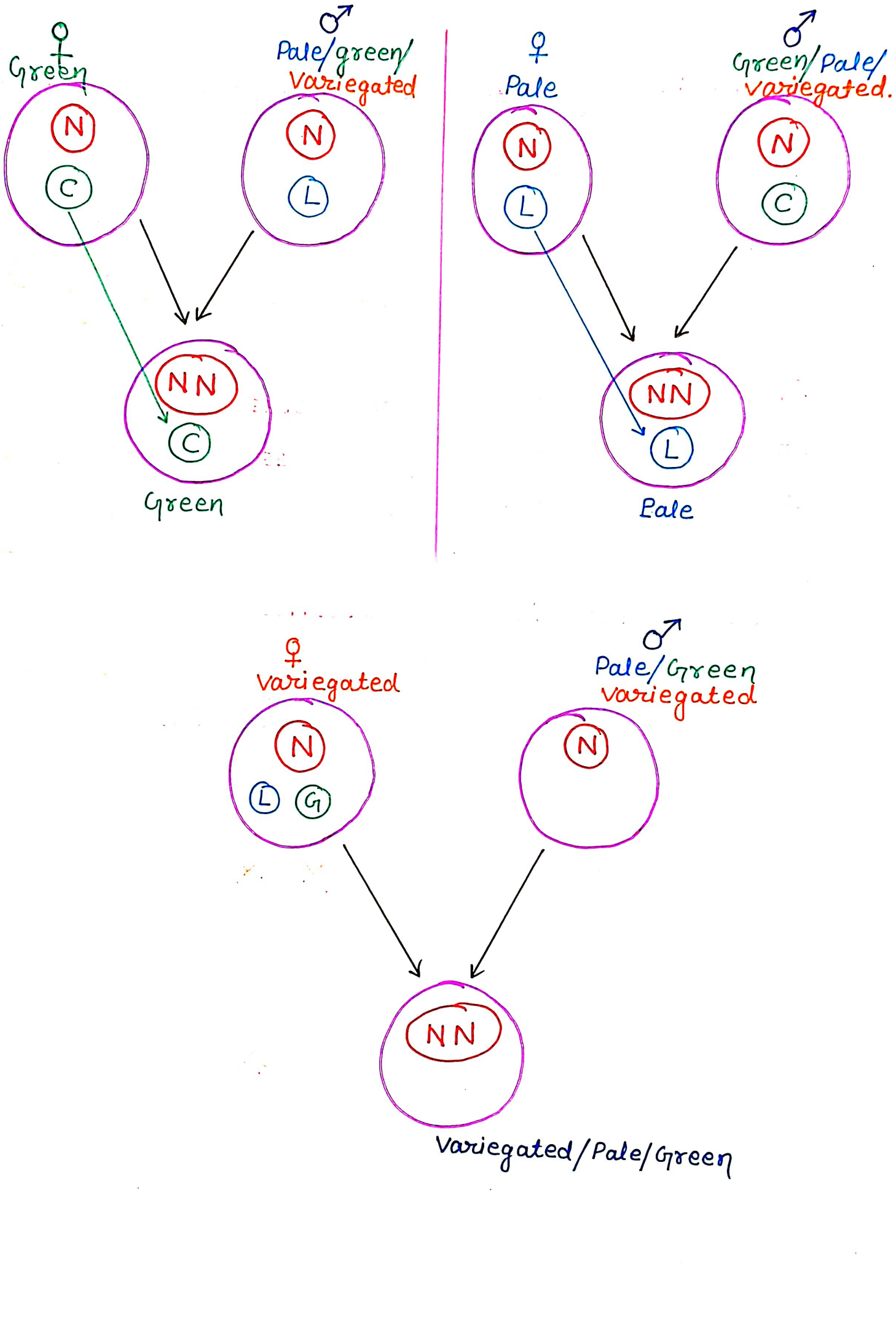
→ Gene for albinism in Corn/maize is Lethal.



b) Branch Colour/leaf Colour in Mirabilis jalapa

First case of Cytoplasmic inheritance to be discovered by Carl Correns.




♀
Green
♂
Pale/green/
Variegated
N
C
N
L
NN
C
Green
♀
Pale
♂
Green/Pale/
variegated.
N
L
N
C
NN
L
Pale
♀
Variegated
♂
Pale/Green
variegated
N
L
G
N
NN
Variegated/Pale/Green

QUALITATIVE AND QUANTITATIVE CHARCT.

Qualitative Character

This character is not dependent on number of dominant alleles.

Genotype	Dominant alleles	Height
TT	2	10 cm
Tt	1	10 cm
tt	0	5 cm

Eg:-
Sickle Cell Anaemia

α	β
α	β

Quantitative Character

This character is dependent on number of dominant alleles.

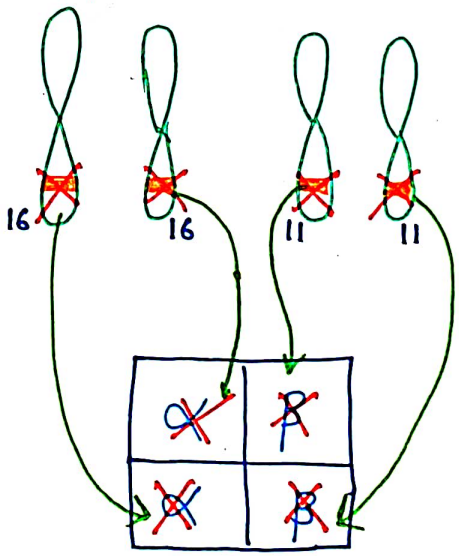
Eg: Human Height (5 gene)

Maximum expression

Genotype	Dominant alleles	Height
AABBCCDDEE	10	200 cm
AaBbCcDDEE	8	180 cm
AaBbCcDdEE	6	160 cm
AaBbCcDdEe	5	150 cm
aabbccddee	0	100 cm

minimum expression

Eg:-
Thalassemia.



POLYGENIC/QUANTITATIVE INHARITANCE

In this inharitance one quantitative character is Controlled by more than one gene.

- The phenotype is dependent on number of dominant allele.
- Each dominant allele contribute in development of phenotype.
- Maximum expression is obtained when all dominant alleles of all genes must be pr. together.
- In this inheritance phenotype is highly influenced by environment.
- Types of Phenotype :- $2n+1$

  Types of Genotype :- 3^n

  Zygotic Combination :- 4^n

Example :-

(a) Kernal Colour of wheat → 2 polygene's

(b) Human Skin Colour → 3 polygene's

(c) Human height → 5 polygene's

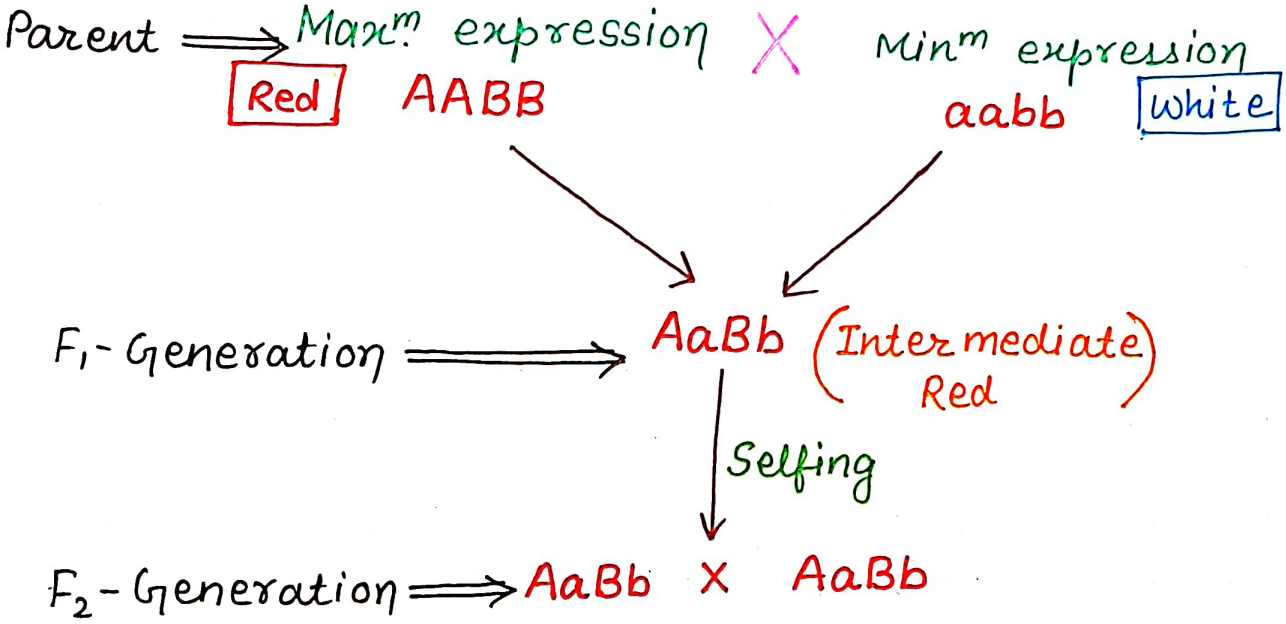
(d) Human intelligence → 25 polygene's

- Father of Polygenic inheritance – Kolreuter

(a) Kernel Colour of wheat

→ Studied by Nilsson - Ehle.

→ Controlled by 2 polygene's 'A' and 'B'.



AABB	AABb	AaBB	AaBb
AABb	AAbb	AaBb	Aabb
AaBB	AaBb	AAbb	aaBb
AaBb	Aabb	aaBb	aabb

Conclusion (F-generation)

No. of Dominant alleles	Genotype	Phenotype	Phenotypic Ratio
4	AABB - 1	Red (Parental)	1
3	AABb - 2 AaBB - 2	Light red	4
2	AaBb - 4 AAbb - 1 aaBB - 1	Intermediate red	6
1	Aabb - 2 aaBb - 2	very light red	4
0	aabb - 1	white (Parental)	1

In F_2 - Generation :-

(1) Phenotypic ratio – 1 : 4 : 6 : 4 : 1

(2) Genotypic ratio – 1 : 2 : 2 : 4 : 1 : 2 : 1 : 2 : 1

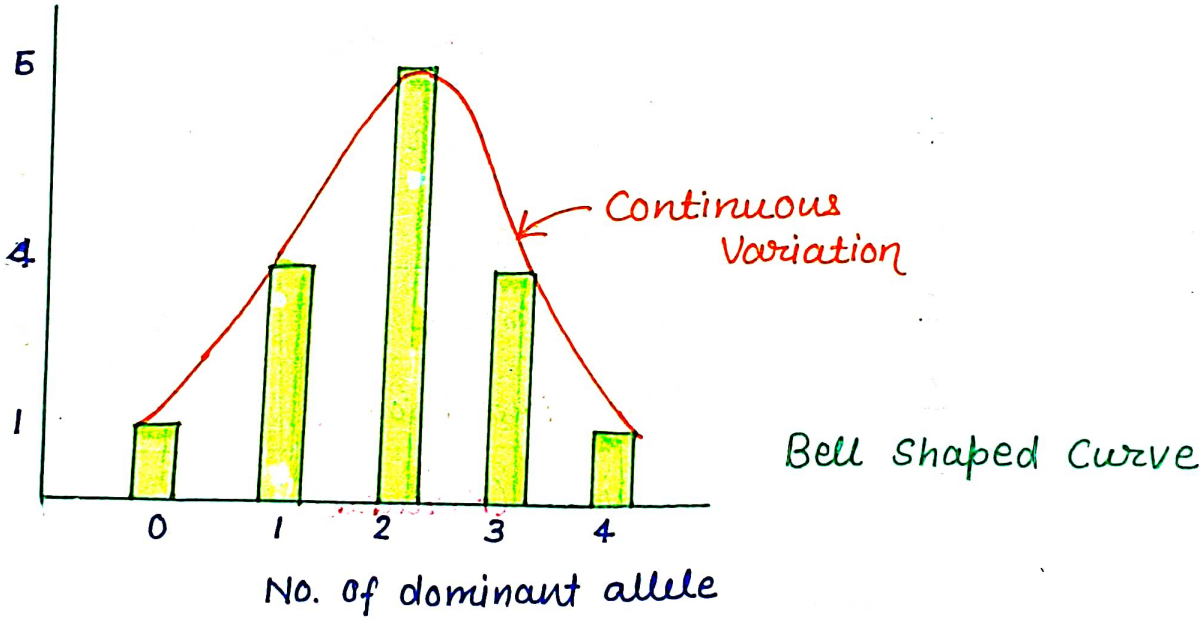
(3) Types of phenotype – $2n+1$
$2 \times 2 + 1 = 5$

(4) Types of Genotype :- $3^n \Rightarrow 3^2 = 9$

(5) Zygotic combination :- $4^n \Rightarrow 4^2 = 16$

(6) % of parental plant – $\frac{2}{16} \times 100 = 12.5\%$

GRAPH



NCERT

(6) Human skin Colour → 3 polygene's

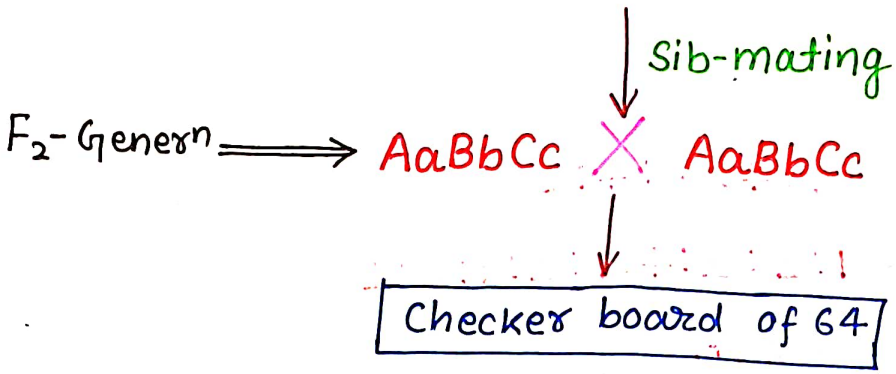
→ Studied by Davenport.

→ Controlled by 3 polygene's 'A' 'B' and 'C'.

Parent ⟹ Max^m expression × Min^m expression

AABBCC (Negro Black) × aabbcc (White)

F_1 Generation ⟹ AaBbCc (Intermediate/Brown/Mulatto)



Conclusion (F_2- Gen..

No. of Dominant alleles	Phenotype	Ratio
6	Negro Black (Parental)	1
5	Very Dark Brown	6
4	Dark Brown	15
3	Mulatto	20
2	Light Brown	15
1	Very light Brown.	6
0	White (Parental)	1

In F_2- Generation :-

(1) Phenotypic ratio - 1 : 6 : 15 : 20 : 15 : 6 : 1

(2) Genotypic ratio - (1 : 2 : 1) X (1 : 2 : 1) X (1 : 2 : 1)

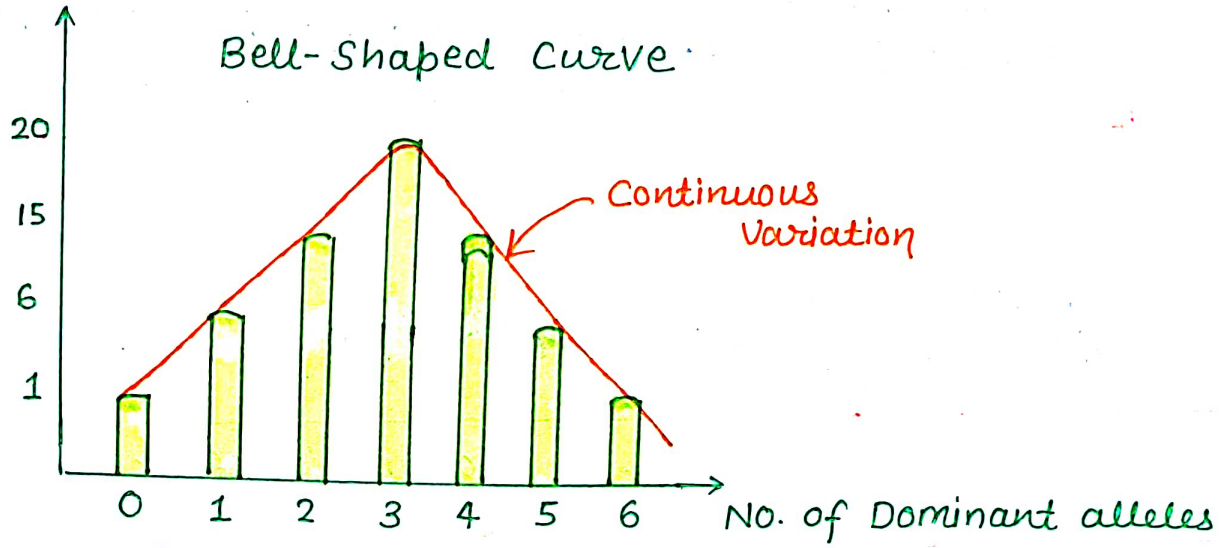
(3) Types of phenotype - $2n+1$
$2 \times 3 + 1 = 7$

(4) Types of Genotype : $3^n = 3^3 = 27$

(5) Zygotic Combination : $4^n = 4^3 = 64$

(6) % of parental phenotype - $\frac{2}{64} \times 100 = 3.125\ \%$

GRAPH :-



Q. A quantitative character is controlled by four polygene's. Find out probablity of parental plant in F_2- generation ?

Polygene's :- four

Zygotic Combination :- $4^n = 4^4 = 256$

parental plant = $\frac{2}{256}$

Q. In F_2 generation of A quantitative character 17 phenotypic Categories are obtained. This character is Controlled by how many polygene's ?

Types of phenotype :- $2n+1$

$17 = 2n+1$

$17 - 1 = 2n$

$16 = 2n$

$n = 8$

Some Formulae :-

$$\text{Contribution of each dominant allele} = \frac{\text{Max. expression} - \text{Min. expression}}{\text{Total no. of dominant alleles}}$$

$$\text{Phenotype of given genotype} = \text{Min. expression} + \left(\text{Contribution of each dominant allele} \times \text{no. of dominant allele}\right)$$

Q. A plant is homozygous for A and B alleles have 200 cm height while the minimum height of plant is 120 cm. Find out :-

(1) Contribution of each dominant allele

(2) Height of Aabb genotypic plant.

AABB (max) = 200 cm

aabb (min) = 120 cm

$$\text{Contribution :-} \frac{200 - 120}{4} = \frac{80}{4} = 20$$

$$\text{Height of Aabb :-} 120 + (20 \times 1)$$
$$= 120 + 20$$
$$= 140$$

Q. A plant with genotype TtRrGg produce fruit of weight 300 gm while the minimum weight of fruit is 210 gm. find out :-

(1) Contribution of each dominant allele

(2) Max. weight of fruit

(3) weight of fruit of TTRrGg genotypic plant.

(max) TtRrGg :- 300 gm

(min.) ttrrgg :- 210 gm

Contribution :- $\frac{300-210}{3} = \frac{90}{3} = 30$

Max. weight (TTRRGG) :- $210 + (30 \times 6)$

$= 210 + 180$

$= 390$

weight of TTRrGg :- $210 + (30 \times 4)$

$= 210 + 120$

$= 330$

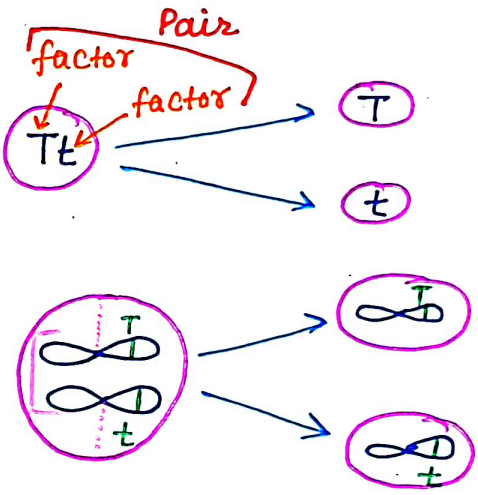
CHROSOMAL THEORY OF INHERITANCE

- Proposed by Sutton and Boveri in 1902.
- Sutton united the knowledge of Mendel's principle (factor) with chromosomal behavior during the meiosis and gave Chromosomal theory of inheritance.
- A/c to this theory the behavior of gene (factor) is similar (parallel) to behavior of chromosomes.

NCERT, TABLE 5.3

A	B
Occur in pairs	Occur in pairs
Segregate at the time of gamete formation such that only one of each pair is transmitted to a gamete.	Segregate at gamete formation and only one of each pair is transmitted to a gamete.
Independent (A & D) pairs segregate independently of each other.	one pair segregates independently of another pair.

A & D ✓
A & B ✗



For gene → true

For Chromosome :- true

For gene → may be true or false.

A & B

A & D

For Chromosome :- true

A and B → Indepedent pa

A and D → ~~Independent pa~~

Chromosomal theory of inheritance —

- This theory experimently proofed by T. H. Morgan.
- He performed experiments on Drosophila melanogaster (fruit fly)

Q. Why did Morgan select drosophila for experiment ?

1) They could be grown on simple synthetic medium (ripe banana) in the laboratory.

2) They complete their life cycle in about two weeks

3) A single mating could produce a large number of progeny flies.

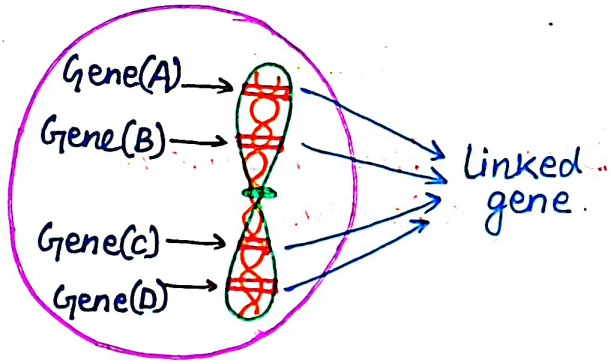
4) There is a clear differentiation of the sexes- male (small) and female (large).

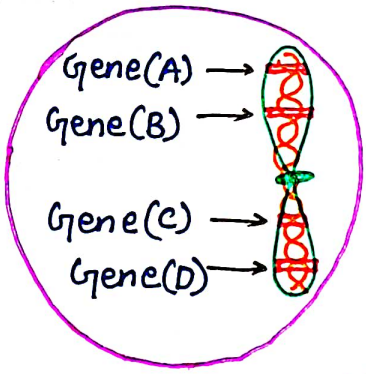
5) It has many types of hereditary variations that can be seen with low power microscopes.

6) It has less number of chromosomes (2n = 8).

LINKAGE

- Exception of Mendel's law of independent assortment.
- Physical association of genes pr. on same chromosome and inheritate as a group is called Linkage.





Next generation-

Linkage first time observed by Bateson and Punnett

Linkage term and detail study by T. H. Morgan.

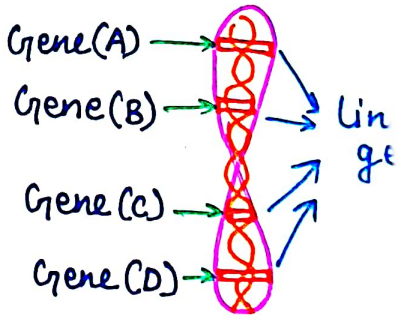
He performed experiment on Drosophila melanogaste (fruit fly) and gave linkage theory.

A/c to linkage theory :-

(a) Genes show linkage called linked genes.

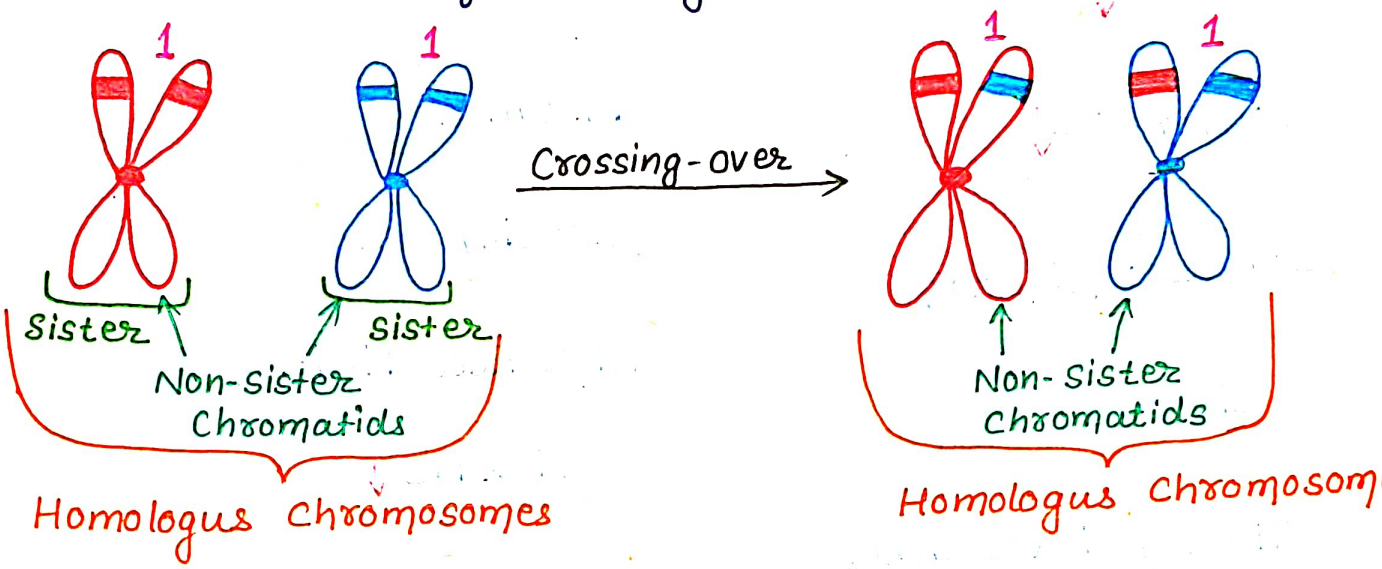
(b) Linked genes are non-allelic

(c) Linked genes are pr. on same chromosome.

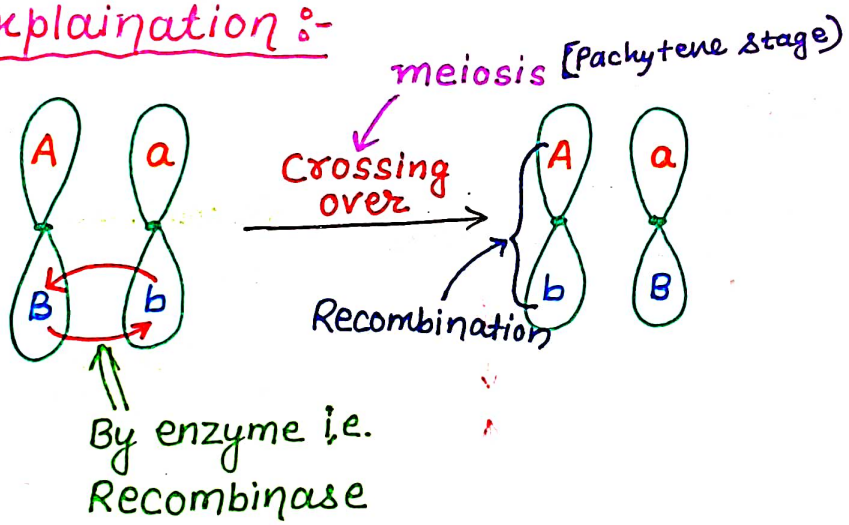


(d) Linked genes can be separated by Crossing over.

Crossing over → exchange of genes b/w non-sister chromatids of homologus chromosomes.



Explaination :-

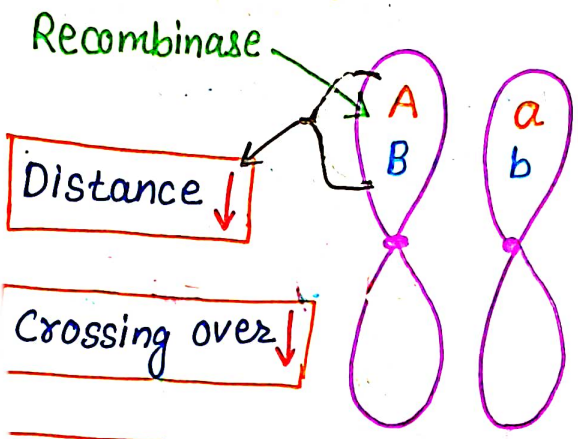


$$\text{Strength of linkage} \propto \frac{1}{\text{Crossing over (Recombination}} \propto \frac{1}{\text{distance b/w linked genes}}$$

$$d \propto C.O \propto \frac{1}{\text{linkage}}$$

$$d \uparrow = C.O. \uparrow$$

$$d \downarrow = C.O \downarrow$$



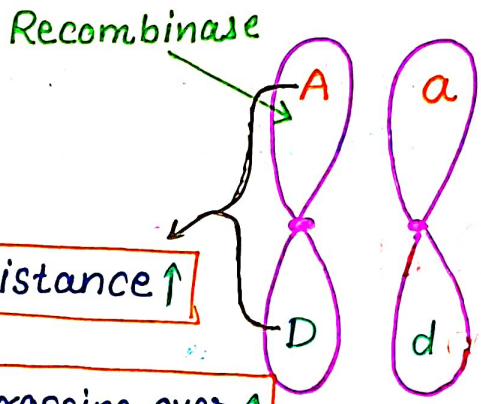
Distance ↓

Crossing over ↓

Low Recombination

Linkage ↑

Tightly linked genes



Distance ↑

Crossing over ↑

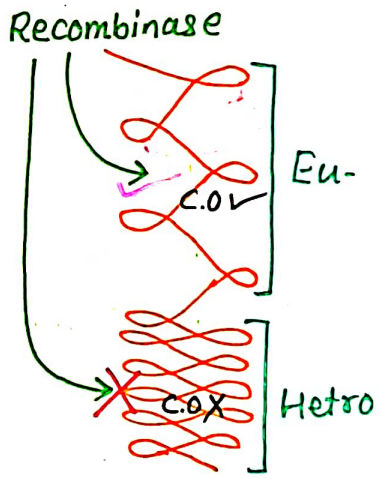
High Recombination

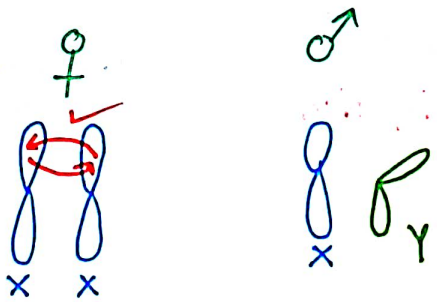
Linkage ↓

Loosely linked gene

Point to Remember :-

Factor's	Crossing over	Linkage
Distance ↑	↑	↓
Euchromatin	↑	↓
Heterochromatin	↓	↑
Age ↑	↓	↑
Sex → Female	↑	↓
Sex → Male	↓	↑

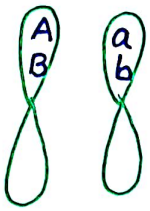




Arrangement of linked genes

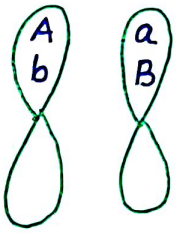
Cis/Coupling

(A) (B)
+ +
a b



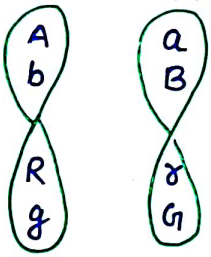
Trans/Repulsion

(A)
+ b
a + (B)



another eg:-

A R
+ b + g
a + γ +
(B) (G)



Types of Linkage :-

- Complete Linkage
  Crossin over ✗
  Vary rare
- Incomplete linkage
  Crossing over ✓

1. Complete Linkage :-

- Very rare
- In this linkage crossing over does not occur b/w the genes.

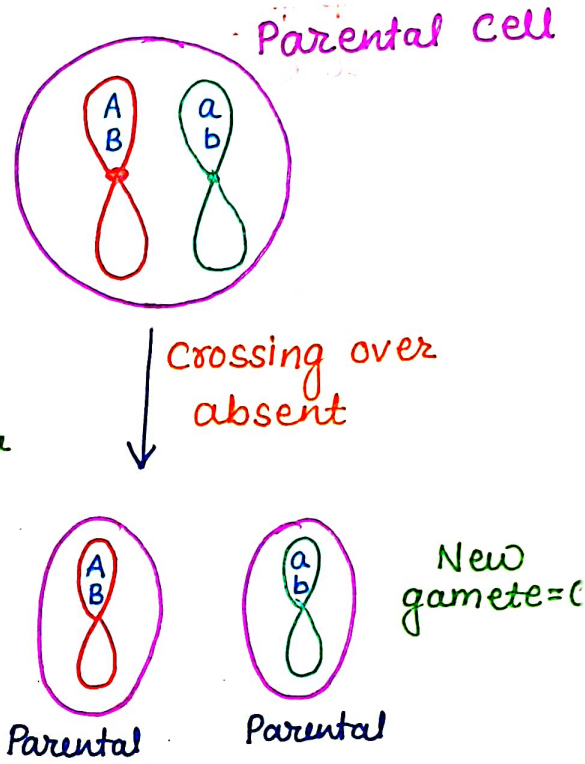
Linkage → 100 %

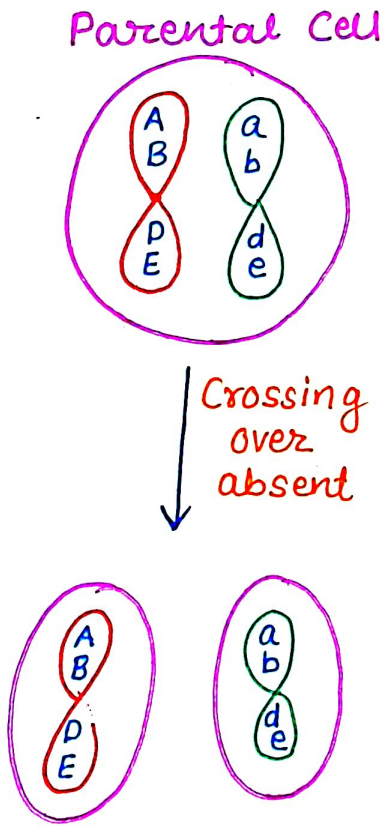
Crossing over → 0 %

New combination → 0 %

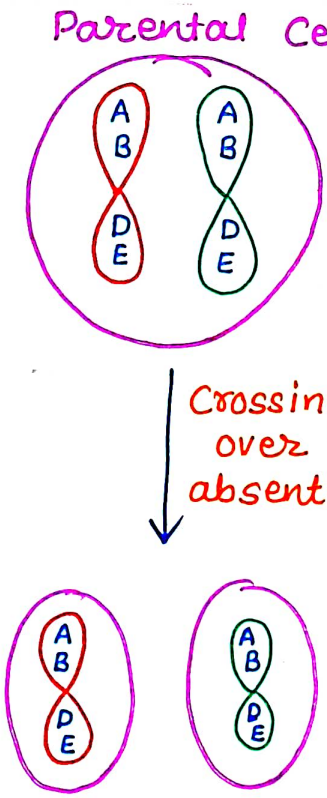
Parental combination → 100 %

Eg:- few genes of male Drosophila and female silkworm.

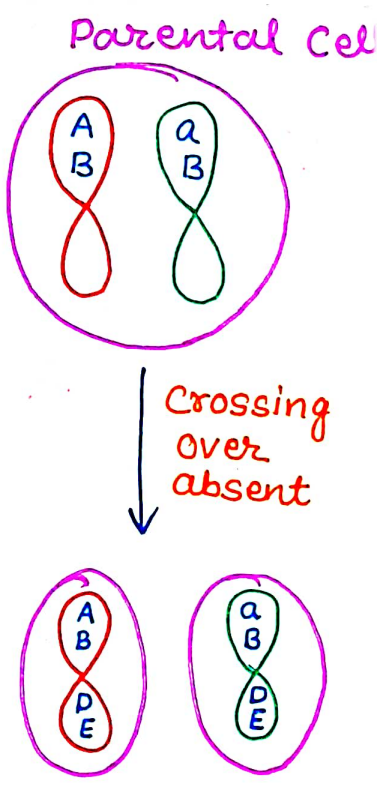




Gametes:- 2 types



Gametes :- 1 types



Gametes :- 2 types

NOTE:-

Complete linkage behaves just like monohybrid cross.

(Test cross)

$\frac{ABD}{abd} \times \frac{abd}{abd}$

	abd
ABD	$\frac{ABD}{abd}$
abd	$\frac{a\ bd}{a\ bd}$

PR ⇒ 1:1

(selfing)

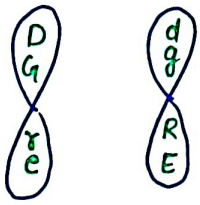
$\frac{ABD}{abd} \times \frac{ABD}{abd}$

	ABD	abd
ABD		
abd		

PR ⇒ 3:1

Q. Genotype of plant is $\frac{++re}{dg++}$ in which all 4 genes show Complete linkage.
Write down genotype of gametes produce by this plant?

$\frac{++re}{dg++}$

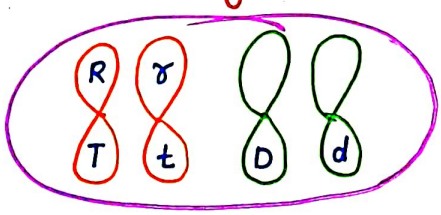


gametes:-
1. DGre
2. dgRE

Q. Genotype of plant is RrTtDd in which all R and T genes show complete linkage with cis arrangement and D genes pr. on non-homologus chromosomes. write down genotype of gametes produce by this plant?

RT → D = RTD
RT → d = RTd

rt → D = rtD
rt → d = rtd



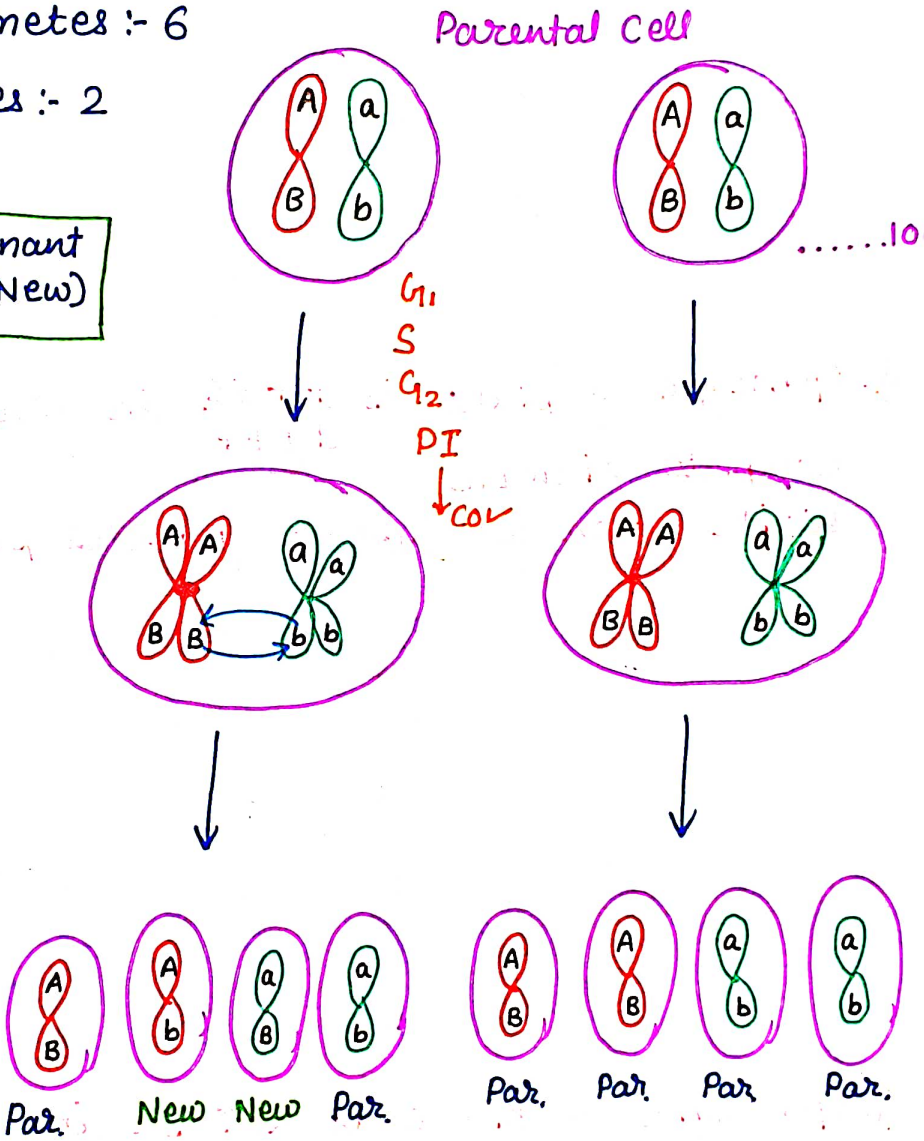
2. Incomple Linkage :-

- Most common type of linkage
- In this linkage crossing over occur b/w the genes.
- So new combinations are formed but parental combinations are greater than new combinations.

Parental type gametes :- 6

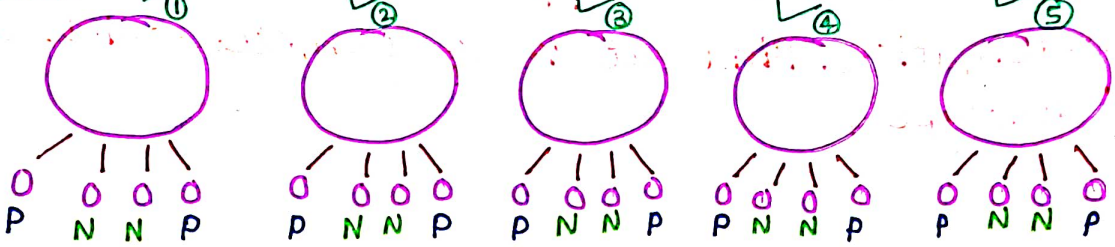
New type gametes :- 2

Parental type > Recombinant type (New)



Crossing over:- X X X X X

Crossing over:- ① ② ③ ④ ⑤



5 cell

Complete linkage ↑ Incomplete linkage

Gamete	C.O. ab. in all cells	C.O. occur in				
		1 cell	2 cells	3 cells	4 cells	(All cells) 5 cells.
Parental	20	18	16	14	12	10
Recombinant	0	2	4	6	8	10

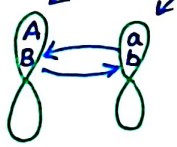
$$\% \text{ of recombination} = \frac{10}{20} \times 100 = 50\%$$

Conclusion :-

- Maximum frequency of recombination is 50%.
- It happen when crossing-over in all cells with respect to desired genes.

Q. genotype of plant is $\frac{++}{ab}$ in which genes show 20% recombination. Find out % of gametes which contains +b genotype ?

$\frac{++}{ab}$

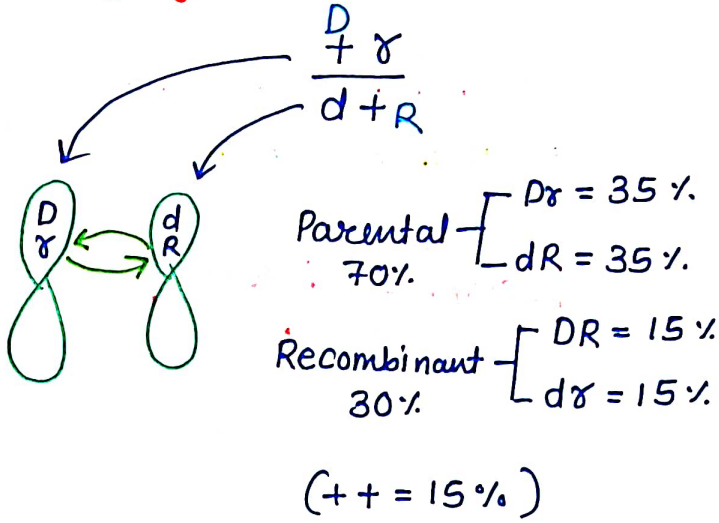


Parental (80%) — AB = 40%, ab = 40%

Recombination — AB = 10%, aB = 10%

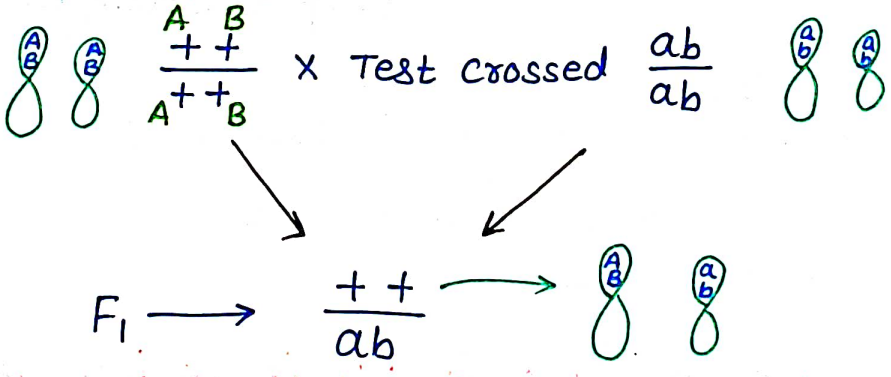
(+b = 10%) Ans

Q. Genotype of plant is $\frac{+\ r}{d\ +}$ in which genes show 30% recombination. Find out % of gametes which contains '++' genotype ?



(++ = 15 %)

Q. Genotype of plant is $\frac{++}{++}$. This plant is test crossed (ab/ab) and produce F_1 generation. Now F_1 produce gametes. Find out % gametes which contains '+b' genotype ? (If gene show 26 % recombination.)



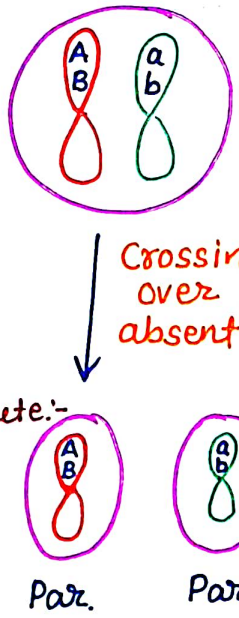
Parental 74 %
- AB / ++ = 37 %
- ab = 37 %

Recombinant 26 %
- Ab / + = 13 %
- aB / + = 13 %

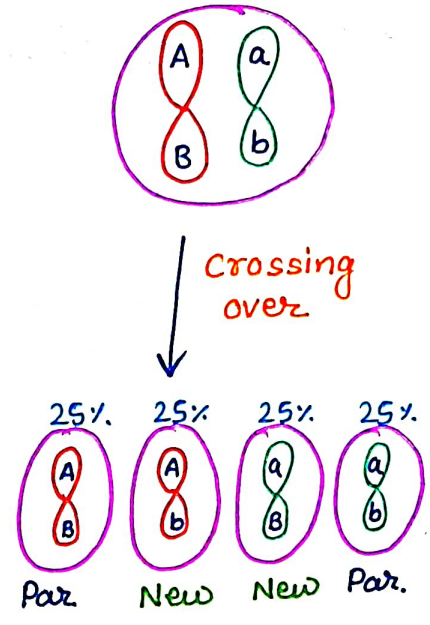
(+b = 13 %) Ans

OVERVIEW

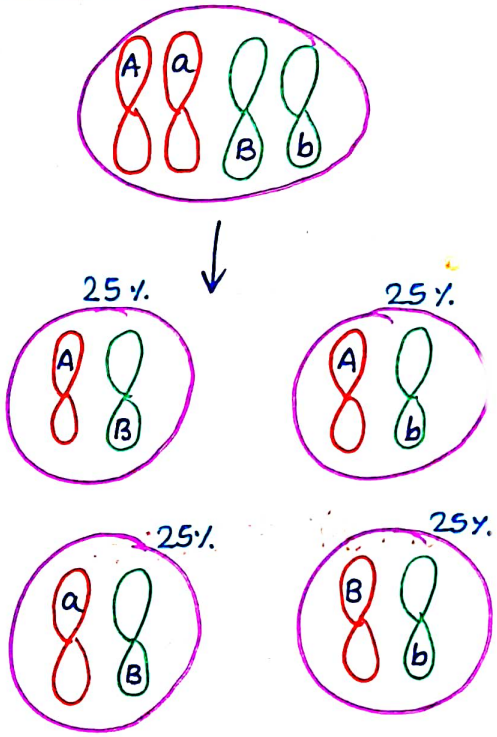
Complete linkage



Incomplete linkage



Independent Assortment



Conclusion :-

Indepedent Assortment occur in two cases —

1. gene pr. on non-homologous chromosomes.
2. genes pr. on same chromosomes but they show 50% recombination.

CHROMOSOMAL MAP/ GENETIC MAP/ LINKAGE MAP

- First prepared by Alfred Sturtevant
- It is diagrammatic presentation of linked genes pr. on same chromosomes.
- It is based on result of test cross.
- It gives two information.
  - i) Sequence of linked genes on chromosomes.
  - ii) Distance b/w linked genes.

$$\text{Recombination frequency} = \frac{\text{No. of recombinant offspring's}}{\text{Total no. of offspring's}} \times 100$$

% of Recombination (C.O) $\propto$ Distance

- 1% recombination = 1 map unit distance (1mu)

  or,

  1 Centi Morgan (1cM)

समझने के लिए :-

AB X Test Cross ↓

AB/ab = 35]
ab/ab = 35] Pare..

Ab/ab = 15]
aB/ab = 15] Recomb^n

Reco % = $\frac{30}{100} \times 100$ ← total.

Distance AB = 30cM

CB X Test Cross ↓

CB/cb = 40]
cb/cb = 40] Pare..

Cb/cb = 10]
cB/cb = 10] Recomb^n

Reco % = $\frac{20}{100} \times 100$

Distance CB = 20cM

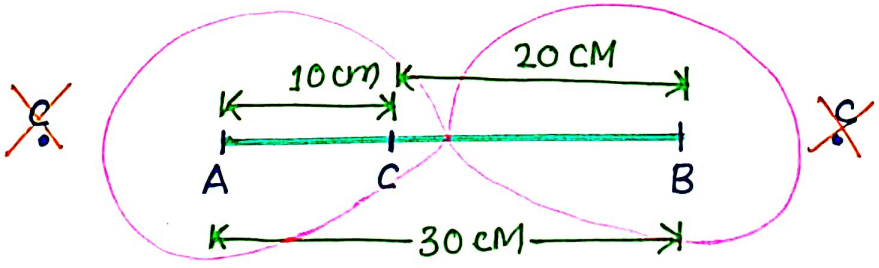
AC X Test Cross ↓

AC/ac = 45]
ac/ac = 45] P..

Ac/ac = 5]
aC/ac = 5] R....

Reco % = $\frac{10}{100} \times 100$

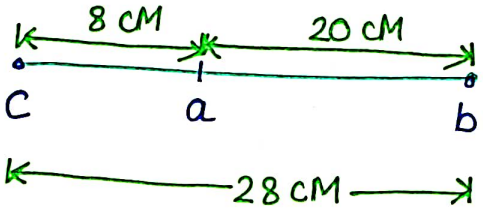
Distance AC = 10c



Q. There are three genes a, b, C. percentage of C.O. b/w a and b is 20%, b and c is 28% and a and c is 8%. what is the sequence of genes on chromosome?

1) b, a, c
2) a, b, c
3) a, c, b
4) c, b, a

ab = 20 cm
cb = 28 cm
ac = 8 cm

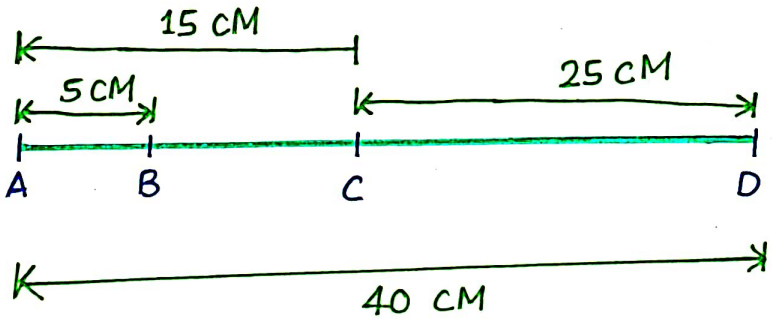


Ans:- Cab or bac

Q. The recombination frequency b/w linked gene are-

DC = 25%.
DB = 35%.
DA = 40%.
CB = 10%.
CA = 15%.
AB = 5%.

what is the sequence of genes on chromosome?



Ans. ABCD or DCBA

Q. Result of test cross in Drosophila is —

++/ab = 41
ab/ab = 41
} Parental

+b/ab = 9
a+/ab = 9
} Neo (Recomb")

Reco. progeny = 18

Total progeny = 100

↳ Reco. % = $\frac{18}{100} \times 100 = 18\%$

↳ Distance = 18 cM (Cis/Coupling)

Find out :-

1) % of recombination
2) Distance b/w linked genes
3) Cis/trans
4) Coupling / Repulsion

Q. Result of test cross in a plant is :-

++/ab = 202
ab/ab = 198
} Recombinant

+b/ab = 798
a+/ab = 802
} Parental

Recombinant progeny = 400

Total progeny = 2000

Reco. % = $\frac{400}{2000} \times 100 = 20\%$

Distance = 20 cM (Trans/ Repulsion)

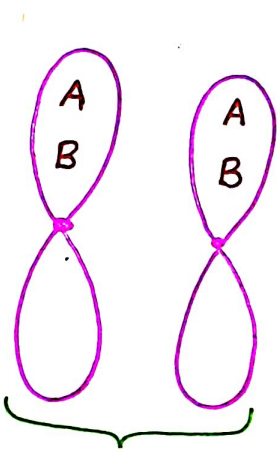
Find out :-

(1) % of recombination
(2) Distance b/w linked genes
(3) Cis/Trans
(4) Coupling / Repulsion

LINKAGE GROUP

Linkage Group :- Genes pr. on a chromosome or pair of homologus chromosomes from one linkage group.

No. of Linkage Group = No. of pairs of homologus chromosomes or, No. of Chromosome pr. in a haploid cell.



Homologus Chromosomes = 1st linkage group

Homologus Chromosome = 2nd linkage group.

In human = 2n = 46

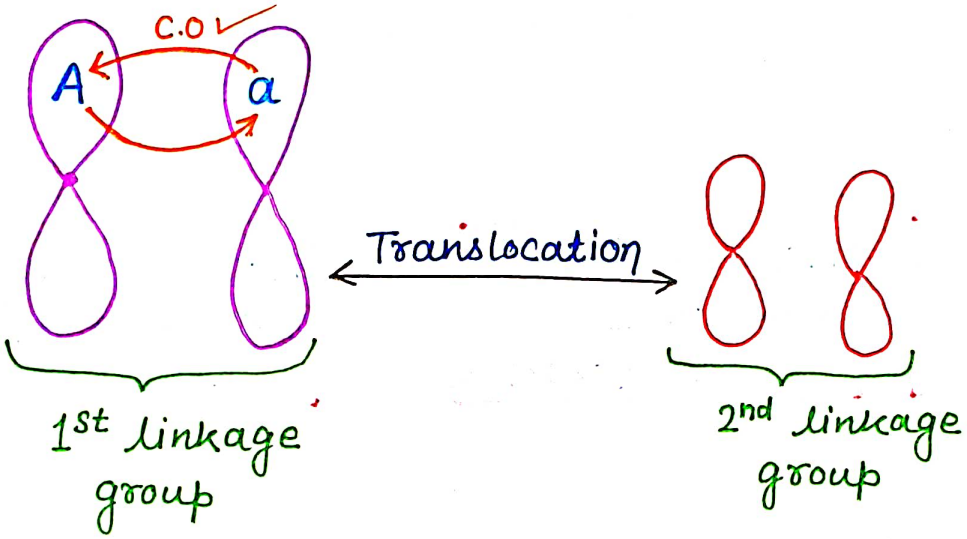
Pairs = 23

Haploid cell n = 23

linkage Group = 23

Organism	2n	n	Linkage group
Pea	14	7	7
Drosophila	8	4	4
Onion	16	8	8
Human → Female	46	23	23
Human → Male	46	23	24
Bacteria			1

- Transfer of genes from one linkage group to another linkage group is called translocation.



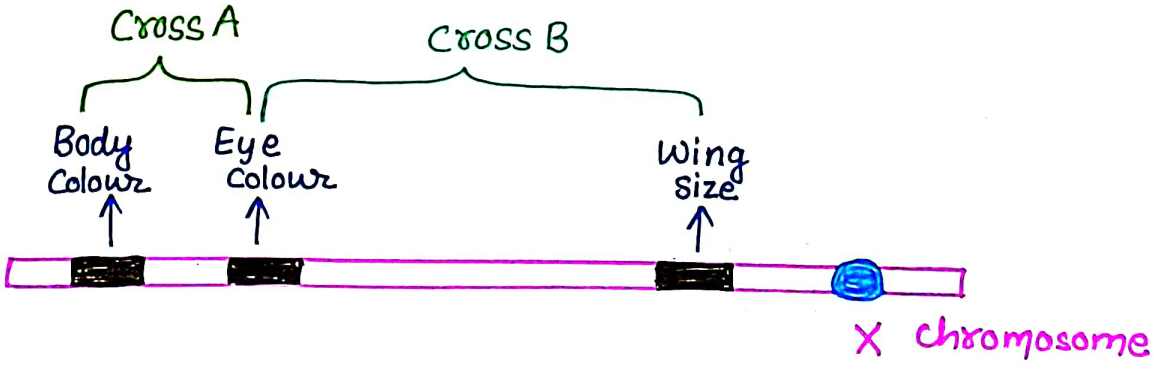
MORGAN'S EXPERIMENT

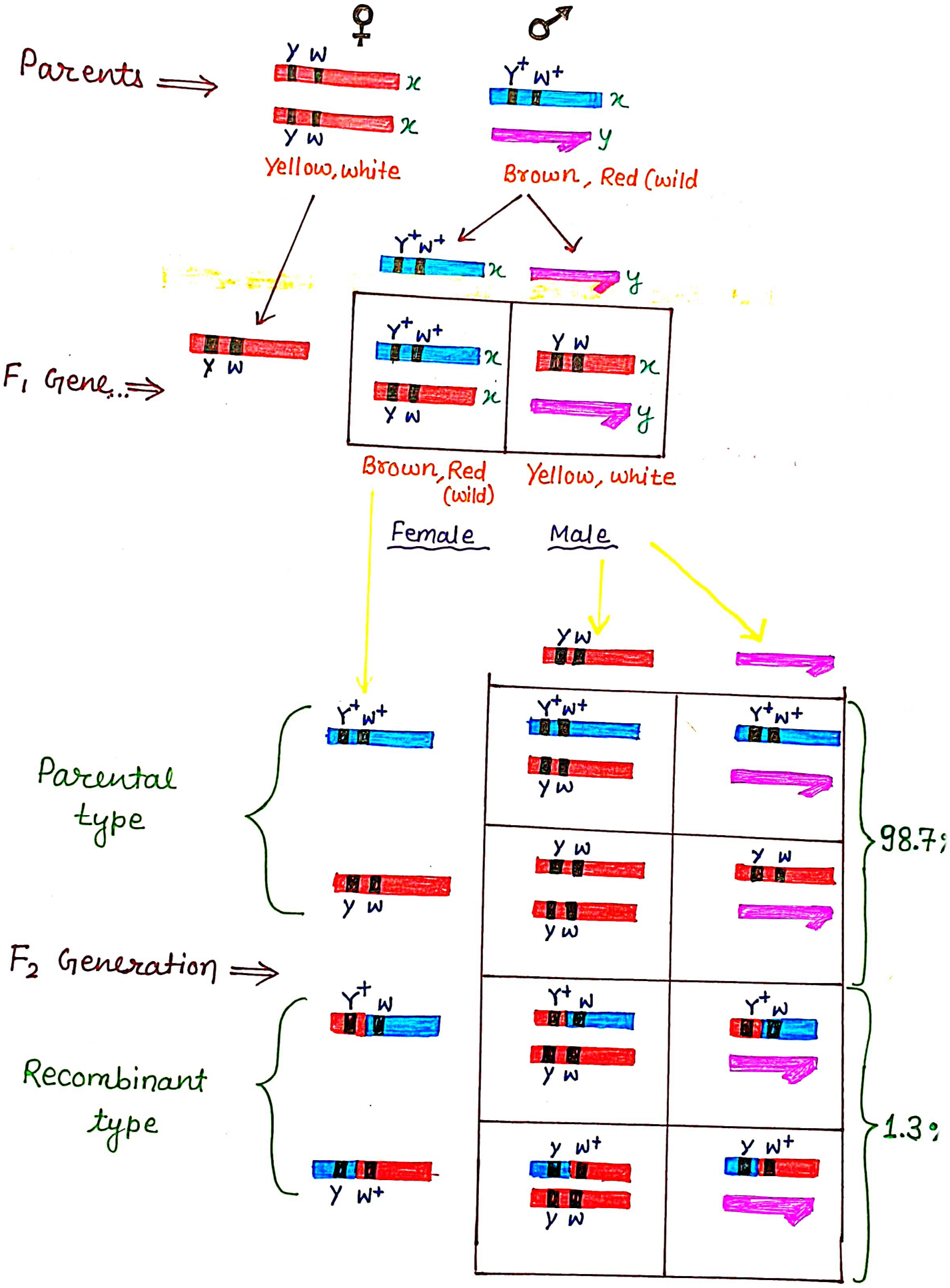
1st Character :- Body Colour
- Brown → y^+ (wild)
- Yellow → y (mutant)

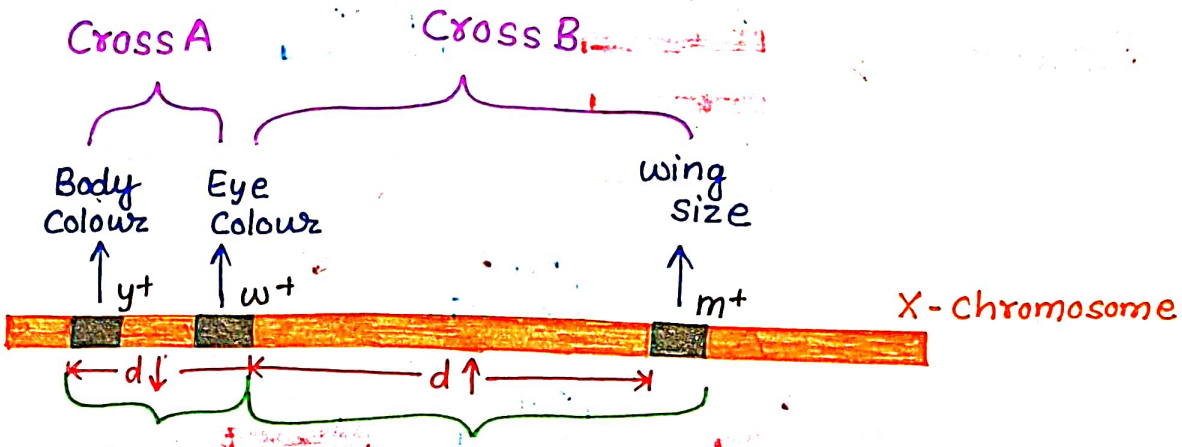
2nd Character :- Eye Colour
- Red → w^+ (wild)
- White → w (mutant)

3rd Character :- Wing size
- Normal → m^+ (wild)
- Miniature → m (mutant)

Dominant allele.




Parents ⟹
♀
♂
y w
x
y w
x
Yellow, white
Y+ w+
x
y
Brown, Red (wild
F1 Gene... ⟹
Y+ w+
x
y
Y+ w+
x
y w
x
y w
x
y
Brown, Red (wild)
Yellow, white
Female
Male
y w
Parental type
Y+ w+
y w
Y+ w+
y w
y w
y w
98.7%
F2 Generation ⟹
Recombinant type
Y+ w
y w+
Y+ w
y w
y w+
y w
1.3%

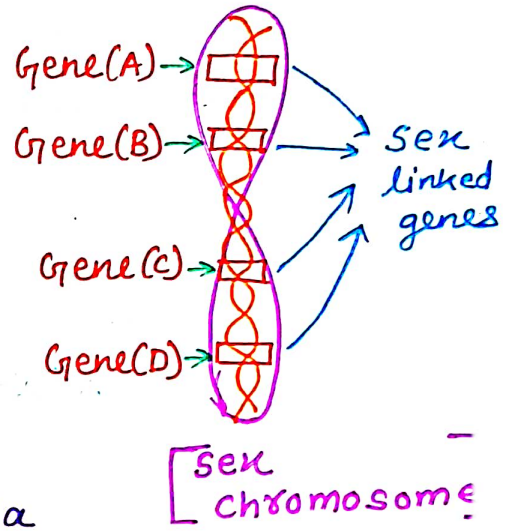


Parental :- 98.7% 62.8%

Recombinant :- 1.3% 37.2 %

SEX LINKAGE

- Genes that are located on sex Chromosome are called sex linked genes and their inheritance is called sex linked inheritance.



- Sex linkage was discovered by Morgan.

- He studied eye colour of drosophila and performed reciprocal and test cross and found that gene of eye colour is located on X-chromosome.

Eye Colour of drosophila

Red	White
X^{W+}/X^{+}	X^{W}

Genotype :- X^{+}, X^{W}

♀

$X^{+}X^{+}$ ⇒ Homozygous red eyed

$X^{+}X^{W}$ ⇒ Heterozygous red eyed

$X^{W}X^{W}$ ⇒ Homozygous red eyed

♂

$X^{+}Y$ ⇒ Hemizygous red eyed

$X^{W}Y$ ⇒ Hemizygous white eyed.

Q. A heterozygous red eyed female Drosophila, is Crossed with hemizygous red eyed male Drosophila. Find out percentage of red eyed female offspring's ?

♀
Heterozygous red eyed
X^+X^w

♂
Hemizygous red eyed
X^+Y

	X^+	Y
X^+	X^+X^+ Red eyed ♀	X^+Y Red eyed ♂
X^w	X^+X^w Red eyed ♀	X^wY White eyed ♂

% of Red eyed female = $\frac{2}{2} \times 100 = 100\ \%$

% of Red eyed male = $\frac{1}{2} \times 100 = 50\ \%$

% of Red eyed offspring's = $\frac{3}{4} \times 100 = 75\ \%$

SEX LINKAGE IN HUMAN

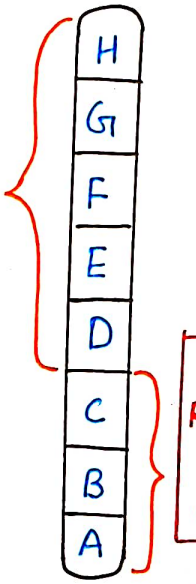
Non-Homologus region of X-Chromosome

↓

X-linked genes

↓

Biparental



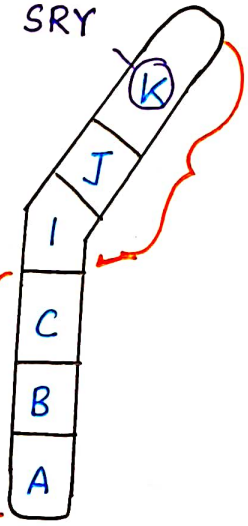
Homologus Region of XY Chromosome

↓

XY-linked gene

↓

Biparental



Non-Homologus region of Y Chromosome

↓

Y-linked genes

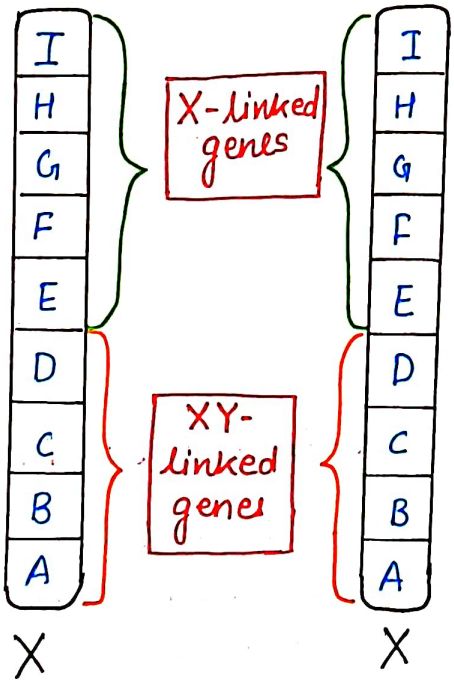
↓

uniparental

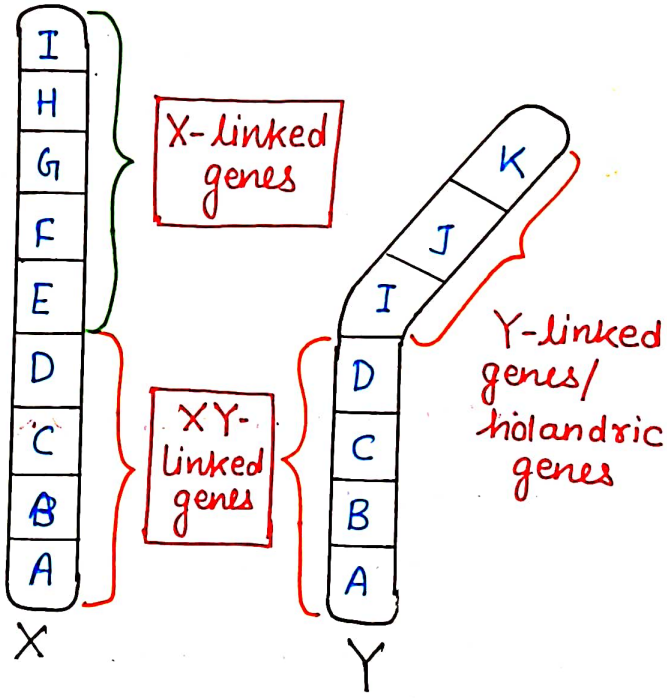
↓

Present only in male
Holandric gene

Female



Male



XY-linked genes :-

- Genes pr. on homologus region of X and Y chromosomes.
- Biparental

Y-linked genes :-

- Genes pr. on non-homologus region of chromosomes.
- uniparental
- Pr. only in male. (Holandric gene)

Example :-

1. SRY (sex determining region on Y-chr.) gene/ TDF (Testis determining factor) gene :-
   - Synthesises a protein - TDF
2. Hypertrichosis - Excessive hairs on ear pinna.

3. Porcupine skin - Rough skin.

X-linked genes :-

- Genes pr. on non-homologus region of X-chromosomes
- Biparental.

2 type

X-linked Recessive (XR)

1. Haemophilia
2. Colourblindness
3. Glucose-6-phosphate dehydrogenase deficiency (G6PD)

X-linked Dominant (XD)

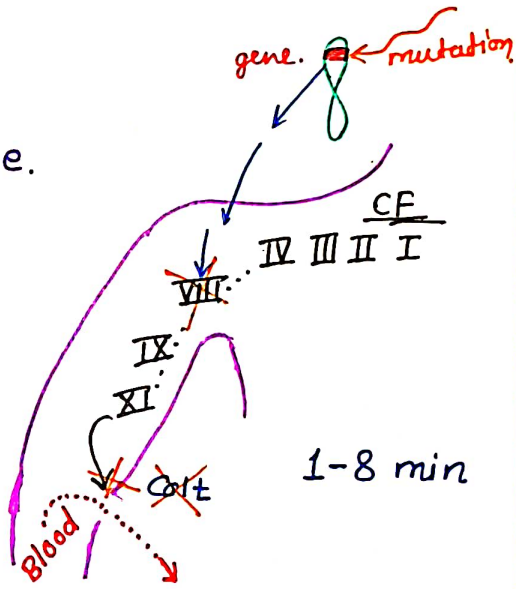
1. Pseudorickets (vitamin D resistance rickets)
2. Defective enamels of teeth.

4. DMD (Duchenne muscular dystrophy).
   → Due to non-synthesis of dystrophin protein.
   → Gene for dystrophin synthesis is Largest gene of human (2.4 million bps)

5. Diabetes insipidus.

HAEMOPHILIA

- X-linked (sex-linked) recessive disease.
- Also called "bleeder's disease"
- First discovered by John Otto.
- Blood clotting time is delayed due to the absence of some blood clotting factor and person die due to excessive bleeding.
- Deficiency of clotting factors is because of mutation in some genes of X-Chromosome.



- Blood clotting time
  - → Normal person :- 1-8 min
  - → Haemophilic person :- 30 min - 24 hr.

Three types of haemophilia-

(1) Haemophilia-A :-

→ Most common types of haemophilia.

→ Royal disease.

- First seen in royal family of england/queen victoria family.
- She was carrier of this disease.

→ Due to absence of blood clotting factor - VIII

- This factor is also called Antihaemophilic Globulin (AHG).

(2) Haemophilia-B/ Christmas disease :-

→ Rare

→ Due to absence of clotting factor - IX.

- This factor also called - Christmas factor/ Plasma Thromboplastin Component (PTC.)

(3) Haemophilia-C :-

→ Very rare.

→ Autosomal disease.

→ Due to absence of blood clotting factor - XI

- This factor also called - Plasma Thromboplastin Antecedent (PTA)

Genotype :-

Haemophilia

- X^+ — Normal
- X^h — Haemophilia

♀

X^+X^+ = Normal

X^+X^h = Normal but carrier

X^hX^h = Haemophilia.

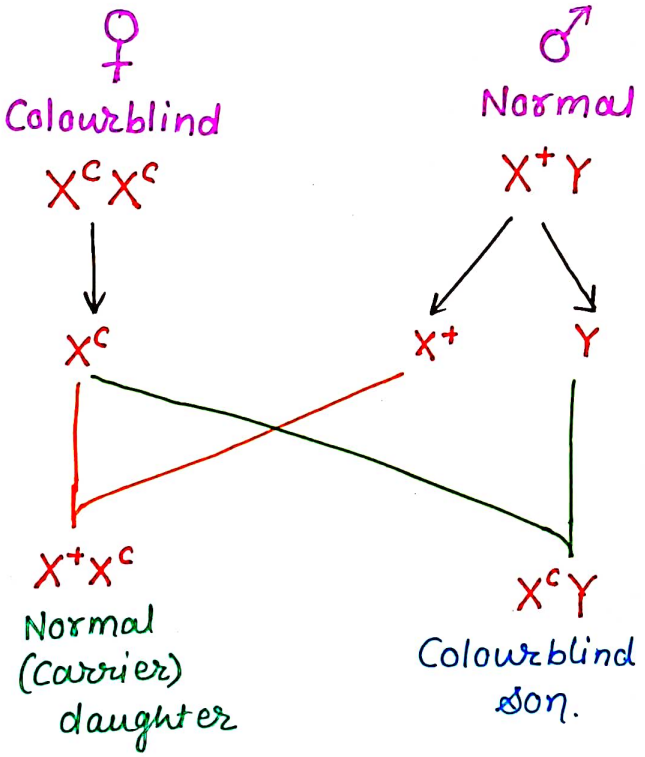
Die during embryonic stage

♂

X^+Y = Normal

X^hY = Haemophilic

COLOUR BLINDNESS



- If father is Normal than daughter should be normal.
- If mother is colour blind than son should be colour blind.

Father Normal → Daughter affacted ~~XR~~

Mother affected → son Normal ~~XR~~

Q. A haemophilic male marries with a normal female whose father is also haemophilic. Find out % of their son to be haemophilic?

Father Haemophilic
X^hY

♂ Haemophilic X^hY × ♀ Normal ~~X^+X^+~~ / X^+X^h

↳ Son haemophilic = $\frac{1}{2} \times 100$
= 50%

X^+X^h Normal ♀	X^hX^h Haemophilic ♀
X^+Y Normal ♂	X^hY Haemophilic ♂

Q A male has colourblind mother. This male marries with a normal female whose mother is also Colourblind. Find out % of their daughter to be Colourblind?

Mother Colourblind X^cX^c → ♂ X^cY × Mother Colourblind X^cX^c → ♀ ~~X^+X^+~~ / X^+X^c

↳ Daughter Colourblind :-
= $\frac{1}{2} \times 100$
= 50%

X^+X^+ Normal ♀	X^cX^c Colourblind ♀
X^+Y Normal ♂	X^cY Colourblind ♂

Q. A normal male has colourblind father. This male marries with a normal female whose father is also colourblind. Find out % of their daughter to be colourblind?

Father Colourblind X^cY ♂ X^+Y × Father Colourblind X^cY ♀ ~~X^+X^+~~ / X^+X^c

↳ Daughter Colourblind = 0%

	X^+	X^c
X^+	X^+X^+ Normal ♀	X^+X^c Normal ♀
Y	X^+Y Normal ♂	X^cY Colourblind ♂

Q. A colourblind male marries with a female whose father is colourblind but mother is homozygous normal. Find out percentage of their daughter to be carrier of colourblindness?

Father Colourblind X^cY ♂ × Mother normal (Homo-Zygous) X^+X^+ ♀ X^+X^c

↳ Daughter carries :-

$\frac{1}{2} \times 100 = 50\%$

	X^+	X^c
X^c	X^+X^c Normal Carrier ♀	X^cX^c Colourblind ♀
Y	X^+Y Normal ♂	X^cY Colourblind ♂

Q. A colourblind female is also a carrier of sickle cell anaemia. Find out % of his gametes contain defective alleles of both disease?

♀

Colourblind
X^cX^c

Carrier of Sickle cell Anaem
Hb^AHb^S

Gamete :- X^cHb^S

$\frac{1}{2} \times \frac{1}{2} = \frac{1}{4} \times 100 = 25\%$

TYPES OF INHERITANCE OF SEX LINKED CHARACTER ---

2 Types

Criss-Cross inheritance

Genes are transfered from parent to offspring through opposite sex.

→ Given by Morgan

2 types

Diandric

♀ Mother
↓
♂ Son
↓
♀ Grand daughter

Diagenic/ Diagynic

♂ Father
↓
♀ Daughter
↓
♂ Grand son

Non-Criss Cross inheritance

Genes are transferred from parents to offspring through same sex.

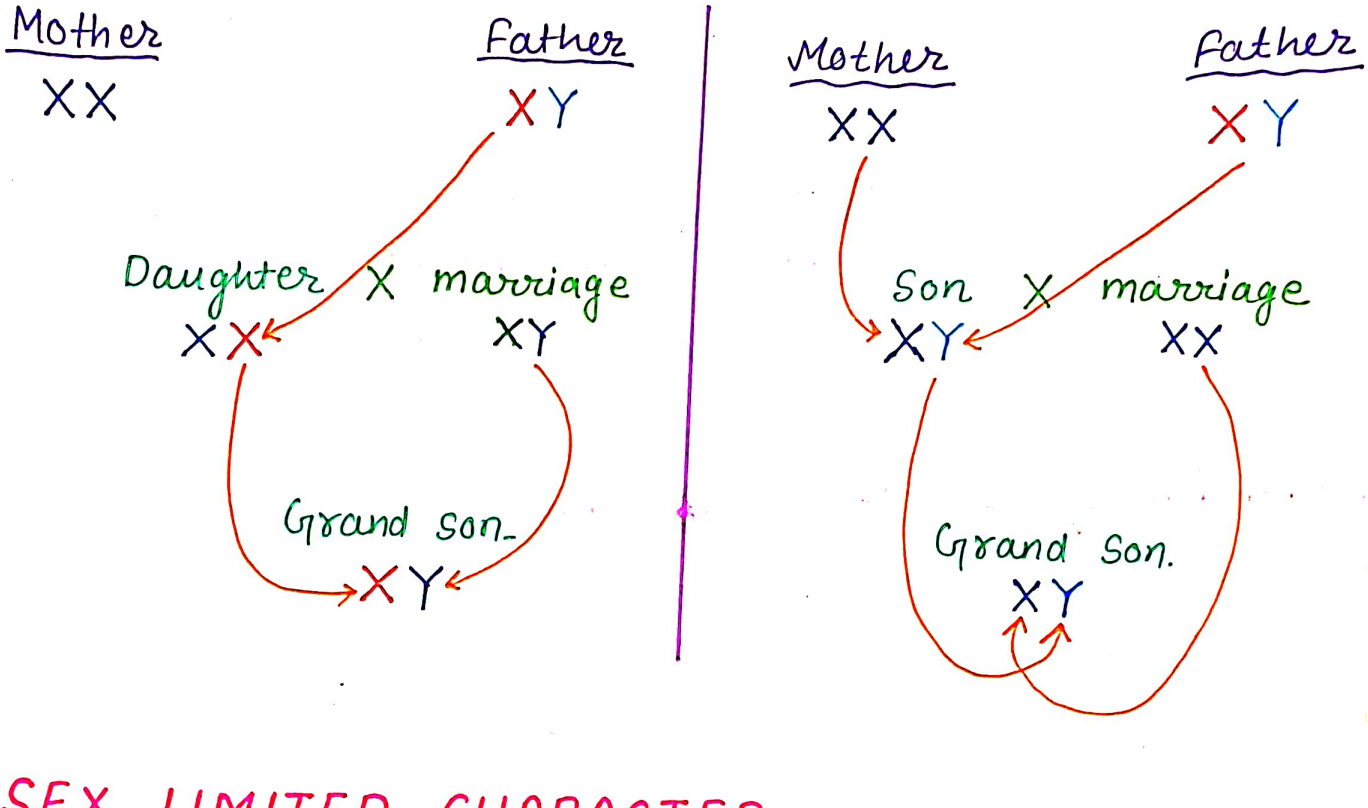
2 types

Holandric

♂ Father
↓
♂ Son
↓
♂ Grand Son

Hologenic/ Hologynic

♀ Mother
↓
♀ Daughter
↓
♀ Grand daughter



SEX LIMITED CHARACTER

- Genes are pr. on autosomes.
- Genes are pr. both male and female.
- Genes are expressed only in one of the sex, either male or female, under the influence of sex hormone.
- Examples :-
  Secondary sexual character in humans :-
  (a) Beard and moustache in male.
  (b) Mammary glands in female.

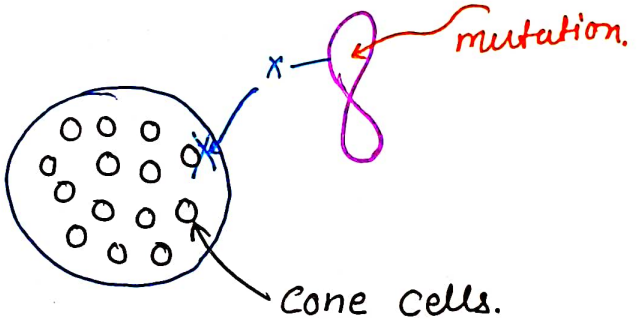
SEX INFLUENCED CHARACTER

- Genes are pr. on autosomes.
- Genes are pr. in both male and female.
- Genes are expressed in both the sex but more frequently in one of the sex, under the influence of sex hormone.
- Example :-
  Pattern baldness in human – more common in males.

Genotype	Male	Female
BB	Bald	Bald
Bb	Bald	Not Bald
bb	Not Bald	Not Bald

Remaining part of Colourblinds :-

- X-linked (sex-linked) recessive disease.
- Discovered by Horner.
- Colourblind person is unable to differentiate some basic colours like Red and green due to defect in cone cells



- This defect is due to certain genes pr. on the 'X' - chromosomes.
- Colour blindness is checked by :- Ishihara Chart.

☐ Types of Colour blindness :-

1> Protanopia – Red Colourblindness.

2> Deuteranopia - Green Colourblindness.

X^+ → mutation → X^c

Wild Allele → Mutant Allele

Normal vision → Colourblind vision

♀

X^+X^+ = Normal

X^+X^c = Normal but Carrier

X^cX^c = Colourblind

↳ Case of Colourblind :-

$= \frac{1}{3} \times 100 = 33.3\%$

♂

X^+Y = Normal

X^cY = Colourblind.

↳ Case of Colourblind :-

$= \frac{1}{2} \times 100 = 50\%$

Important Point :-

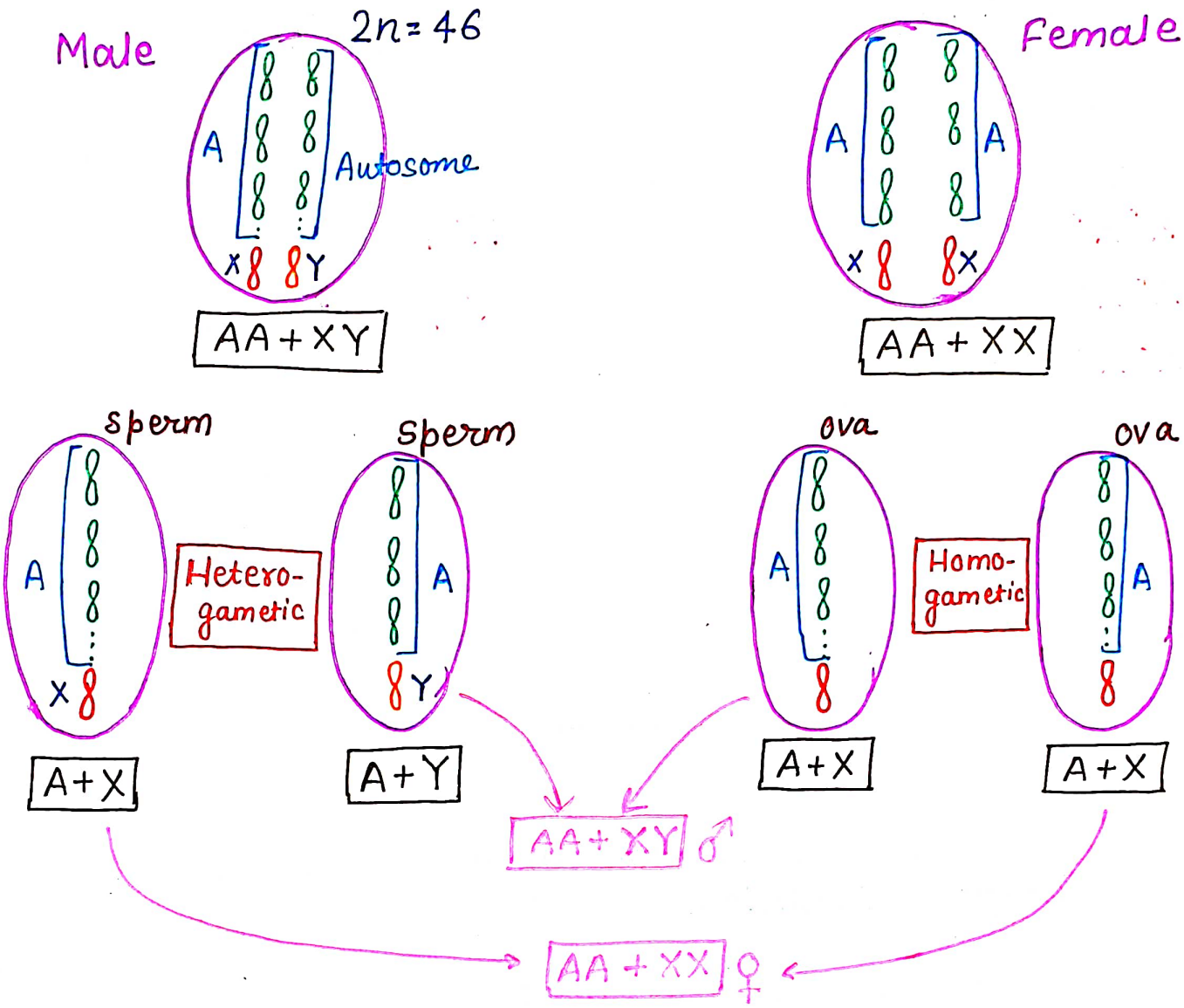
→ It is not a lethal disease, so found in both male and females.

→ This disease more common in males, due to hemizygous condition.

→ Occur in about 8% of males.

0.4% of females.

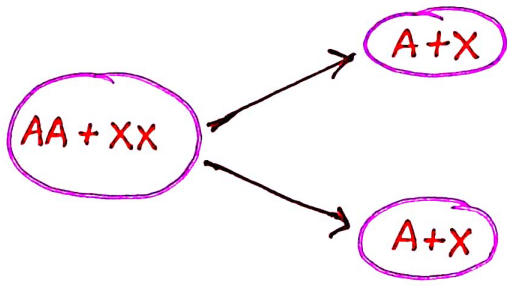
SEX DETERMINATION



Homogametic parent-

Both sex chromosomes are similar and produce one type of gamete.

eg: Human female.

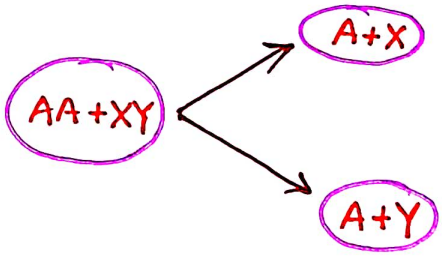


Heterogametic parent-

Both sex-chromosomes are dissimilar and produce 2 types of gametes.

→ Decide sex of offspring's.

eg: Human male.



SEX DETERMINATION

Establishment of sex of an organism at an early stage of life is called sex determination.

On the basis of fertilization, sex determination is of following types:

1) Progamic :- Sex determination before fertilization.
   eg: Male honey bee (Drone)

2) Syngamic :- Sex determination during fertilization.
   eg: Most of the plants and animalls.

3) Epigamic :- Sex determination after fertilization.
   eg: Crocodile, Turtle.
   (Environmental basis of sex determination)

$\frac{30^\circ C}{♀}$ $\frac{>30^\circ C}{♂}$

Mechanism of sex determination :-

1. Allosomic (sex chromosomes) method of sex determin...
2. Haploid - Diploid Mechanism of sex determination.
3. Genic balance theory.
4. Environment basis of Sex determination.

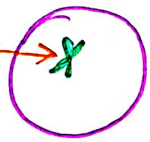
1. Allosomic method of sex determination -

- In this method sex of an offspring is determined by Sex Chromosome/ Heterosome/ Allosome.
- Chromosomal theory of sex determination was proposed by Wilson and Stevens.

Sex Chromosome

X-Chromosome

Discovered by Henking ☆☆ in insect and called it as X-body.

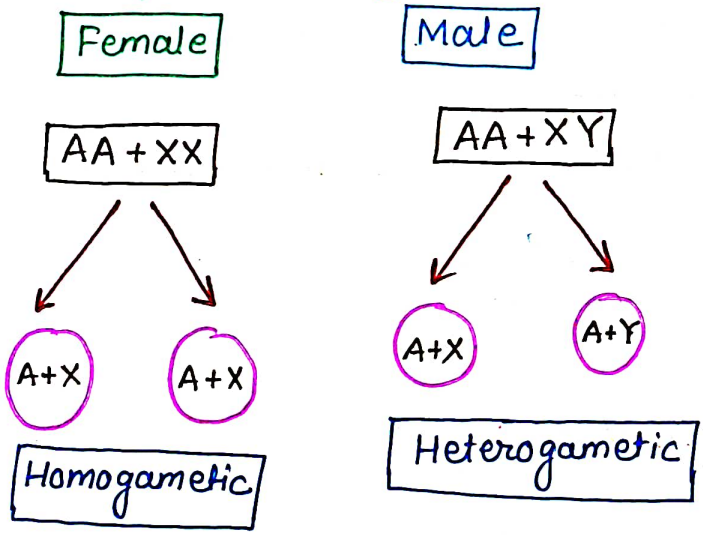


Y-chromosome

Discovered by Stevens and called it as Y-Body.

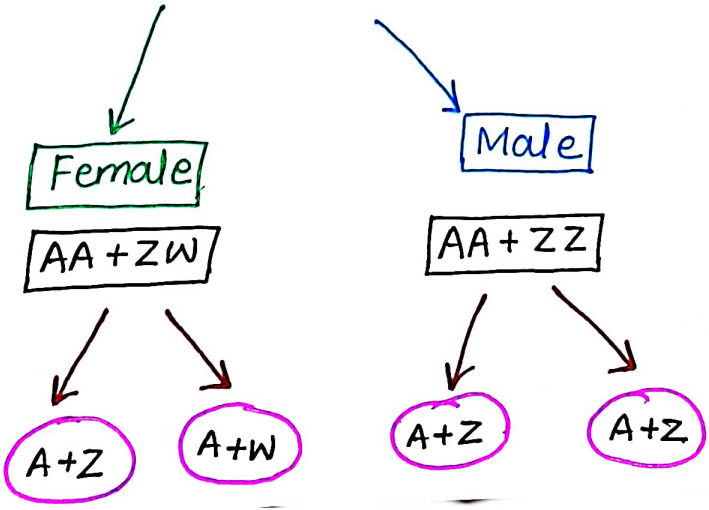
TYPES

(A.) XX-XY type / Lygaeus type



- 1st observed by Wilson and Stevens in Lygaeus insect.
  eg: Human, many mammals, Drosophila.

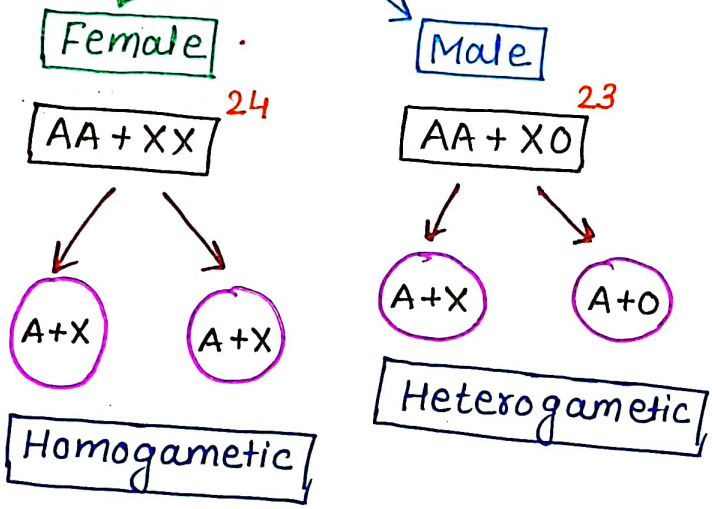
(B.) ZW - ZZ type / XY - XX type.



Heterogametic Homogametic

eg: Most of bird (Fowl)

(c) XX - XO type / Protenor type -



- Have odd no. of chromosome.
- Deficiency of one sex chromo...
- Found Monosomic condition.

eg: Most of the insects like grasshopper, cockroach.

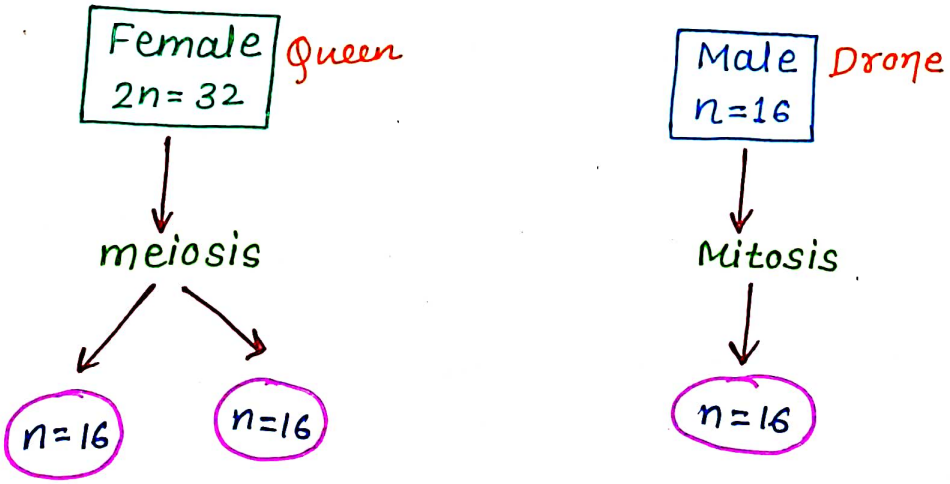
2. Haploid - Diploid Mechanism---

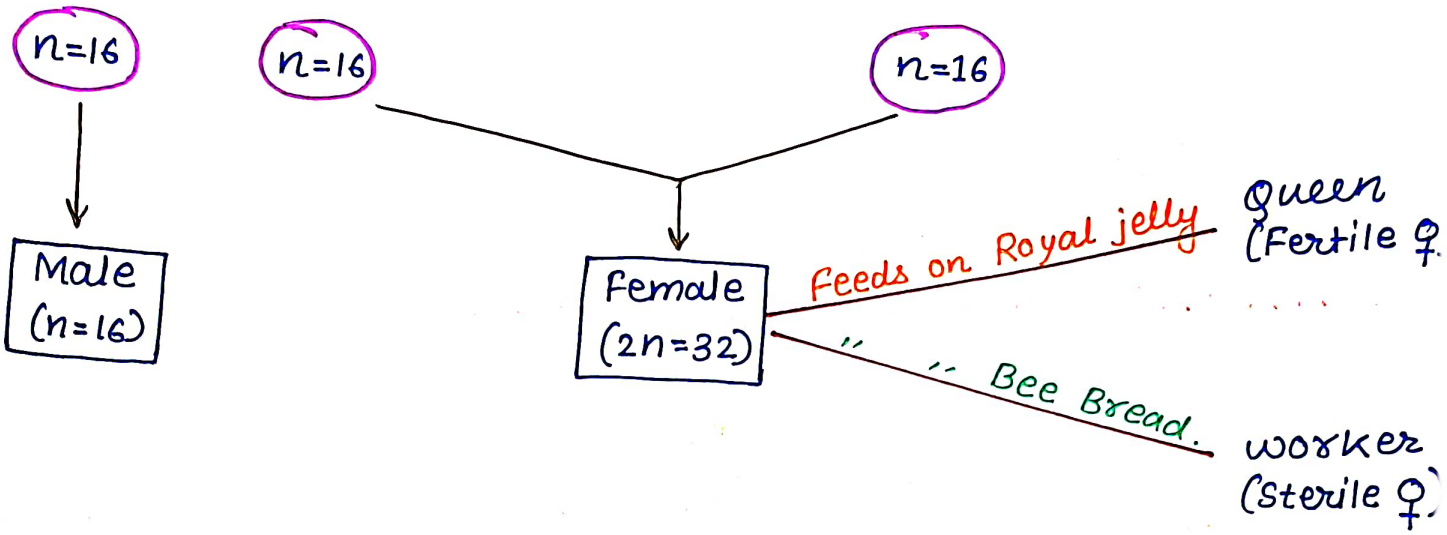
→ Seen in insect like honey bee.

→ Based on no. of sets of chromosome.

→ Haploid (one set) ⟹ Male (drone)

→ Diploid (2 sets) ⟹ Female — Queen (fertile)
                                — worker (Sterile)

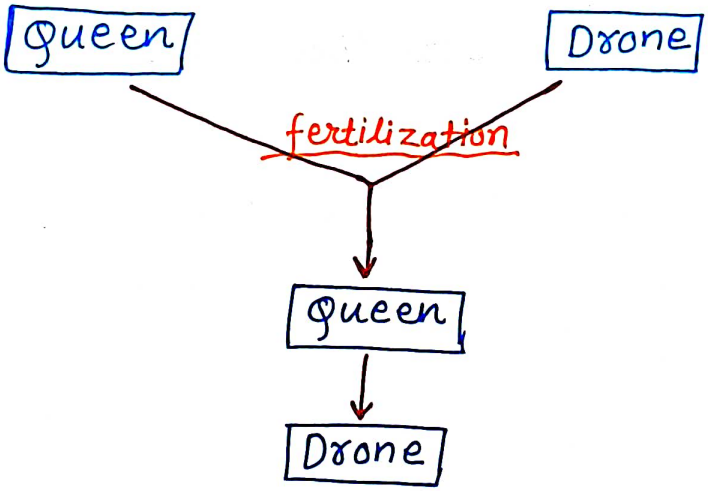




NOTE

Male honey bee (Drone) does not have father but have grandfather.

Male honey bee (Drone) does not have son but have grandson.



3. Genic Balance theory :-

- Proposed by C.B. Bridges for sex determination in Drosophila.
- A/C to Bridges, in Drosophila Y-chromosome does not play active role in sex determination.
- In Drosophila, Y-chrosome play role in spermato-genesis so Y-chrosome is essential for the production of fertile male.

In the absence of Y-chrosome, strile male develops.

> In Drosophila :-

- Gene for femaleness → on X-chrosome
- Gene for maleness → on autosome
- Gene for fertility [male] → on Y-chromosome

> In Drosophila, sex is determined by Sex Index Ratio (SIR)

$$\text{Sex Index Ratio (SIR)} = \frac{\text{No. of X-Chromosomes (X)}}{\text{No. of sets of autosome (A)}}$$

If value of X/A ratio is _

1 = Normal Female

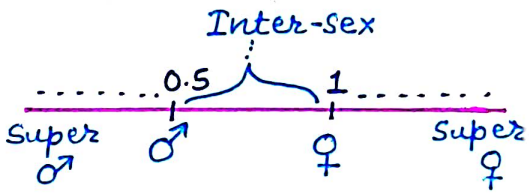
0.5 = Male

>1 = Super female/meta female

<0.5 = Super male/meta male

b/w 0.5-1 = intersex

→ Sterile



Example :-

$2A + XX = \frac{X}{A} = \frac{2}{2} = 1 \rightarrow$ Normal female

$2A + XY = \frac{X}{A} = \frac{1}{2} = 0.5 \rightarrow$ fertile male

$2A + XO = \frac{X}{A} = \frac{1}{2} = 0.5 \rightarrow$ Sterile male

$3A + XX = \frac{X}{A} = \frac{2}{3} = 0.66 \rightarrow$ Inter sex

$3A + XO = \frac{X}{A} = \frac{1}{3} = 0.33 \rightarrow$ Super male

$2A + XXX = \frac{X}{A} = \frac{3}{2} = 1.5 \rightarrow$ Super female

HUMAN GENETICS

Study/analysis of genetics characters in human is called human genetics.

Eugenics:-

- Improvement of human being by applying principles of genetics.
- Father of Eugenics → Francis Galton.

**** Direct study of genetics in human is not possible:**

> Controlled genetic crosses can not be performed in human.

> Long life span, so very long time is required to study genetic characters.

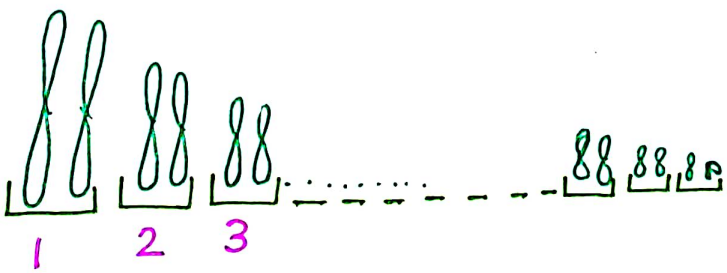
> Reproduction rate is low (less number of offspring's).

> Human have large number of quantitative/ polygenic characters.

> Human cells are smaller in size, but number of chromosomes are more.

**** Indirect methods to study human genetics:-**

1.) Pedigree analysis
2.) Population genetics
3.) Karyotype analysis



Point to keep:

Genetic disorders

Chromosomal disorder
- → Change in chromosomes no.
- → Studied by Karyotype analysis.

Eg:-
- Down Syndrome - 21st chromo..
- Klinefelter syndrome - (XXY) (Male)
- Turner syndrome - (XO) (Female)

Mendelian disorder (Gene point mutation)
- → Change in structure and function of gene.
- → Studied by Pedigree analysis.

Mendelian disorder

- Autosomal
  - Dominant
  - Recessive
- Sex-linked
  - X-linked
    - Dominant
    - Recessive
  - Y-linked

PEDIGREE ANALYSIS

Pedigree = Family tree

It is a record of some genetic characters or diseases for two or more generation in a family, which is represented by some specific symbol.

○ → Normal female

□ → Normal male

 → Affected female

 → Affected male

 → Heterozygous/Carrier for autosomal reccesive disear

 → Carrier female of sex linked recessive disease

 → Sex unspecified

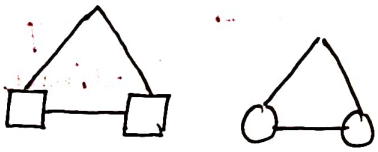
 → five unaffected offspring's

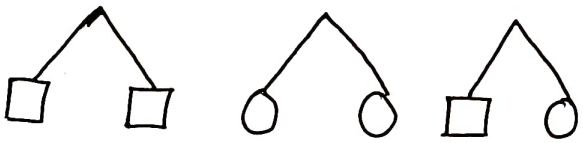
 → Death of individual

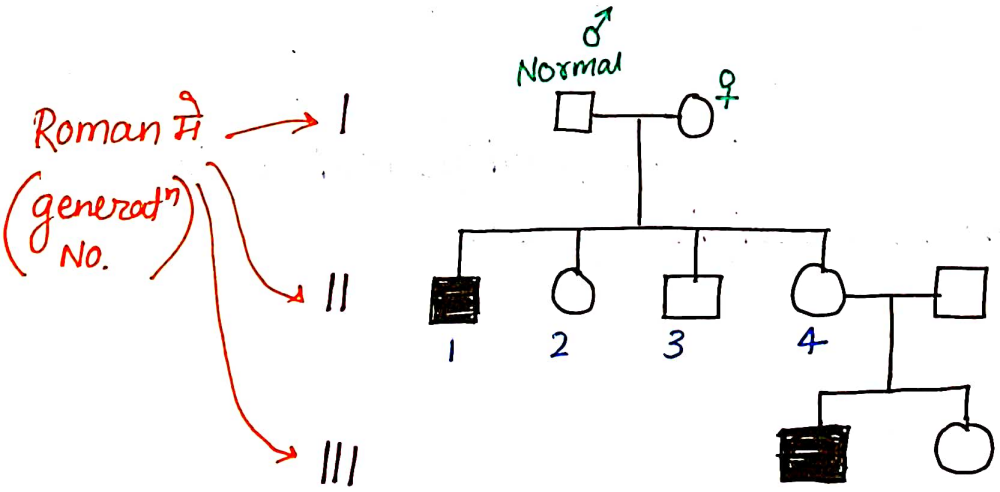
 → abortion or still birth
(death during embryonic stage)

 → Mating (marriage)

 → Consanguineous marriage
(Marriage b/w close relatives)

 → Monozygotic twins

 → Dizygotic twins
(fraternal)



There are 6 case in Pedigree Analysis—

Autosomal

Autosomal Recessive disease (AR)

A — Dominat (Normal)

a — Recessive (Disease)

AA → Normal
Aa → Normal but Carrier
aa → Affected.

↳ It is used in both ♂ and ♀ due to Autosome.

Eg: Sickle Cell Anaemia
Thalassemia
Phenylketonuria
Alkaptonuria
Albinism

Autosomal Dominant disease (AD)

A — Dominant (Disease)

a — Recessive (Normal)

AA → affected
Aa → affected
aa → Normal

↳ It is also used in both ♂ and ♀

Eg: Huntington's chorea.
Myotonic dystrophy.
Polydactyly.

X-Linked

X-Linked Recessive (XR)

X^+ — Dominant

X^a — Recessive (Disease)

♀
X^+X^+ = Normal
X^+X^a = Normal but Carrier
X^aX^a = affected

♂
X^+Y = Normal
X^aY = affected

eg: Haemophilia
Colourblindness
G6PD
DMD (Duchenne muscular dystrophy)

X-Linked Dominant (XD)

X^+ — Dominant (Disease)

X^a — Recessive

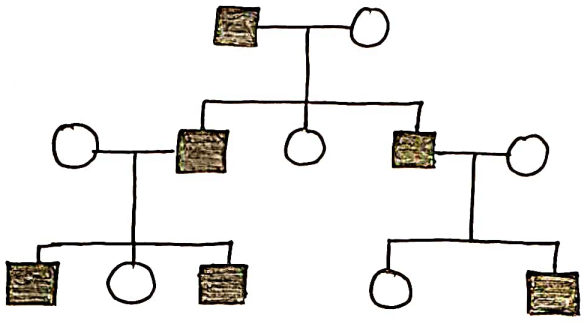
♀
X^+X^+ = affected
X^+X^a = affected
X^aX^a = Normal

♂
X^+Y = affected
X^aY = Normal

eg: Pseudorickets (Vitamin D resistance rickets)
Defective enamels of teeth.

*** Y-linked :-

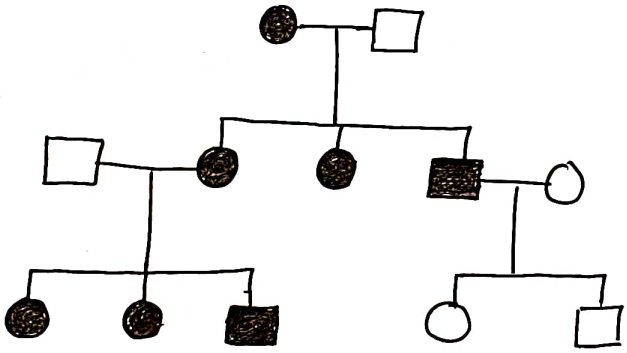
If father affected than all son should be affected



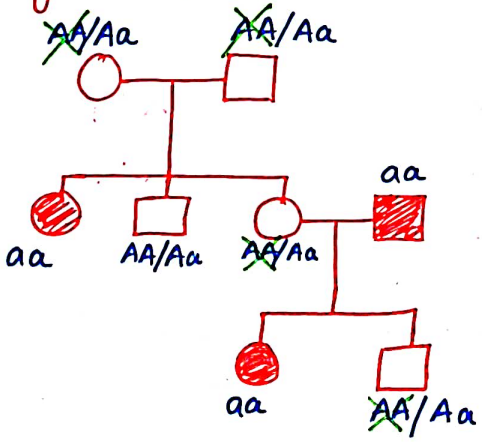
*** Cytoplasmic inheritance/ Maternal inheritance :-

↳ If mother affected than all offspring's should be affected.

↳ If father affected than any offspring's is never affected.



Q. Given pedigree show the inheritance of alkaptonewia What will be the genotype of all members of given pedigree ?



Alkaptonewia :-

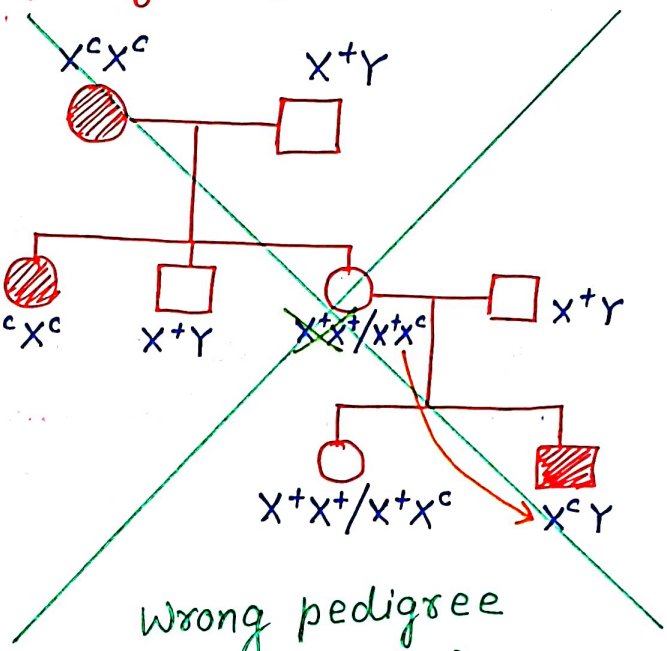
Autosomal recessive disease.

AA :- Normal

Aa :- Normal but Carrier

aa :- affected.

Q. Given pedigree show the inheritance of Colourblindness. what will be the genotype of all members of given pedigree ?



Wrong pedigree
(By mistake)

Colourblindness :-

- X-linked recessive disease

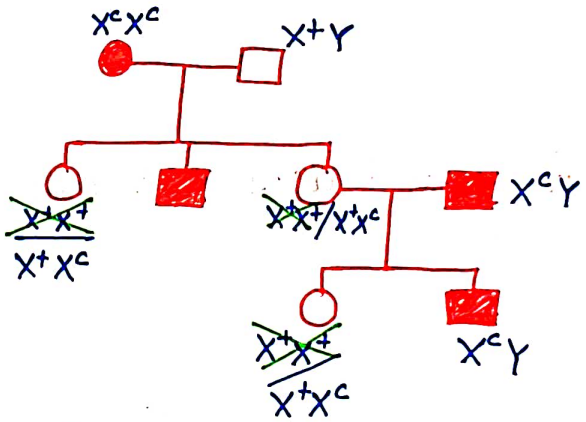
♀

X^+X^+ → Normal
X^+X^c → Normal but Carrier
X^cX^c → affected

♂

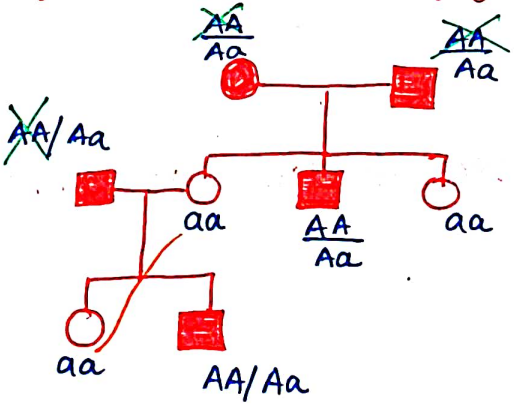
X^+Y → Normal
X^cY → affected

Q. Given pedigree show the inheritance of Colourblindness. what will be the genotype of all members of given pedigree ?



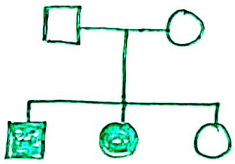
↳ Colourblindness :-
X-linked recessive disease

Q. Given pedigree show the inheritance of myotonic dystrophy. What will be the genotype of all members of given pedigree ?



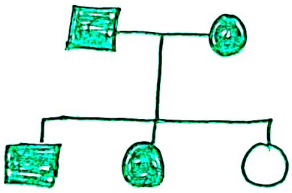
↳ Myotonic dystrophy
Autosomal dominant disease.

Step 1 :- If both parents are normal and any one child affected than AD and XD do not possible.



~~AD~~
~~XD~~

Step 2 :- If both parents are affected and any one child normal than AR and XR do not possible.



~~AR~~
~~XR~~

** If Step 1 and 2 do not apply than AR and AD possible.

Step 3 :-

XR doesn't possible

- Father normal daughter affected.
- Mother affected son normal.

** If Step 3 does not apply than XR possible.

Step 4 :-

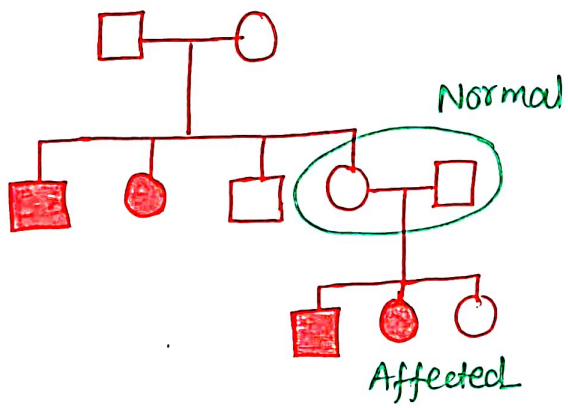
XD doesn't possible

- Father affected daughter normal
- Mother normal son affected

** If Step 4 does not apply than XD possible

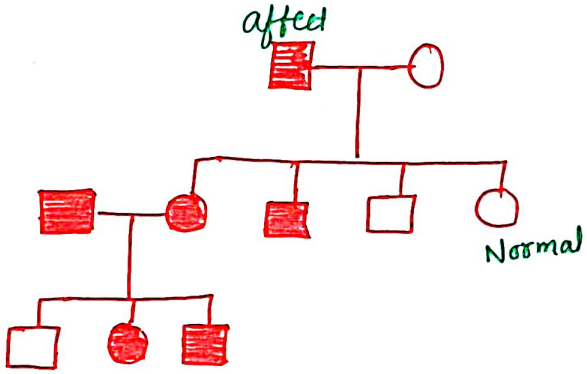
Q. Given pedigree show the inheritance of :-

(1)



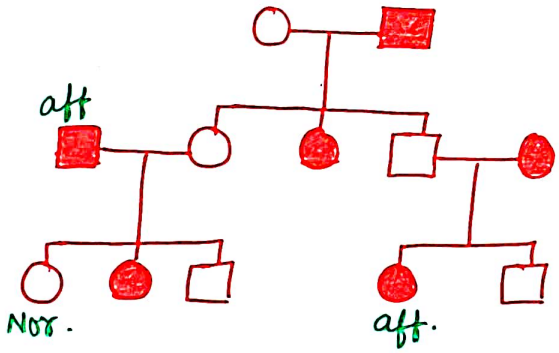
AR ✓
AD ✗
XR ✗
XD ✗

(2)



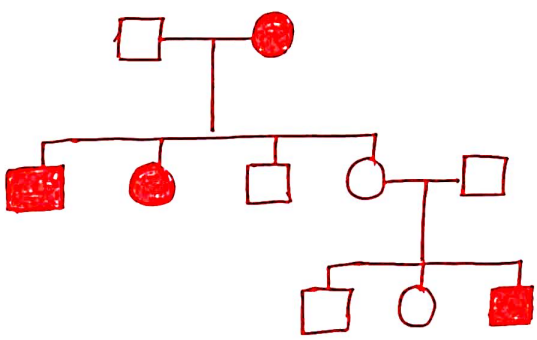
Y-linked ✗
Cytoplasmic ✗
AR ✗
AD ✓
XR ✗
XD ✗

(3)



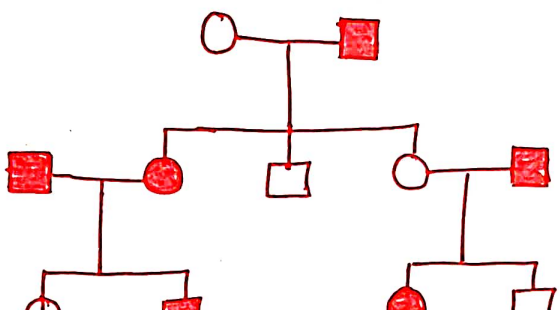
AR ✓
AD ✓
XR ✗
XD ✗

(4)



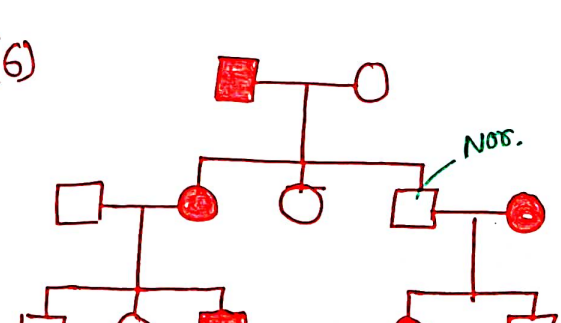
AR ✓
AD ✗
XR ✗
XD ✓

(5)



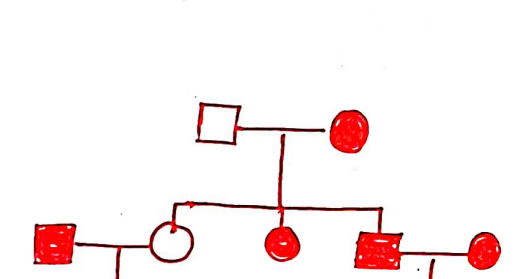
AR ✗
AD ✓
XR ✗
XD ✗

(6)



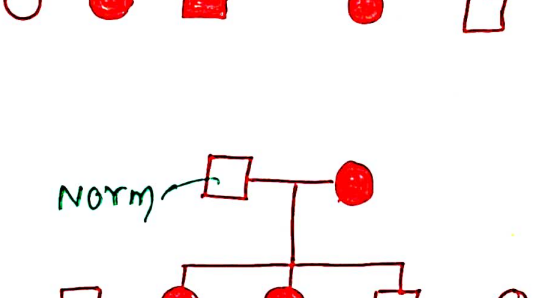
AR ✓
AD ✓
XR ✗
XD ✗

(7)



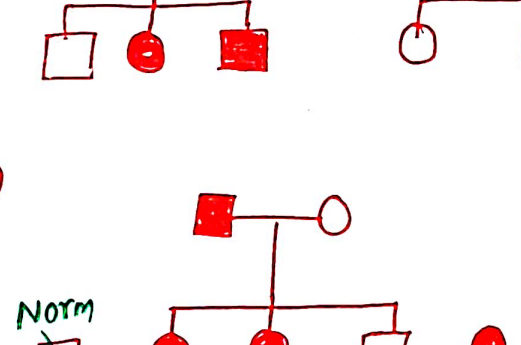
AR ✗
AD ✓
XR ✗
XD ✗

(8)



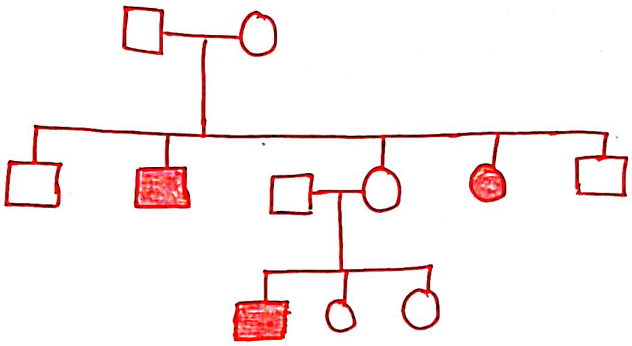
AR ✓
AD ✗
XR ✗
XD ✗

(9)



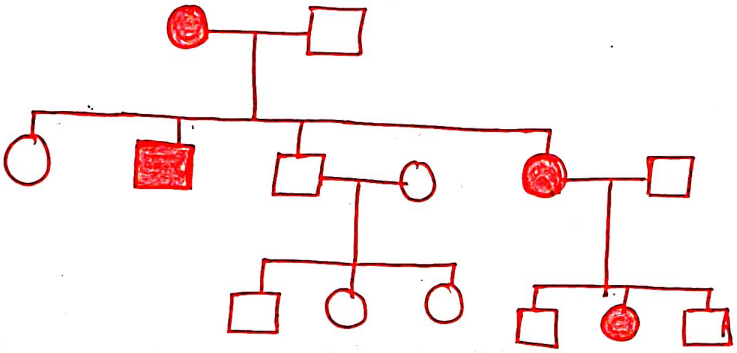
AR ✓
AD ✓
XR ✗
XD ✓

(10) NCERT ☆☆



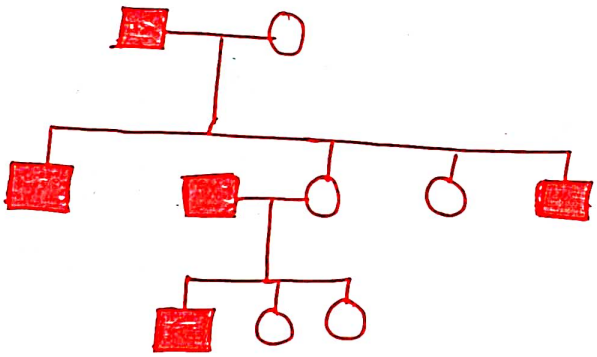
AR ✓
AD ✗
XR ✗
XD ✗

(11) NCERT ☆☆☆



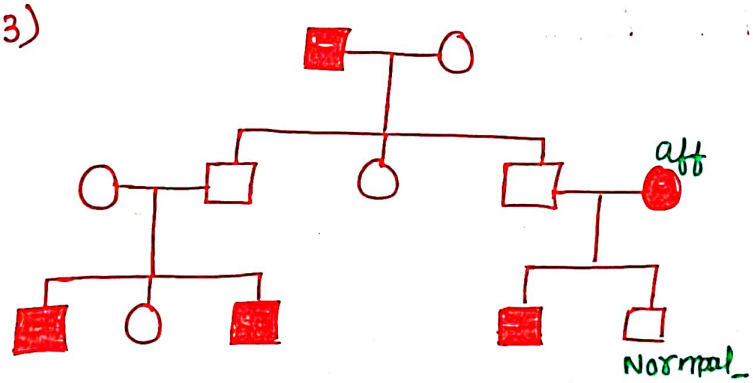
AR ✓
AD ✓ ← NCERT
XR
XD ✓

(12)



Y-linked ✓
Cytoplasmic inh... ✗
AR ✓
AD ✓
XR ✓
XD ✗

(13)



AR ✓
AD ✗
XR ✗
XD ✗

POPULATION GENETICS

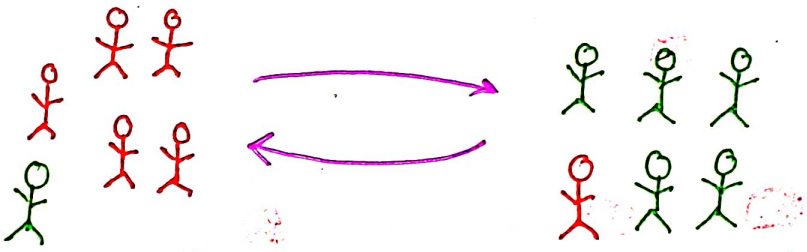
- Study / analysis of genetic characters at population level is called population genetics.

Population study is essential for :-

1. To study of multiple alleles.
2. To find frequency of given allele.

> Gene Pool :- Sum total of all the genes and their alleles pr. in a population.

> Gene flow :- Migration of gene from one population to another population is called gene flow.



> Genetic load :- Presence of harmful recessive allele in heterozygous condition in a population.

Autosomal recessive disease_

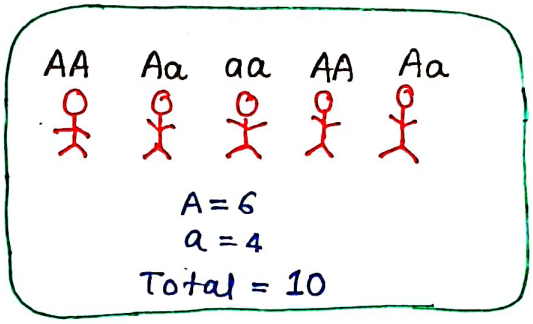
AA → Normal
Aa → Normal but Carrier
aa → affected

Carrier
Aa

> Gene frequency :- Population of given allele out of total alleles of a gene in a population.

$$\text{Frequency of a given allele} = \frac{\text{No. of given allele}}{\text{Total no. of allele}}$$

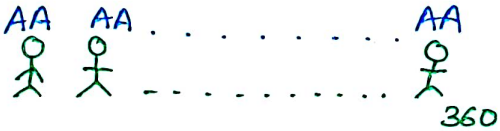
समझने के लिए।



$A = \frac{6}{10} = 0.6$ $\quad a = \frac{4}{10} = 0.4$

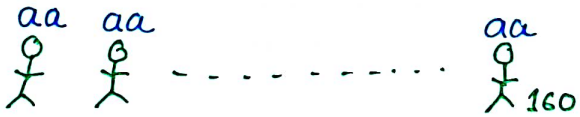
Q. In a population of 1000 individuals, 360 belong to genotype AA, 480 to Aa and the remaining 160 belong to aa, then Calculate the frequency of allele 'A' in the population ?

AA = 360



Aa = 480

aa = 160



Soln:- Total A :- $360 \times 2 + 480 \times 1 = 1200$

Total a :- $160 \times 2 + 480 = 800$

Total allele = 2000

Frequency of A = $\frac{1200}{2000} = 0.6$

Frequency of a = $\frac{800}{2000} = 0.4$

Q. In a population of 200 individuals, 128 belong to genotype AA, 64 to Aa and the remaining 8 belong to aa, then calculate the frequency of allele 'A' and a allele in the population?

AA = 128
Aa = 64
aa = 8

Total A :- $128 \times 2 + 64 = 320$

Total a :- $8 \times 2 + 64 = 80$

Total allele = 400

✓ Fredency of A = $\frac{320}{400} = 0.8$

✓ Frequency of a = $\frac{80}{400} = 0.2$

HARDY WEINBERG LAW

Given by Hardy and weinberg

Hardy: British mathematician

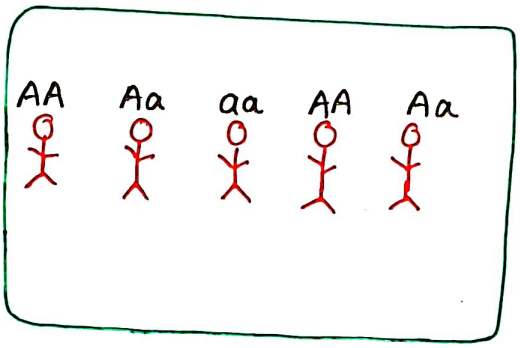
weinberg: German Physician

A/c to this rule :-
In an ideal population frequency of allele remain Const generation after generation.

Ideal population means, in this population :-

1. Random mating occur.
2. No mutation.
3. No migration.
4. No natural selection.
5. Population is large.

Explanation :-



A = 0.6 a = 0.4

After 10 yrs

A = 0.6 a = 0.4

After 50 yss

A = 0.6 a = 0.4

Factor's affecting Hardy weinberg law :-

1) Seletive mating occur
2) Mutation occur
3) Migration occur
4) Natural selection occur
5) Genetic drift ← Sudden change in gene frequency due to any reason (sampling error) is called genetic drift.

$$\text{Genetic drift} \propto \frac{1}{\text{population size}}$$

Mathematical :-

A/c to Hardy weinberg law -

$$\underset{A}{P} + \underset{a}{q} = 1$$

P → frequency of dominant allele

q → frequency of recessive allele

$$P + q = 1$$

↳ Square on both side -

$$(P+q)^2 = (1)^2$$

$$\underset{AA}{P^2} + \underset{Aa}{2pq} + \underset{aa}{q^2} = 1$$

~~$P \times q = 1$~~

$$p^2 + 2pq + q^2 = 1$$

AA Aa aa

p^2 = frequency of homologous dominant genotype/ phenotype/ character/ organism.

$2pq$ = frequency of heterozygous dominant genotype/ phenotype/ character/ organism/ carrier.

q^2 = frequency of homologous recessive genotype/ phenotype/ character/ organism.

$p^2 + 2pq$ = frequency of dominant genotype/ phenotype/ character/ organism.

$p^2 + q^2$ = frequency of homologous genotype/ phenotype/ character/ organism.

Q. In a large population, frequency of recessive allele is 0.7, then find out frequency of homozygous dominant organisms?

Recessive allele = 0.7

$q = 0.7$

↳ $p + q = 1$

$p = 1 - q \Rightarrow p = 1 - 0.7$

$= 0.3$

↳ Homozygous dominant $= p^2$

$= (0.3)^2$

$= 0.3 \times 0.3$

$= 0.09$

3. In a random mating population of 1000 individuals, frequency of recessive phenotype is 0.16, then find out number of homozygous organisms?

Recessive phenotype = 0.16

$q^2 = 0.16$

$q = 0.4$

↳ $p + q = 1 \Rightarrow p = 1 - q$

$= 1 - 0.4$

$\boxed{p = 0.6}$

↳ Homozygous organism :- $p^2 + q^2$

$= (0.6)^2 + (0.4)^2$

$= 0.52 \times 1000$

$= 520$

Q. In a random mating population of 2000 individuals, % of dominant allele is 90%, then find out number of dominant organisms?

Dominant allele = 90%

$p = 90\% = \frac{90}{100} = 0.9$

↳ $p + q = 1$

$0.9 + q = 1$

$q = 1 - 0.9 \Rightarrow \boxed{q = 0.1}$

Dominant organism = $p^2 + 2pq$

$= (0.9)^2 + 2 \times 0.9 \times 0.1$

$= 0.81 + 0.18$

$= 0.99$

Q. In a random mating population of 10000 individuals 36 % are albinic, then find out number of carrier and normal individual respectively?

Albinism :-

Autosomal recessive disease

AA - Normal p^2

Aa - Normal but Carrier $2pq$

aa - albinic (affected) q^2

Albinic = 36 %

$q^2 = 36\% = \frac{36}{100}$

$q = 0.6$

$p + q = 1$

$p + 0.6 = 1$

$p = 1 - 0.6$

$\boxed{p = 0.4}$

Normal = $p^2 + 2pq$

$= (0.4)^2 + 2 \times 0.4 \times 0.6$

$= 0.16 + 0.48$

$= 0.64 * 10000$

$= 6400$

Carrier = $2pq$

$= 2 \times 0.4 \times 0.6$

$= 0.48 \times 10000$

$= 4800$

Q In a random mating population of 5000 individuals, frequency of dominant phenotype is 0.51, then find out number of homozygous organisms?

Dominant phenotype = 0.51

$p^2 + 2pq = 0.51$

↳ $p^2 + 2pq + q^2 = 1$

$0.51 + q^2 = 1$

$q^2 = 0.49$

$q = 0.7$

↳ $p + q = 1$

$p + 0.7 = 1 \Rightarrow \boxed{p = 0.3}$

Homozygous organism = $p^2 + q^2$

$= (0.3)^2 + (0.7)^2$

$= 0.09 + 0.49$

$= 0.58 \times 5000$

$= 2900$

Q. A family has 4 girls, probability of son at 5th birth is—

$\frac{1}{2} = 50\%$

6th son —

7th son —

Q. Probability of four son to a Couple is —

$\frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2}$

Q. A diploid organism is heterozygous for 4 loci, how many types of gametes can be produce?

Types of gamete = 2^n

$= 2^4$

$= 16$