PRINCIPLES OF INHERITANCE AND VARIATION

Gregor Mendel experimented on Garden pea or Pisam sativum. In garden pea mendel selected seven contrasting characters.

	characters	Dominant	Recessive
1.	Seed colour	Yellow	Green
2	Seed shape	Round	Wrinkled
3.	Pod colour	Green	Yellow
4	Pod shape	inflated	constricted
5	Flower colour	Violet	White
6.	Flower position	Axial	Terminal
7	Plant height	Tall	Dwarf

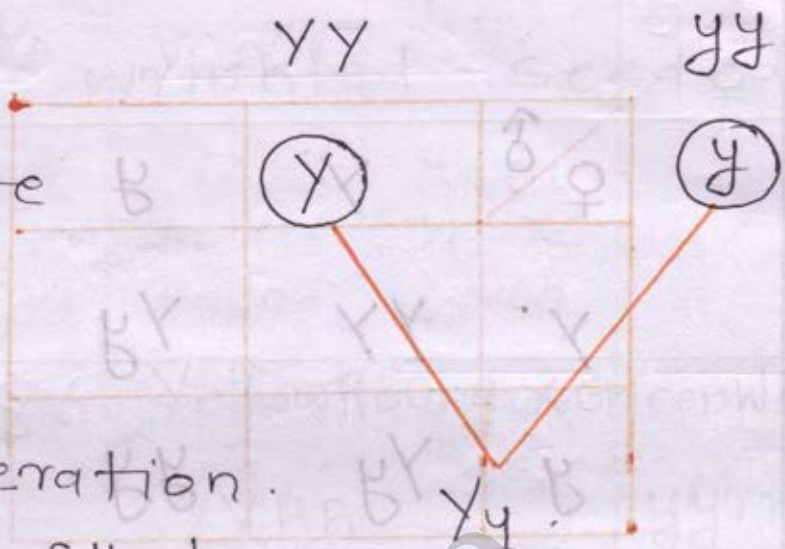
→ Mendel selected Pisum sativum because of the following reasons.

1. It is easly available
2. It has a short lifespan
3. Different varities are present
4. It can be self Pollinated

→ Monohybrid Cross

It is the cross involving a single character. Mendel selected seed colour for his monohybrid cross. He crossed a pure breeding Yellow seed coloured Plant with a pure breeding green seed coloured Plant.

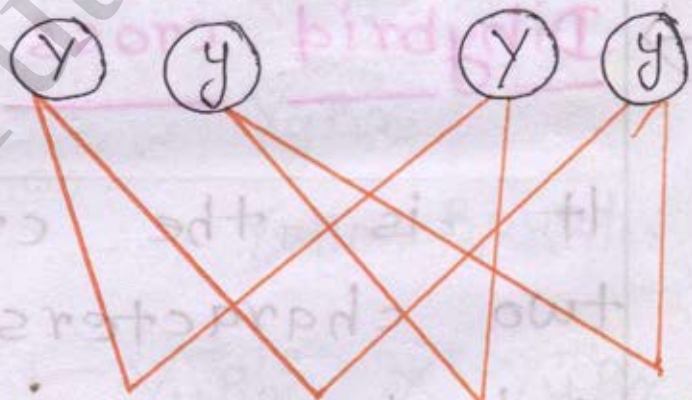
Parents. Yellow x Green.



F1 generation. Yy.
(First filial generation) Yellow.

F1 Parent Yy x Yy

Gamete



F2 generation YY Yy Yy yy

Yellow Yellow Yellow Green

→ Punnet square

♀ \ ♂	Y	y
Y	YY	Yy
y	Yy	yy

Phenotypic ratio:— 3:1
Genotypic ratio :— 1:2:1

→ Dihybrid cross

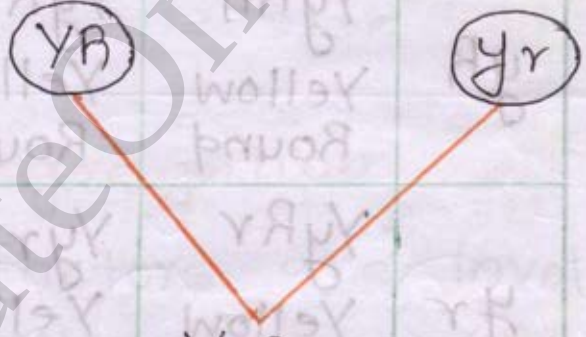
It is the cross involving two characters. Mendel selected seed colour and seed shape for his dihybrid cross. He crossed a pure breeding yellow round seeded

Plant with a pure breeding Green wrinkled seeded Plant.

Parents. YellowRound × GreenWrinkled

YYRR yyrr

Gametes (YR) (yr)



YyRr

F1 generation.

Yellow Round.

F1 Parent YyRr × YyRr

Gametes (YR) (Yr) (yR) (yr) (YR) (Yr) (yR) (yr)

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

phenotypic ratio :— 9 : 3 : 3 : 1

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

YYRR — 1 YyRR — 2 yyRR — 1

YYRr — 2 YyRr — 4 yyRr — 2

YYrr — 1 Yyrr — 2 yyrr — 1

Law of Mendels.

1. Law of Dominance.

When two factors are involved in a cross one factor will mask the effect of other. The expressed factor is known as Dominant and other one is Reccessive.

2. Law of segregation.

When two factors are involved in a cross the factor pairs segregates during the formation of gametes. It is based on monobybrid cross.

3. Law of independent assortment

It is based on dihybrid cross. When two characters are involved in a cross the factor pairs —

assort independent of each other

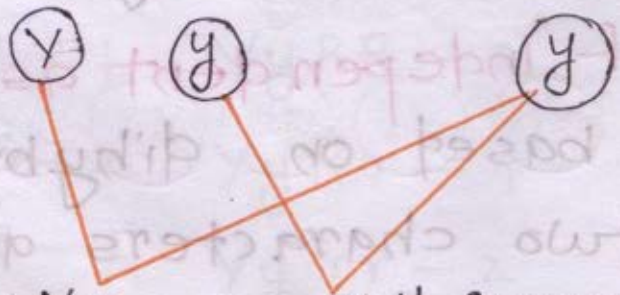
→ Backcross and Test cross.

When the F1 hybrid is crossed with anyone of its parent. It is backcross.

When the F1 is crossed with its Recessive parent. It is Test cross. The test cross is used to find out unknown genotype of individual.

Monohybrid test cross:

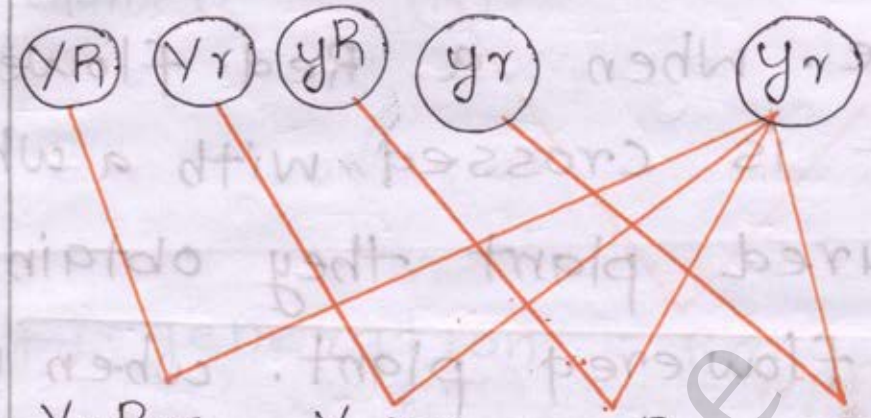
Yy x yy



Yellow Yy yy Green

Dibybrid test cross.

YyRr X yyrr



YyRr Yyrr yyRr yyRr.

Yellow Round | Yellow Wrinkled | Green Round | Green Wrinkled.

1 : 1 : 1 : 1

→ Other Patterns of Inheritance.
(Non-Mendelian inheritance).

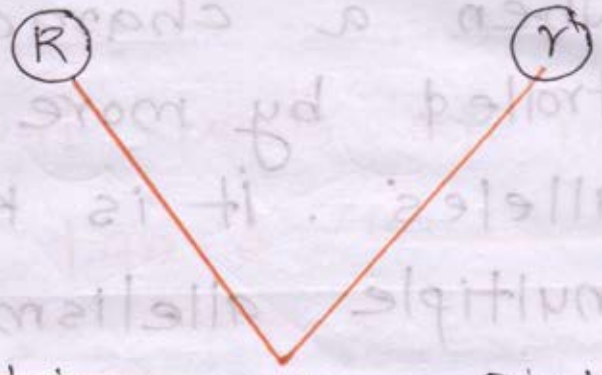
1. Incomplete dominance.

It was observed by carl correns in Mirabilis jalapa (4°clock plant) and also in Antirrhinum / snap

dragon / dog flower. In these plants there was two varrities of flower colour Red and white. When a Red flowered plant is crossed with a white coloured plant they obtained Pink flowered plant. when it was self fertilised they obtained Red flowered, Pink flowered and white flowered plant in the ratio of 1:2:1. It is due to Incomplete dominance. The red is incompletely dominant over white.

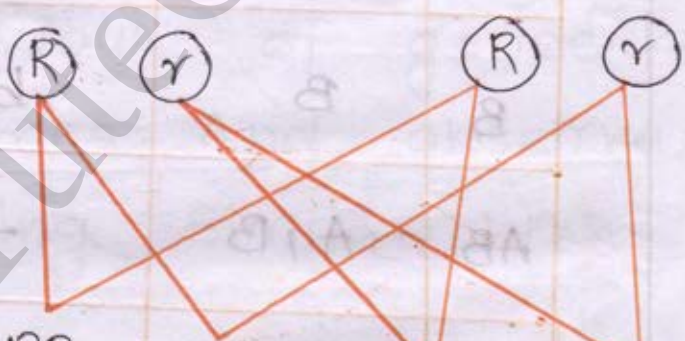
Parent Red X White

RR rr

Gamete 

F1 generation . Rr Pink

F1 Parent Rr X Rr .

gamete 

RR Rr Rr rr

Red Pink Pink White

1 : 2 : 1

2. Multiple Allelism.

Alleles are copies of genes. When a character is controlled by more than two alleles. it is known as multiple allelism.

Group	Antigen	Antibody	Genes
A	A	a	I^AI^A, I^Ai
B	B	b	I^BI^B, I^Bi
AB	A, B	—	I^AI^B
O	—	a, b	ii

Blood group is controlled by the alleles I^A, I^B, and i. So it is an example for multiple allelism.

In AB group I^A and I^B express together. So known as codominance.

→ Chromosomal basis of inheritance.

(Sutton and Bovery bypothesis)

Sutton and Bovery observed the behaviour of genes and chromosomes. And observed the following similarities.

1. The genes and chromosomes are found in paired condition.

2. Genes and chromosomes separate during the formation of gamete.

3. The paired condition is restored after fertilization.

4. Genes and chromosomes show independent assort ment.

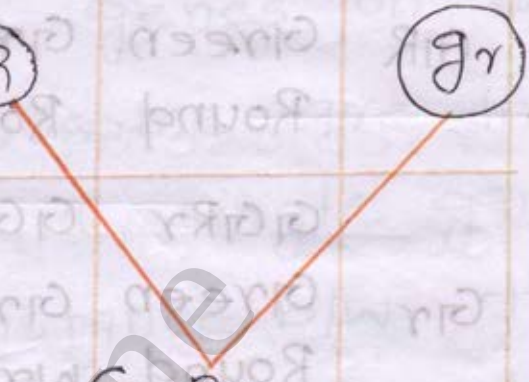
Based on these similarities Sutton and Bovery proposed that chromosomes are the basis of inheritance.

Q A pea plant with green pod coloured and round seed was crossed with yellow pod coloured wrinkled seeded plant. find out the ratios in F_2.

Parent : Green Round × Yellow Wrinkled

GGRR ggrr

Gamete : (GR) (gr)



F1 generation. GgRr.

Green Round.

F1 Parent GgRr X GgRr

gametes (GR) (Gr) (gR) (gr) (GR) (Gr) (gR) (gr)

♀ \ ♂	GR	Gr	gR	gr
GR	GGRR Green Round	GGRr Green Round	GgRR Green Round	GgRr Green Round
Gr	GGRr Green Round	GGrr Green wrinkled	GgRr Green Round	Ggrr Green wrinkled
gR	GgRR Green Round	GgRr Green Round	ggRR Yellow Round	ggRr yellow Round
gr	GgRr Green Round	Ggrr Green wrinkled	ggRr Yellow Round	ggrr Yellow wrinkled

phenotypic ratio :— 9:3:3:1

Genotypic ratio :— 1:2:1:2:4:2:1:2:1

Linkage

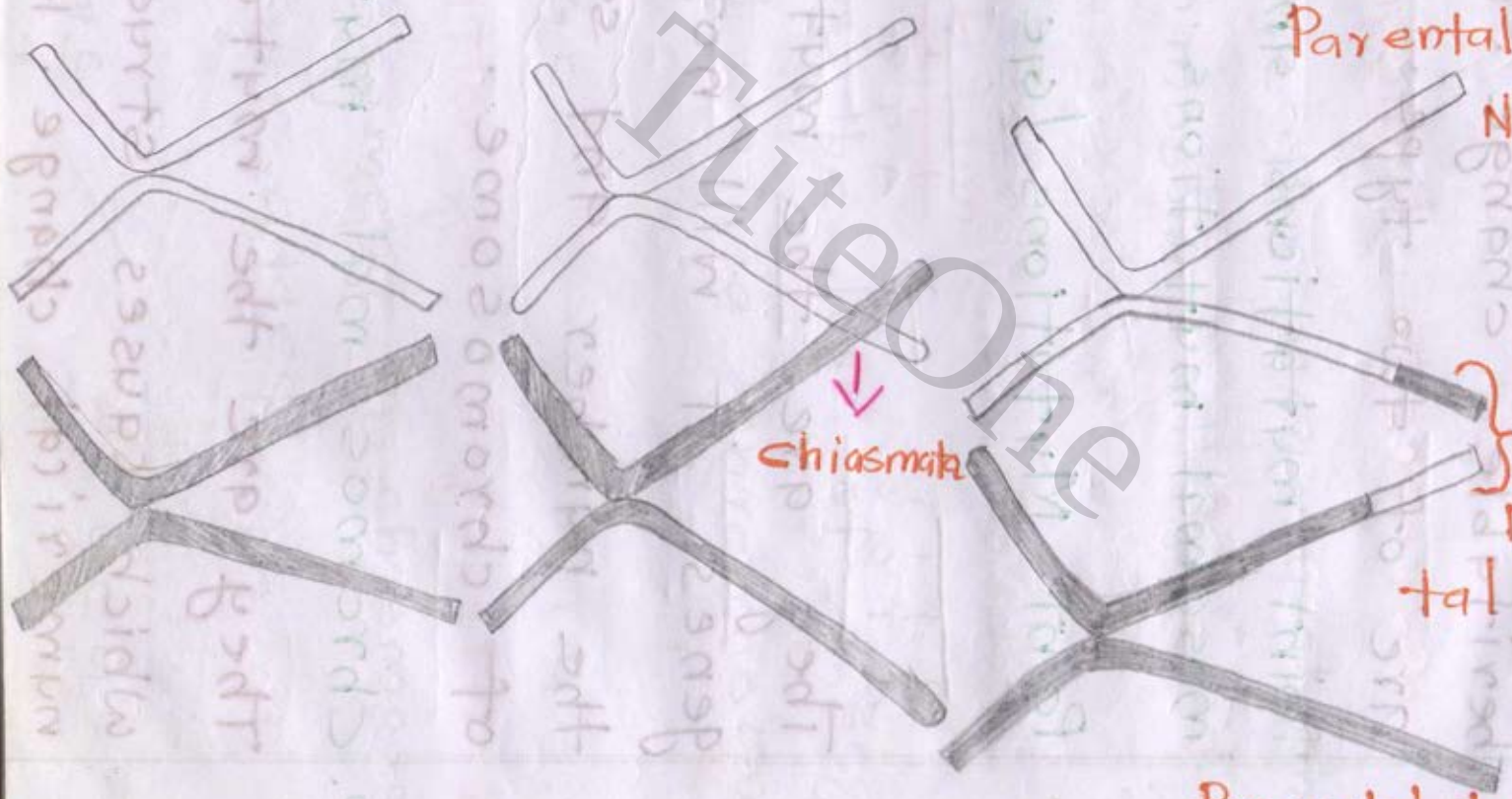
Genes on a single chromosome are said to be linked together. The genes on a single chromosome are inheritanted into a single gamete. As the distance b/w the genes increases linkage decreases. It is known as incomplete linkage. As the distance b/w genes decreases linkage increases. It is known as complete linkage.

→ Crossing over and Recombination

crossing over is the overlaping of chromosomal segments. The region where chromosomal

segments overlaps is
chiasmata. chromosomal
segments breaks at
chiasmata exchange of
chromosomal segments
occur when it rejoints.
It is known as recombination.
Recombination increases
Variation. As the distance
b/w genes increases linka-
ge decreaces and recombi
nation increases. As the
distance b/w genes decreases
linkage increases and recom-
bination decreases.

Crossing over and Recombination



Parental types / Non Recombinants.

Recombinants / Non parental types.

Parental types / Non Recombinants.

→ Mutation

Mutations are the sudden beritable change. Mutations are of two type.

Point mutations and chromosomal mutations.

1. Point Mutations / Gene mutation.

They are the mutations in genes it will not alter the number and structure of chromosome.

2. Chromosomal mutations

They are the mutations which causes structural or numerical change. It is of

two types.

chromosomal aberrations and ploidy.

1. chromosomal aberration.

They are the structural changes in chromosomes. It is of 4 types.

(a). Deletion.

It is the lose of a segment of a chromosome.

$\overline{ATGC} \longrightarrow \overline{ATG}$

(b) Addition or Duplications.

A segment of chromosome is added.

$\overline{ATGC} \longrightarrow \overline{ATGCGC}$

(c) Inversion

A segment of chromosome is inverted.

$\overline{ATGC} \longrightarrow \overline{ATCG}$

(d) Translocation.

It is the exchange of chromosomal segments.

$\overline{ATGC}$ $\overline{AT34}$

$\longrightarrow$

$\overline{1234}$ $\overline{12GC}$

2. Ploidy

It is the numerical changes in chromosomes. It is of two type.

(a) Euploidy

It is the change in chromosome number as sets of chromosomes.

$\varphi n - n \longrightarrow$ Monoploidy / Haploid

$\varphi n + n \longrightarrow$ Triploidy

$\varphi n + \varphi n \longrightarrow$ Tetraploidy

} Polyploidy

(b) Aneuploidy

It is the change in chromosome number as one or more chromosomes.

$\varphi n + 1 \longrightarrow$ Trisomy

$2n - 1 \longrightarrow$ Monosomy

$\varphi n - \varphi \longrightarrow$ Nullisomy.

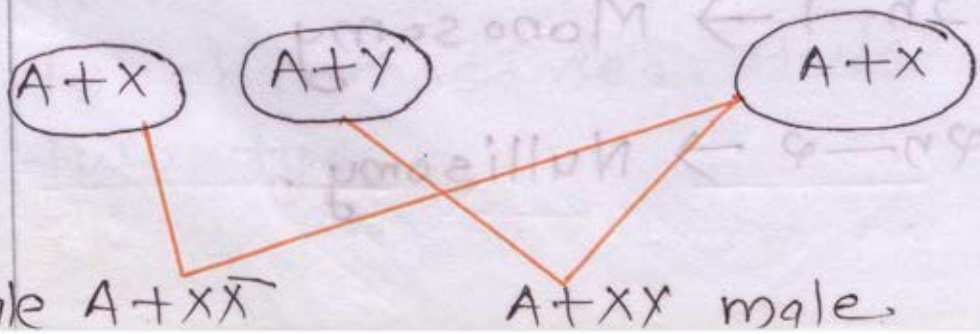
→ Mechanism of Sex determination.

We have two types of chromosome Autosomes and Allosomes or sex chromosome. Allosomes controlls sex and Autosomes controlls other body characters.

→ The mechanism of sex determination in human beings and in drosophila is XX-XY mechanism.

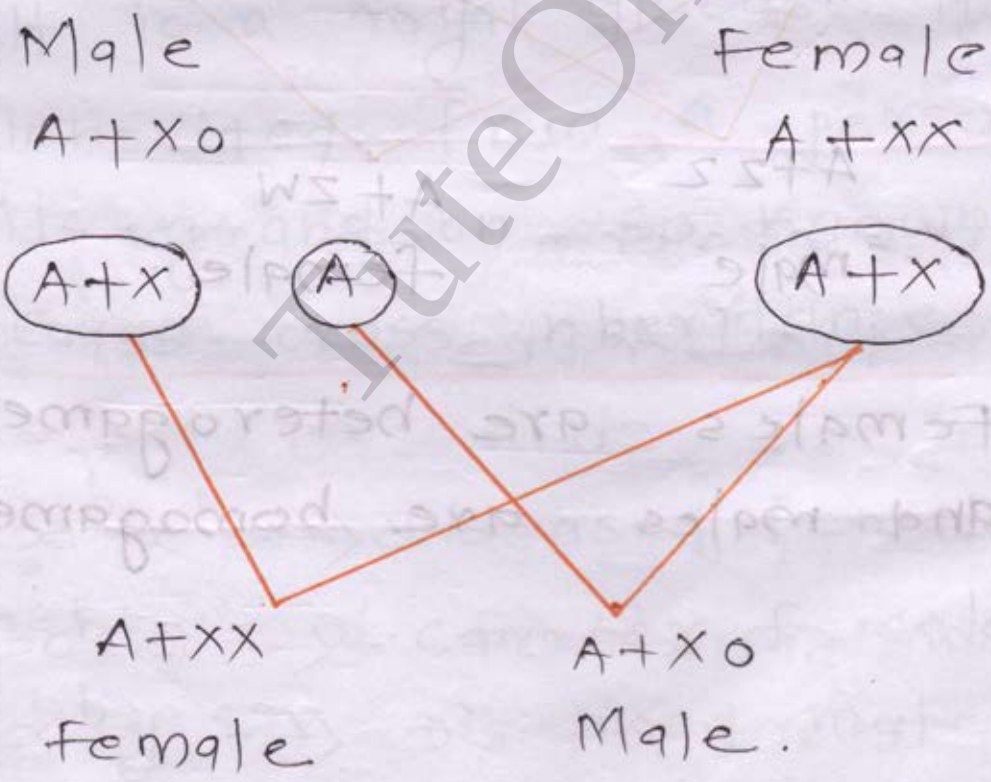
Male
A+XY

Female
A+XX



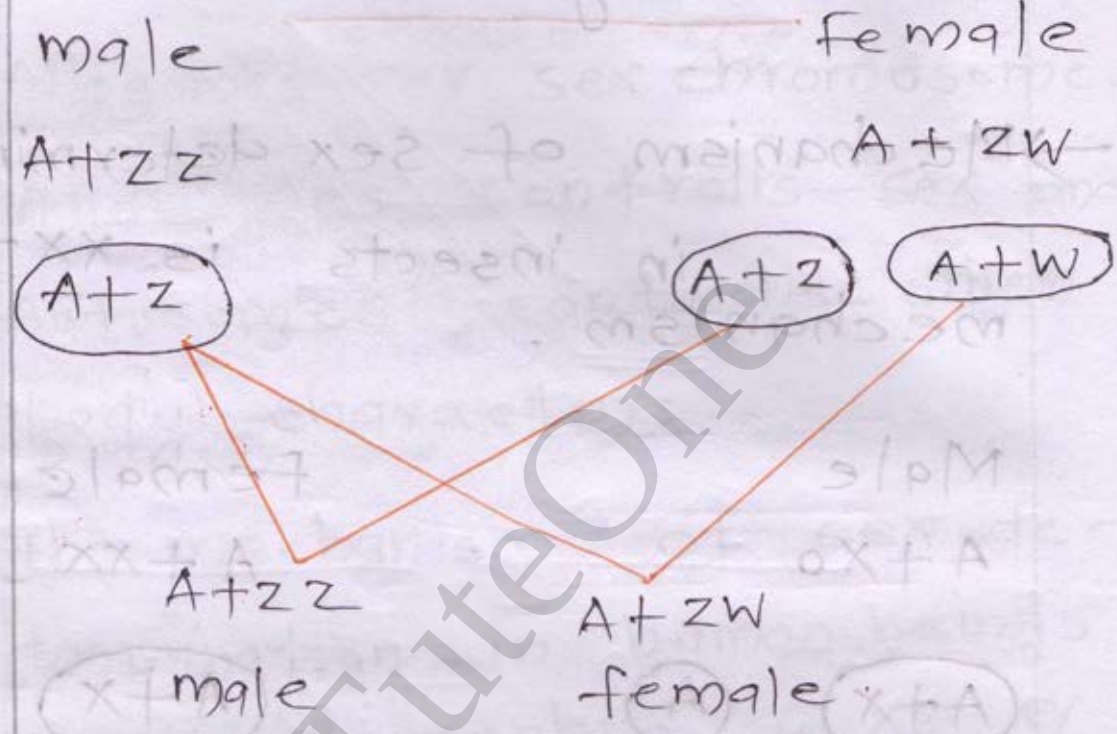
Males produces two types of gametes. So they are heterogametic and females are homogametic.

→ Mechanism of sex determination in insects is XX–XO mechanism.



Males are heterogametic and females are homogametic.

→ Mechanism of sex determination in Birds is ZZ-ZW mechanism.



Females are heterogametic and males are homogametic.

Disorders.

Mendelian Disorders.

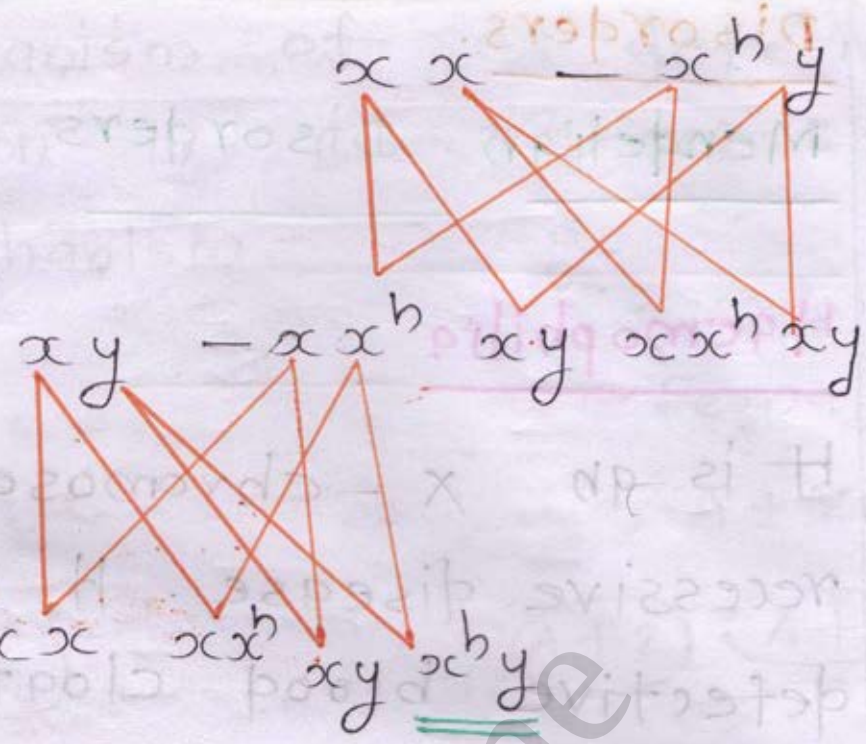
1. Haemophilia

It is an X-chromosomal recessive disease. It causes defective blood clotting. It is a royal disease. It is inherited from a person to its grandson. So known as criss-cross inheritance.

$x^h x^h$ → Diseased female

$x^h x$ → carrier female

$x^h y$ → Diseased male.



9. Sickleced anaemia

Haemoglobin has two polypeptid chains α and β. In the β chain at the 6th position aminoacid is glutamic acid. In diseased persons it is replaced by Valine. So their RBC becomes ~~sin~~ sickle shape and will not be able to transport oxygen.

Hb^S Hb^S — Genotype of diseased person.

Hb^S Hb — Genotype of carrier person.

3. Phenylketonuria

It is due to the absence of enzyme phenyl alanine hydroxylase this converts phenyl alanine to Tb. Tyrosine. So the phenyl alanine will be accumulated in body and converted into phenyl pyruvic acid. It will be deposited in brain causing braine damage and keton bodies are eliminated through urin.

chromosomal disorders.

1. Down's syndrome.

It is due to 21th trisomy. They have 3 21th chromosome. So they have 47 chromosomes with 45 Autosomes and ♀ sexchromosomes. It is known as Mongolism. They have mental retardation and congenital heart diseases.

♀. Klinefelters Syndrome

They have 44 Autosomes + XXY. So they have 47 chromosomes. So they are sterile males with female

characters (Gynaecomastia).

3. Turners Syndrome

They have 44 Autosomes + xo. They are sterile females

→ Pedegree analysis

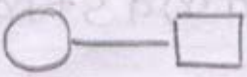
It is a chart to represent inheritance of a character or disease in human family.

○ → Female

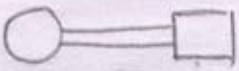
□ → male

◇ → Sex unspecified

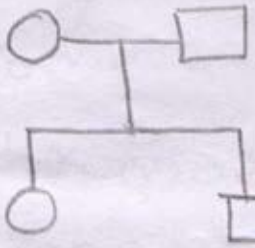
● → Diseased



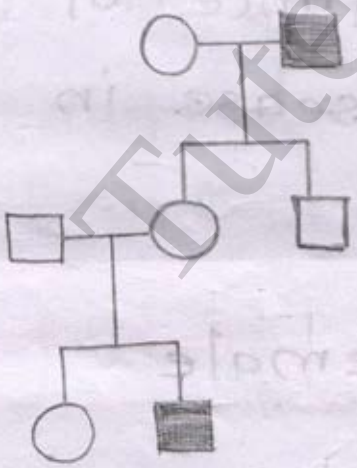
→ Marriage



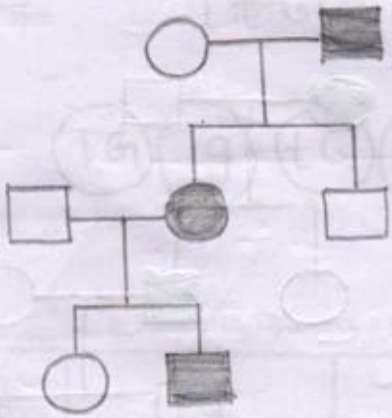
→ Consangineous marriage



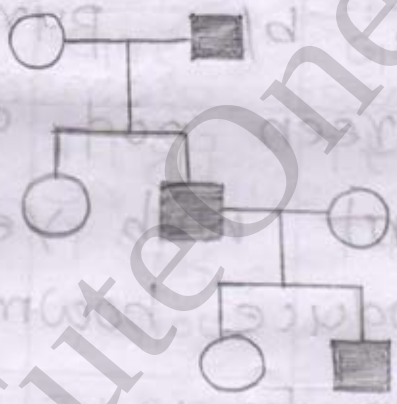
→ family



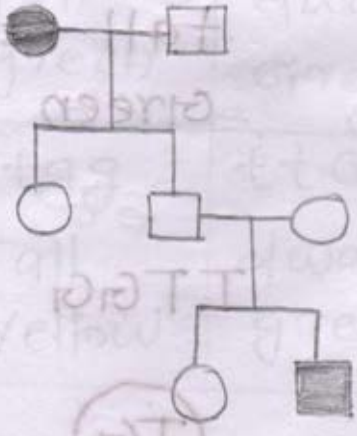
X — Recessive



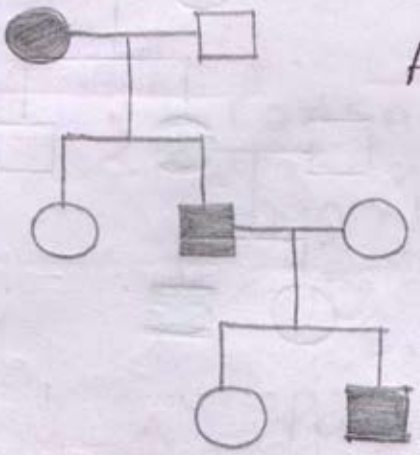
X — Dominant



Y — chromo
Somal



Autosomal
Recessive.



Autosomal dominant.

② A cross b/w pure tall plant with green pod and dwarf Pea plant with yellow pod - will produce how many shorts plants in F2.

An: Parents tall Green × dwarf yellow

TTGG ttgg

Gametes TG tg

F1 generation. TtGg tall Green

F1 parent TtGg × TtGg

Gametes (TG) (Tg) (tG) (tg) × (TG) (Tg) (tG) (tg)

♀/♂	TG	Tg	tG	tg
TG	TTGG Tall Green	TTGg Tall Green	TtGG Tall Green	TtGg Tall green
Tg	TTGg Tall Green	TTgg Tall yellow	TtGg Tall Green	Ttgg Tall yellow
tG	TtGG Tall Green	TtGg Tall green	ttGG dwarf Green	ttGg dwarf green
tg	TtGg Tall Green	Ttgg Tall yellow	ttGg dwarf green	ttgg dwarf yellow.

phenotypic ration – 9:3:3:1

Genotypic ratio — 1:2:1:2:4:2:1:2:1

H will produce 4 short plants in F2.

Q Blue eye colour is recesive to brown eye colour. A brown eyed man whose mother was blue eyed marries a blue eyed woman. Their children will be

Ans: Brown — B

blue — b

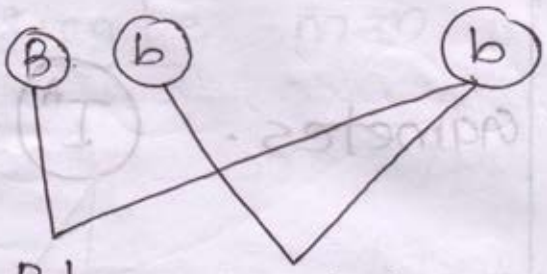
mother — bb.

man — Bb

woman — bb.

Parent Bb × bb

gametes



F1 generation. Bb bb

Brown blue.

1 : 1

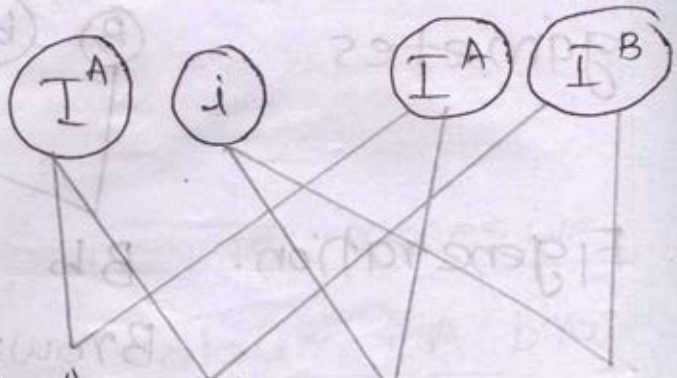
Their children will be Brown or blue

Q A man of blood group A marries a woman of blood group AB which type of their progeny indicates man is heterozygus.

An: Hetero

Parent. $I^A i$ X $I^A \cdot I^B$

Gametes.



F1 gene ration.

$I^A I^A$ A

$I^A I^B$ AB

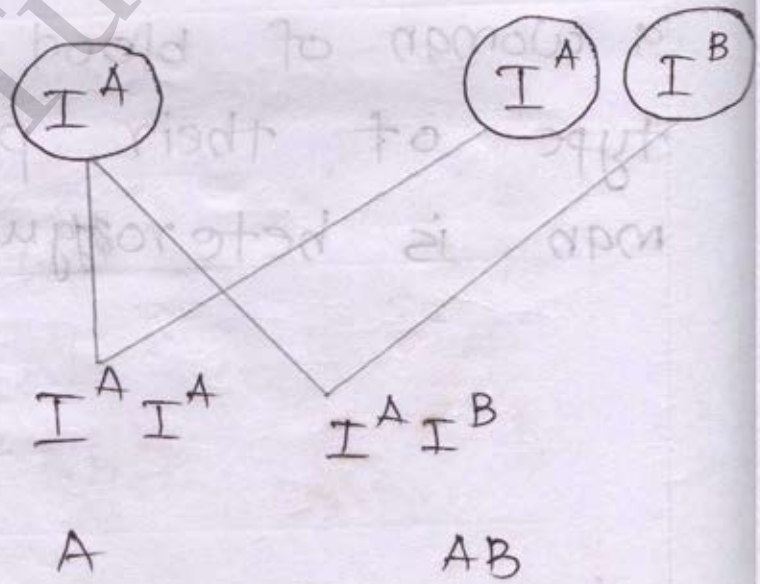
$I^A i$ A

$I^B i$ B.

Homo

Parent $I^A I^A$ X $I^A I^B$

Gamete



B ~~group~~ blood grouped progeny indicate man is heterozygous.

Q A haemophilic man marries a woman carrier for haemophilia what would be the possibility to their daughter to be haemophilic.

Ans: Parents. Father $x^h y$ mother $x x^h$

gametes x^h, y, x, x^h

$x x^h$ $x^h x^h$ $x y$ $x^h y$.

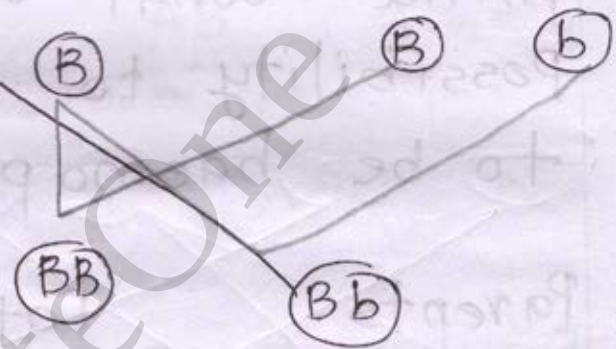
25%.

The chance daughter should be haemophilic is 50%.

Q A brown eyed couple has a blue eyed child. find out the genotype of the couple.

An: Parents. BB Bb.

gametes.



man : BB or Bb

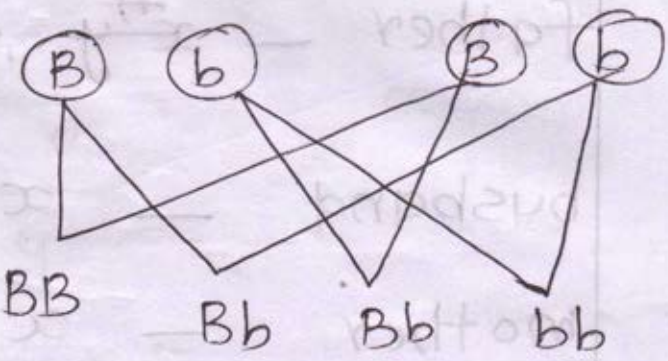
female : BB or Bb

P

The genotype is Bb and Bb.

Parents I Bb Bb

gametes



F1 gene ration

BB Bb Bb bb

∴ The genotype of couple is Bb.

man — Bb

woman — Bb.

Q. A husband and wife normal vision but fathers of both of them ~~their~~ were colour blind. find out the posibility of their first daughter to be colour blind.

father — $x^h y$ $x^c y$

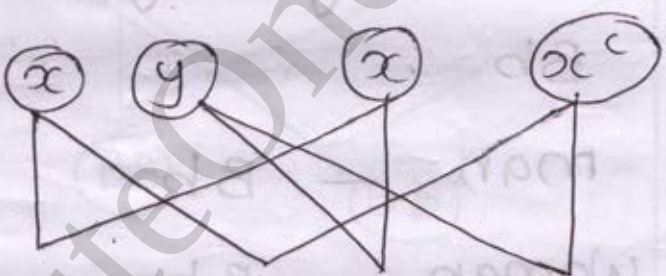
father — $x^h y$, $x^c y$

husband — $x y$

mother — $x x^c$

Parents $x y$ $x x^c$

gametes



xx xx^c xy $x^c y$

The Possibility of their first daughter to be colourblind is 0%.

Q A person whose father is colour blind marries a lady whose mother is daughter of colourbind man and woman.

Their children will be?

father — $x^c y$ $x\ x$

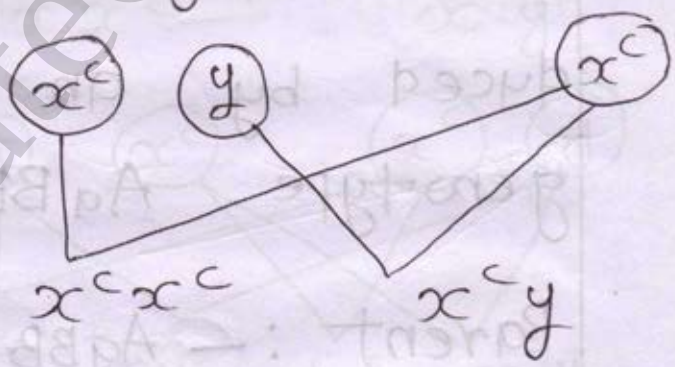
Son — $x\ y$

grand father — $x^c y$

grand mother — $x^c\ x^c$

Parents $x^c y$ $x^c x^c$

gametes



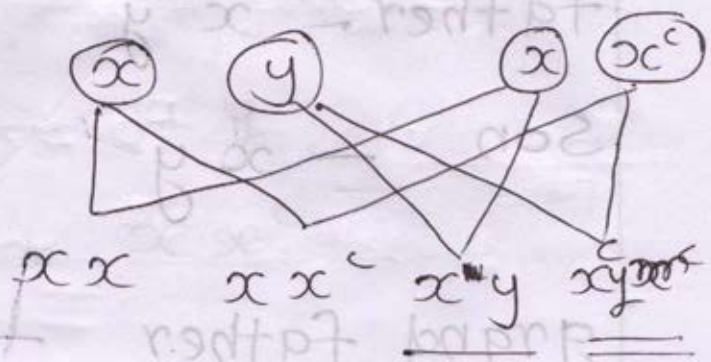
ladies mother — $x^c\ x^c$.

lady — $x\ x^c$

Parents son lady

$x\ y$ $x\ x^c$

gametes



50% of their son.

Q find out the gametes produced by an individual of genotype AaBB cc Dd

Parent :— AaBB cc Dd

gametes (ABcD) (ABcd) (aBcD) (aBcd)

no. of gametes = 2^n

n = heterogametic condition

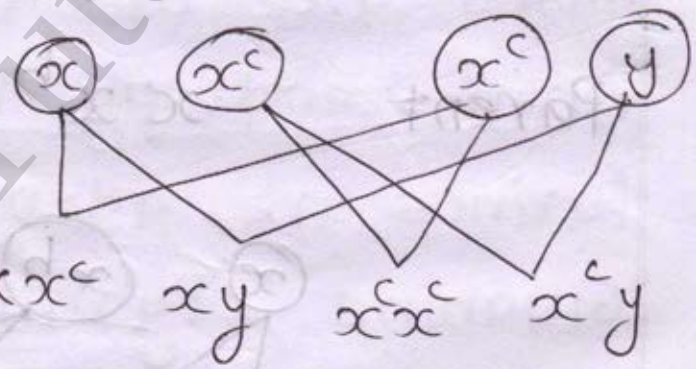
Q A colour blind man has a colour blind sister and a normal brother. Find out the genotype of father and mother.

An: man — $x^c y$

sister — $x^c x^c$

normal man — xy

Parents xx^c — $x^c y$



xx^c xy $x^c x^c$ $x^c y$

∴ the genotype of father is $x^c y$ and mother is xx^c.

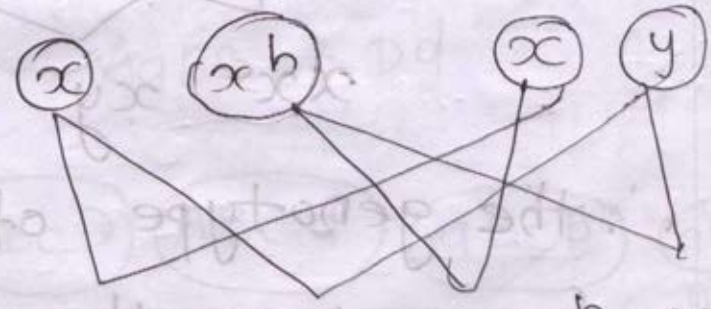
Q A woman's father has haemophilia but her husband does not. what is the changee of their son to has the disease.

Ah. father — $x^h y$ $x\ x$

woman — $x x^h$

husband — $x y$

Parent $x\ x^h$ $x\ y$



$x x$ $x y$ $x x^h$ $x^h y$.

Their son has to be disease 50%.

50/. chance