Unit: I. Genetics Dr. S.K.
II M.Sc, Zoology

Mendel's Law of Inheritance :-

⇒ Based on mendel's experimental results certain principles are framed.
⇒ These principles are called Mendel's Law. There are as follows.
1. Law of dominance
2. Law of segregation (or) Law of purity of gametes.
3. Law of independent assortment.

1. Law of Dominance :-

⇒ Each organism is formed of a bundle of characters is controlled by a pair factor of genes (Tort).
⇒ Each of paired factors (TT) is responsible for the expression of a particular character (height).
⇒ Mendel's Law of dominance states that one factor in a pair may mask or prevent the expression of the other.
⇒ The F_1 generation of his monohybrid cross as dominant.
⇒ which did not appear in the F_1 generations as recessive.

⇒ A recessive factor freely expresses itself in absent of its dominant alleles.

⊛ This Law is formulated based on the monohybrid experiment

Cross No	Characters of the Parents	Dominant Character in F1 offspring
1.	Tall Stem x Dwarf Stem	Tall Stem
2.	Axial flower x Terminal flower	Axial flower
3.	Green pods x yellow pods	Green pods
4.	Inflated pods x wrinkled pods	Inflated pods
5.	Round Seeds x Wrinkled Seeds	Round Seeds
6.	Coloured Seeds x white Seeds Coat	Coloured Seed Coat
7.	Yellow Cotyledon x Green Cotyledon	Yellow Cotyledon

2. Law of Segregation:-

⇒ Each organism is formed bundle of characters.

⇒ Each character is controlled a pair of genes

⇒ The two genes of a particular character remain uncontaminated,

⇒ when they are inside the organism.

⇒ During gamete formation the genes of a particular character separate and enter different gametes.

⇒ This is Law of Segregation.

⇒ This Law is also called Law of purity of gametes.

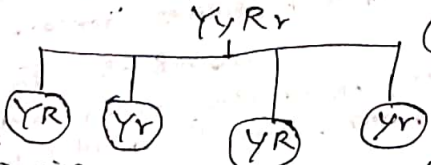
Ex:- During gamete formation paired factor (Tt) present in the F1 plant segregate.

⇒ So each gamete receives either T or t from paired of factors Tt,.

3. Law of Independent Assortment:-

⇒ This Law is based on dihybrid Experiment

⇒ "The genes for each pair of characters separate independentaly from those of other characters during gametes formation.



(independent assortment of genes from a dihybrid)

Ex:-

⇒ During gamete formation a dihybrid cross.

⇒ The gene Y may combine with the dominant gene R (or) the recessive gene r of the other character enter a gamete.

⇒ So F1 dihybrid plants produce four types of gametes and they are YR, Yr, YR, yr.

Monohybrid Experiments

⇒ The crossing of two plants differing in one character is called Monohybrid Crossing.

⇒ Mendel carried out monohybrid experiments on pea plant for all seven characters.

⇒ Independently and based on the results monohybrid experiments, formulated "Law of Segregation".

⇒ Mendel selected two pea plants
⇒ one with a tall stem, and other with the dwarf or short stem.

* Parental generation (P) : Tall × Dwarf
  ↓
  First filial generation (F_1) : Tall

  F_1 plants are crossed : Tall × Tall

  Second filial generation (F_2) : Tall 75% , Dwarf 25%

Monohybrid experiments

⇒ They were tall and dwarf. Mendel Counted the numer of tall and dwarf
⇒ Of the 1064 plants F_2 generation

⇒ 787 plants were tall and 277 plants were dwarf, i.e; 75% were Tall plants and 25% dwarf plants.

Parents : Male — Tall TT ; Female — Dwarf tt

Gametes : T , t → Tt

F_1 : Tall : Tall
Tt × Tt

F_1 plants are crossed.

Gametes : T, t, T, t

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

Monohybrid Experiment.

Phenotypic ratio : 3 : 1 Tall : Dwarf
Genotypic ratio : 1 : 2 : 1 TT : Tt : tt

Dihybrid Experiment:

⇒ The crossing of two plants differing in two characters is called dihybrid experiment.

⇒ For this experiment Mendel considered the combination – Colour (yellow and green) and seed – Shape (round and wrinkled) of pea plants as two characters.

⇒ Mendel selected a pure breeding yellow round, seed producing plant another pure breeding green, wrinkled seed producing plant.

⇒ The two plants were treated as parents and were crossed.

⇒ F1 generation plants produced only yellow round seeds. F1 plants were self-fertilized.

⇒ F2 generation, four kinds of plants were produced, they were,

a) plants producing yellow round seeds.
b) plants producing yellow wrinkled seeds
c) plants producing green round seeds
d. plants producing green, wrinkled seeds.

and

The occured in the ratio 9 : 3 : 3 : 1 respectively

Parents : Yellow Round × Green wrinkled
YYRR yyrr

Gametes : (YR) (yr)

F1 : YyRr
Yellow Round

F1 plants are crossed: YyRr × YyRr

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

Gametes	(YR)	(Yr)	(yR)	(yr)
(YR)	YYRR Y,R	YYRr Y,R	YyRR Y,R	YyRr Y,R
(Yr)	YYRr Y,R	YYrr Y,W	YyRr Y,R	Yyrr Y,W
yR	YyRR Y,R	YyRr Y,R	yyRR G,R	yyRr G,R
yr	YyRr Y,R	Yyrr Y,W	yyRr G,R	yyrr G,W

F2 Phenotypic ratio 9 : 3 : 3 : 1.

Yellow Round : 9
Yellow wrinkled : 3
Green Round : 3
Green wrinkled : 1

✱ Incomplete dominance

⇒ Incomplete dominance is an allelic interaction.
⇒ Both alleles of a character express their characters in the F_1 generation.
⇒ Eg. Mirabilis Jalapa (Four O'clock plants)

I. Inheritance of flower colour in Mirabilis.

⇒ Homozygous red flowered (RR) 4'o clock plant Mirabilis crossed.
⇒ Homozygous white flowered plant (rr).

Parents : Red flower × white flower
RR ♀ ↓ rr ♀

F_1 : Pink colour
Rr ♀
↓
Pink × Pink
Rr × Rr

F_1 crossed :

RR	Rr	Rr	rr
♀	♀	♀	♀
Red	Pink	Pink	white.

Ratio : 1 : 2 : 1

Inheritance of flower colour in Mirabilis.

2. Inheritance of flower colour in pea plant.

⇒ In the pea plants (the same plant which Mendel selected for his experiments)
⇒ red flower dominant (RR)
⇒ white flower is recessive (rr)
⇒ F_1 plants produces pink colour Rr
⇒ F_2 plants in the ratio 1 Red : 2 pink : 1 white.

✱ Over dominance :-

⇒ The two genes controlling a character are called alleles.
⇒ Two alleles, one alleles expresses its character in the F_1 generation.
⇒ It is the dominant allele.

P : Tall × Dwarf
F_1 : ↓
Tall

⇒ dominant allele completely masks expression recessive allele.
⇒ The dominance is called complete and over dominance.
⇒ The phenotype of the heterozygote is always like that of homozygous.
⇒ F_1 tall plant of mendel's experiment.

⊛ Co-dominance

⇒ Codominance is an allelic Interaction.

⇒ In heterozygote, both allele express their character. These genes Co dominant genes.

⇒ In Codominant inheritance, monohybrid ratio is 1 : 2 : 1

The following exples for codominance.

1. Coat Colour in Short horn cattle
2. ABO blood group
3. MN blood group
4. Sickle cell Anaemia.

1. Inheritance of Coat colour in Short horn Cattle.

Parents : Red × white
RR ↓ rr

F1 Individual : Rr
Roan

F1 crossed : Rr × Rr

F2 : RR Rr rr
Red Roan white

⇒ There are two colours of hair
⇒ Red and white.
⇒ F1 has third colour having both red and white hairs.

2. ABO Blood group:-

⇒ ABO blood group in man is a codominant characters.

⇒ Human beings are classified into 4 group in the ABO systems.

⇒ They are A, AB and O. The homozygous A group has genotype $I^A I^A$.

⇒ The gene I^A produce antigen A in A group persons.

A group
$I^A I^A$

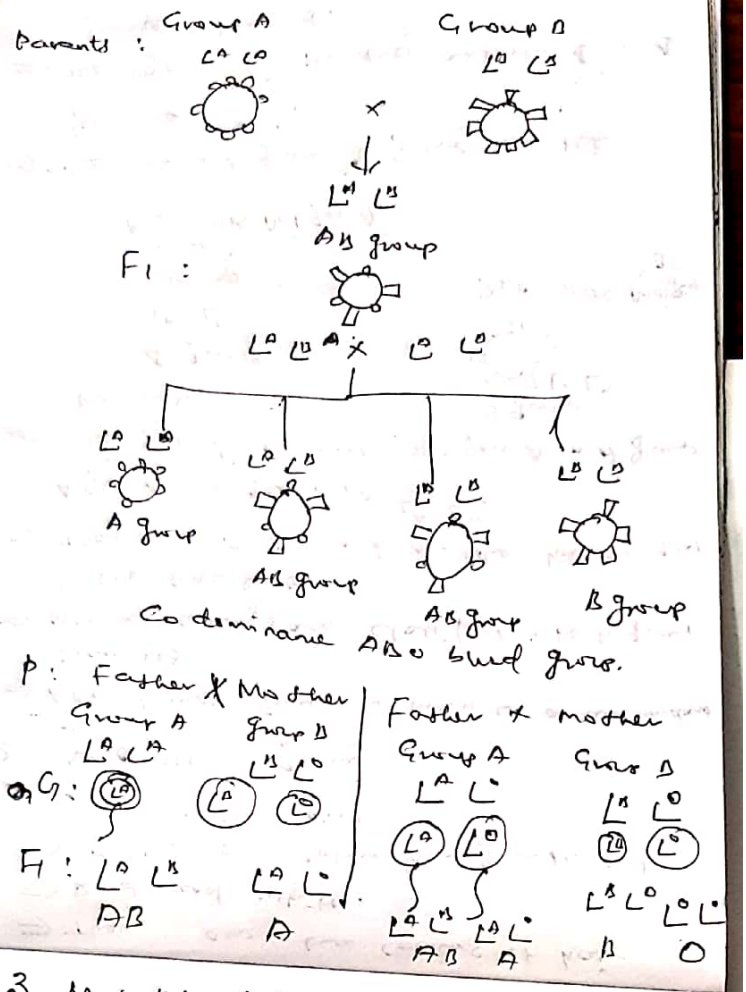
RBC with Antigen 'A'

B group
$I^B I^B$

RBC with Antigen 'B'

⇒ The homozygous 'B' group has the genotype $I^B I^B$.

⇒ The gene I^B produces antigen 'B' in B group persons.



P : Father × Mother

Father: Group A, Mother: Group B

G :

F1 : AB, A

Father × mother

Father: Group A, Mother: Group B

AB, A, B, O

3. MN Blood group:-

⇒ Human beings are classified 3 types,
⇒ MN blood group.
⇒ They are M, N and MN groups. The M group persons have genotype $L^M L^M$.
⇒ The gene L^M produces antigen 'M' on the surface of RBC.
⇒ The N group persons genotype $L^N L^N$,
⇒ The gene L^N gene produces antigen N on the surface RBC.

P : M group × N group

$L^M L^M$ × $L^N L^N$

$L^M L^N$

F1 :

MN group

$L^M L^N$ × $L^M L^N$

F2 : $L^M L^M$, $L^M L^N$, $L^M L^N$, $L^N L^N$

M group | MN group 2 | N group

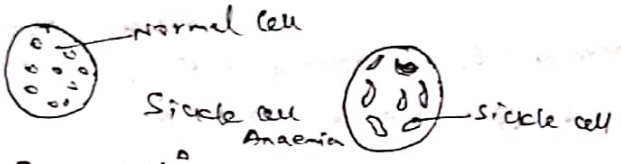
4. Sickle cell Anaemia:-

⇒ Sickle cell Anaemia is hereditary blood disease characterised by the presence sickle shaped RBC under Low Oxygen pressure

⇒ Sickle cell anaemia person have the genotype $Hb^S Hb^S$.

⇒ The gene Hb^S produes defective haemoglobin (Hb) Causing sickling of RBC (S = Sickle)

⇒ The normal person have the genotype $Hb^A Hb^A$.



⇒ The gene Hb^A produe adult haemoglobin

⇒ Normal haemoglobin (A = Adult)

⇒ heterozygous individuals ($Hb^A Hb^S$) both normal haemoglobin and defective

⇒ So the gene Hb^A and Hb^S are Codominant.

⊛ Multiple Alleles.

⇒ A set of three or more alleles of the same gene on the homologous chromosomes to control a particular traits is called Multiple Alleles.

⇒ The ABO blood group is controlled by multiple alleles. The following are example

1. ABO blood group
2. Rh blood group
3. Nature of wings in Drosophila
4. Coat colour in rabbit
5. Self sterility in tobacco.

1. ABO blood group:-

⇒ Landsteiner found four types of human beings depending on the presence (or) absence antigens in blood.

⇒ They are A, B, AB and O

⇒ 'A' group persons antigen 'A' on the RBC

⇒ 'B' group persons antigen 'B' on the RBC

⇒ 'AB' group persons contain both antigen 'A' and 'B' on the RBC.

⇒ 'O' group persons contain no antigen on the RBC.

⇒ A group person have antigen A and antibody b. O group person has antigen B and

Antibody a-

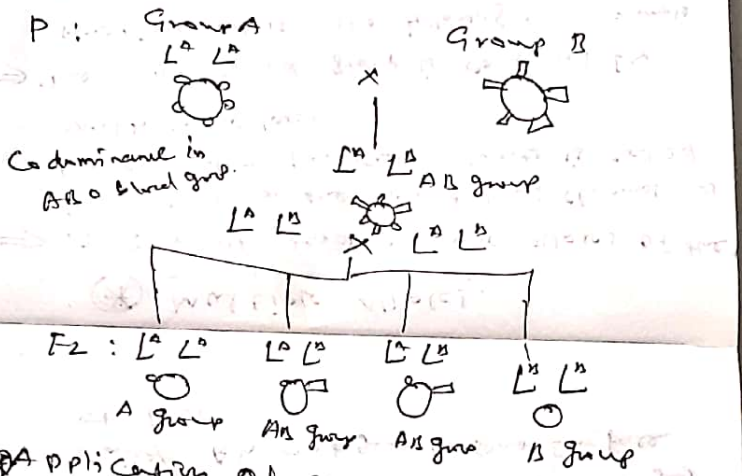
⇒ A cannot co-exist with antibody a in any man.

⇒ Similarly, antigen 'B' cannot co-exist with antibody b.

Distribution of antigen and antibody in ABO blood group

Group	Antigen	Antibody
A	A	b
B	B	a
AB	A and B	Nil
O	Nil	a and b

⇒ AB group person contains $L^A L^B$, O group contains $L^O L^O$.



Application of ABO Blood Group:-

1. Blood Tranfusion
2. Disputed parantage
3. Identification of culprit.

1. Blood Transfusion:-

⇒ The Transfer of blood from one person to another is called "blood transfusion".

⇒ The person donating blood is called donor.

⇒ The receiving blood is called recipient.

⇒ O group person is the "universal donor"

⇒ AB group person is called universal recipient.

	A	B	AB	O
A	−	+	−	+
B	+	−	−	+
AB	+	+	−	+
O	−	−	−	−

Grouping of blood.

+ : agglutination − : No agglutination

2. Disputed parentage:-

⇒ The parents of a disputed baby can be confirmed by testing the blood groups of the doubtful parents.

⇒ Two mothers for a single child case is happened in the court of (King Soloman)

3. Identification of culprits:-

⇒ In murder cases.

⇒ The culprits can be confirmed, if the culprits blood stain is available at the place of Murder.

⊛ Rh. Blood Group:- "Rhesus Monkey"

⇒ Rh blood group was discovered Landsteiner and wiener in 1940.

⇒ It is controlled by multiple allales same homologous chromosomes.

⇒ There are two groups of human beings 'Rh' positive (Rh^+) and (Rh^-) negative.

⇒ Rh positive person contain antigen called Rh antigen present surface of RBC.

⇒ Rh antigen is "Rhesus antigen" as it was first discovered in "Rhesus Monkey".

⇒ Rhesus antigen is also called 'Rh' factor.

⇒ The Rh factor follows the Mendelian principles of inheritance.

Parents:	Father × mother	Father × Mother
	Rh^+ Rh^-	Rh^+ Rh^-
	RR × rr	Rr × rr
Gamets:	(R) (R) (r)	(R) (r) (r)
children	(RR) : Rr	Rr rr
	Rh^+ Rh^+	Rh^+ Rh^-

Marriages and children of Rh blood group

⇒ There are two views regarding of Rh blood group.

⇒ They are as follows,

1. wiener's theory
2. Fisher's theory.

⇒ 1. wiener's Theory:-

⇒ wiener proposed that Rh blood ~~group~~ and ~~the remaining genes control Rh+ blood~~. group is controlled by 8 multiple alleles.

r	R_1
R_0	R_2
R_1	R_y
R_{2L}	R_y

Of these r controls the Rh⁻ blood the remaining genes control Rh⁺ blood.

As per

⇒ Hypothesis, the Rh⁻ group is controlled by rr genes

⇒ Rh⁺ group controlled any one follow genotype,

R_0R_0 R_2R_2 R_yR_y R_0R_1 R_1R_x

R_1R_1 R_xR_x R_0r R_1r R_1R_y

2. Fisher's theory:-

⇒ Fisher proposed that three genes are involved in the production of Rh antigen and three genes are lying so close together on the chromosome.

⇒ Such as gene are "Pseudoalleli".

⇒ So the different genotype of the Rh positive person as follow,

CDE/CDE	CDE/cDe	CDE/cde
CDE/cde	CDe/cde	Cde/cde
Cde/cdE	Cde/cDE	cde/CDE
cde/CDE	CDE/CDE	etc...

Application of Rh Blood Group

1. Erythroblastosis foetalis
2. Blood Transfusion.

1. Erythroblastosis foetalis:-

⇒ Erythroblastosis foetalis is a haemolytic disease of new born baby characterized by Jaundice and anaemia due to haemolysis.

⇒ It is so named because of circulating erythroblasts.

parents:	Father	Mother
	Rh⁺	Rh⁻
	RR	rr
Gametes:	R	r
	Rr	
Child:	Rh⁺	

⇒ The Rh antigen of the baby enters the blood of the mother.

⇒ The blood of the mother produces Rh antibody. When this antibody enters the foetus, the foetus is affected.

⇒ The Rh antibody destroys the RBC of the foetus.

⇒ The destruction of RBC leads to haemolytic jaundice and anemia.

⇒ The dead RBC's are carried to liver for disintegration.

⇒ The waste is taken out of the body.

Prevention in haemolytic disease:

⇒ The anti-D or anti Rh vaccine prevents the mother.

⇒ The destruction of Rh+ foetal cell in the maternal blood can be simple using injection of anti-Rh vaccine here.

Treatment:

⇒ The best treatment for fetal haemolytic disease is an exchange transfusion carried out soon after birth.

Gene Interaction

⇒ The expression of a single character by the interaction of more than one pair of genes is called "Gene Interaction".

⇒ "Bateson and Punnet" proposed factor hypothesis to explain gene interaction.

⇒ The gene interaction is of two types, namely

I. Non-Allelic gene interaction

II. Allelic gene interaction.

I. The genic interaction occurring between genes located in different loci of the same chromosomes or different chromosome is known as non-allelic interaction.

II. The genic interaction between the two alleles of a single locus is known as allelic gene interaction.

⇒ Some of the important kinds of gene interaction are as follows.

I
1. Complementary genes
2. Supplementary genes
3. Duplicate genes
4. Epistasis
5. Lethal genes

non allelic gene interaction.

II
1. Simple dominance
2. Incomplete dominance
3. Co-dominance
4. Allelic gene interaction.

⊛ Epistasis

⇒ Epistasis is the prevention of the expression of one gene by another non-allelic gene. Epistasis means stopping or inhibiting.

⇒ The inhibiting gene is called epistasis gene.

⇒ The inhibited gene is called hypostatic gene.

⇒ Dominant epistasis

⇒ The prevention of the expression of a gene by a dominant non-allelic gene is called dominant epistasis.

⊛ -

Unit-II Genetics Dr. S.K.

M.Sc. Zoology

⊛ CHROSOME AND MUTATIONS :-

Sex chromosome : determination of sex.

⇒ The development of a zygote into male or female sex determination.

⇒ Sex is a character.

⇒ It has two alternatives namely
* Maleness
* Femaleness

⇒ The male prodves the sperm and the female produces the egg.

⊛ Sex determination in Man

In man

⇒ Sex is determined by three factors namely, 1. Chromosomes
2. Barr body
3. Hormones.

1. Sex determination by Chromosomes :-

⇒ The determination of sex by chromosomes is called Chromosomal theory of sex determination.

⇒ It was proposed Mc Clung.

Parents : Father × mother

Gametes : 22AA+X 22AA+X | 22AA+X

F1 : 22AA+XX | 22AA+XY

Female | Male

2. Sex Determination Barr body :-

⇒ The Barr body darkly stained inactivated X chromosomes attached to the inner surface of nuclear membrane is called Barr body. It was discovered Barr.

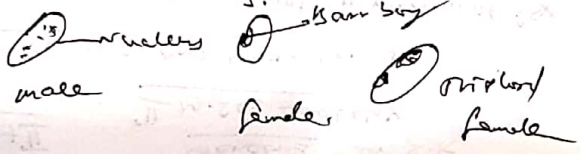
⇒ The Barr body is inactivated X chromosome

⇒ The sex is identified by the presence or absence of Barr body.

⇒ The male has no Barr body in the nucleus

⇒ The female have one Barr body

⇒ The triploid female have two Barr bodies.



2. Sex Determination by Hormones :-

⇒ In man, sex is regulated by Hormones.

⇒ Sex reversal occurred due to hormonal unbalance.

⇒ When the testes of the male are removed before puberty, female characters develop.

⇒ Tumours of the adrenal in woman causes masculine characters.

Sex determination Diplophilus :-

Two mechanisms of Diplophilus.

1. Chromosomal Theory of Sex determination
2. Genic Balance Theory.

(*) Cytoplasmic Inheritance

⇒ The transmission of characters controlled by plasmagenes is called cytoplasmic inheritance.

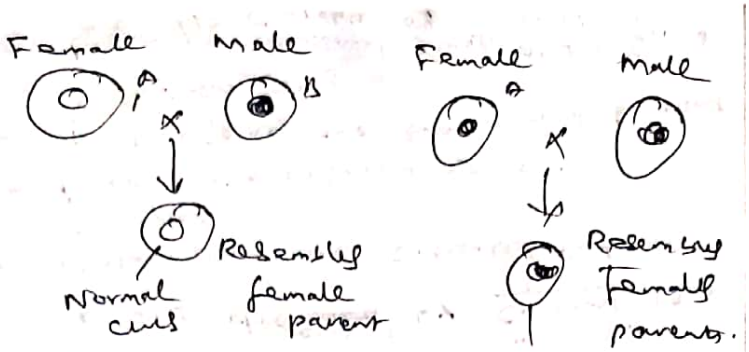
It was discovered by "Correns" 1908.

⇒ plasmagenes are situated in the cytoplasm.

⇒ Like chromosomal genes.

⇒ plasmagenes are transmitted by means "cytoplasm" only.

⇒ Like chromosomal genes, plasma genes are also capable of mutations.



Ex:-

1. Kappa particles in paramecium
2. Shell coiling in snail
3. Plastid inheritance in mirabilis.

(*) Linkage :-

=> Linkage is defined as the tendency of two or more genes to remain together in the original combination in the same chromosome during the process of inheritance for a number of generations

=> Linkage was discovered by T.H. Morgan

=> Linkage was in Drosophila, sweet pea, maize, man, etc.

Complete and Incomplete Linkage.

=> In complete Linkage, linked genes inherit together for many generations.

Ex:- => 1. Body colour and shape of wings in male Drosophila.

2. Beaut wings and shaven bristles in the 4th chromosomes of Drosophila.

=> Complete linkage is the phenomenon in which two or more genes or characters are inherited together for a number of generations.

=> The phenomenon is very rare. it is found only in male Drosophila.

=> F1 male hybrid is back crossed with recessive female parent.

=> F1 male hybrid ~~is~~ produces and(l) are inherited together.

Incomplete Linkage

=> The separation of linked genes during inheritance is called incomplete linkage.

Ex: 1. Body colour and wing shape in female Drosophila.

2. Seed colour and shape in maize

3. Flower colour and pollen grain shape in sweet pea.

⊛ Crossing over

Definition:-

⇒ Crossing over is the interchange of chromosomal parts between non-sister chromatids of a homologous pair of chromosomes resulting in recombination of genes.

⇒ Crossing over was discovered "Morgan"

Mechanism:-

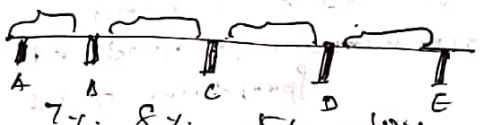
⊛ Chromosome mapping:-

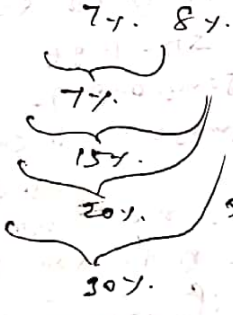
⇒ The chromosome map may be defined as a line, on which the genes are represented by points separated by distances proportional to the amount of "crossing over."

⊛ Procedure for the chromosome Mapping

⇒ The actual distance between two genes is said to be equivalent to the percentage of crossing over between those genes.

For Ex:- Five genes; A, B, C, D and E. are plotted chromosomes.





Diagramatic representation of the method of locating genes on a chromosome based on % crossing over.

***Construction of chromosome map in Drosophila:-**

⇒ In Drosophila, the chromosome map is constructed with the help of test cross.

⇒ F1 female hybrid is test crossed.

⇒ Two types of parental type (G:L & B:V) and other two are non-parental type (G:V & B:L).

⇒ F1 female hybrid is test crossed.

⇒ So the distance between the gene G & L is equivalent 17 Morgan Units.

⊛ Chromosome Numerical changes :-

Aneuploidy :-

⇒ Aneuploidy is a chromosomal abberrations where there is a gain (or) loss of one more chromosomes in a set.

⇒ Aneuploidy is caused by non-disjunction of chromosomes.

There are 3 types,

1. Monosomy
2. Nullisomy
3. Trisomy.

1. Monosomy :-

⇒ Monosomy is a chromosomal aberration where one chromosome is lost from a pair.

⇒ A monosomic Drosophila 8-1 = 7 chromosomes. A monosomic man has 46 - 1 = 45 chromosomes.

⇒ It is unviable.

⇒ Ex: Produced woman when an egg without an X chromosomes

⇒ Turner's Sysdrome.

(22 + 0) + (22 A + X) → 22 A A + XO

Monosomy with the loss of one X chromosome. Turner's Syndrue.

2. Nullisomy :-

⇒ Nullisomy is a chromosomal aberration where both the chromosomes of a pair are lost. It is represented by 2n - 2

(3A + 0) + (3A + 0) → 3AA + 00

3. Trisomy :-

⇒ Trisomy is a chromosomal aberration where one chromosome is added to a pair.

⇒ It represented by 2n + 1.

⊛ Euploidy :-

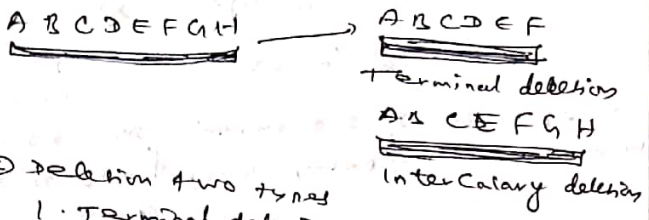
⇒ Euploidy is a chromosomal abberration involving change in the number of chromosome sets. two types.

1. Haploidy
2. Polyploidy.

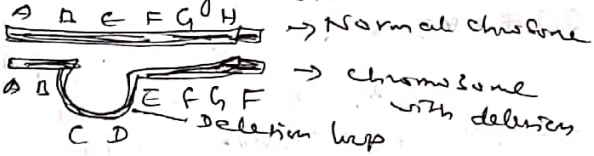
Structural changes:-

(*) Deletion

⇒ Deletion is a chromosomal aberration where a segment of the chromosome is lost.

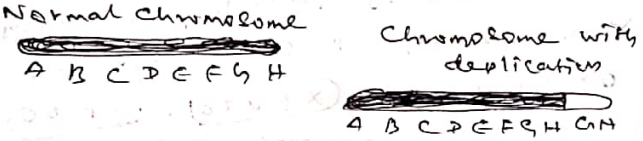


⇒ Deletion two types
1. Terminal deletion
2. Intercalary deletion.



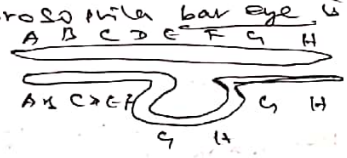
(*) Duplication:-

⇒ Duplication is chromosomal aberration where a segment is repeated.



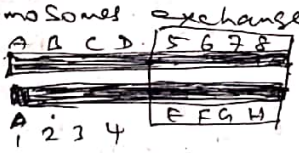
⇒ During meiosis, the duplicated segment forms a loop.

⇒ Drosophila bar eye is a due duplication



(*) Translocation:-

⇒ Translocation is a chromosomal aberration where non-homologous chromosomes exchange segments.



⇒ Translocation produces a cross-shaped structure during pairing.

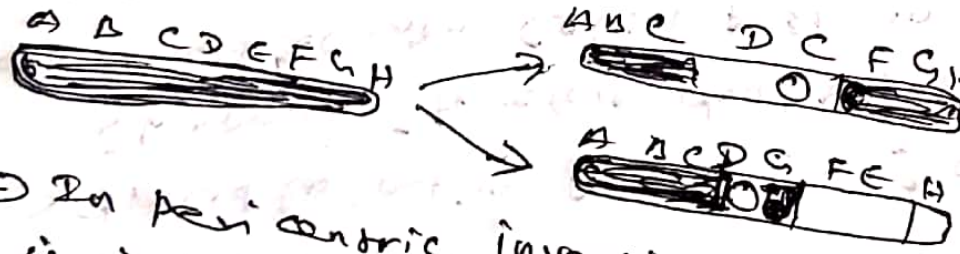
⇒ Translocation causes position effect.

⇒ Translocation alters the linkage groups.

Inversion

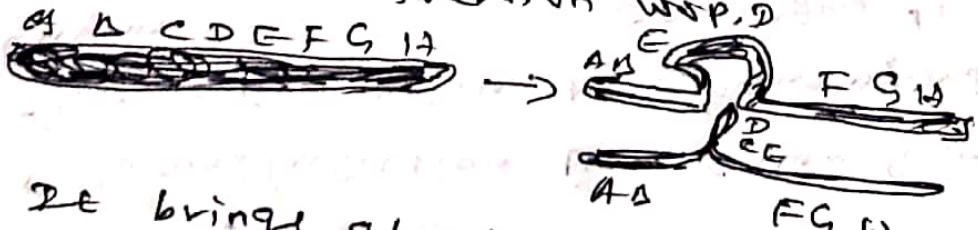
⇒ Inversion is a chromosomal aberration where a segment of chromosome breaks and reunits in the reverse order.

⇒ In version two types namely Pericentric Inversion and Paracentric Inversion.



⇒ In pericentric inversion, the centromere is included in the inverted segment.

⇒ The chromosome with the inverted segment produces an inversion loop.



⇒ It brings about position effect

⇒ Inversion produces variation and Speciation.
