Genetics

Botany (H) 3rd sem

Second unit

TYPES OF CYTOPLASMIC INHERITANCE

cytoplasmic inheritance are off three type

→ cytoplasmic inheritance involving essential organ-nail like chloroplast and mitochondria called as organellar inheritance
(Chloroplast and mitochondria show maternal inheritance)

→ Maternal effect depending indirectly on nuclear genes and involving no known cytoplasmic hereditary unit ~~and involving~~ called as predetermination. In this maternal effect is determined before fertilisation
eg - shell coiling in snail (Limnae peregra)

→ cytoplasmic inheritance involving dispensable and infective heriditary particle in cytoplasm which may or may not depend on nuclear gene called as Dauer modification
eg - Sigma particle in drosophilla, kappa particle in paramecium

Linkage

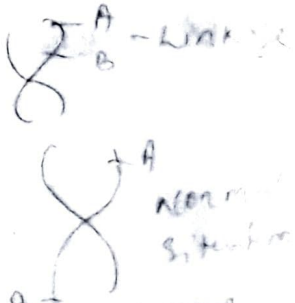
→ It is phenomenon of certin (2 or more) genes staying togather during inheritance through generation with out changes or separations as they are present on same chromosome

→ It is first discovered by Bateson & Punnet (1905) sweet pea (Lathyrus odoratus)

→ They give coupling and repulsion phenomenon.

→ Linkage can be thought of exception of Independent assortment

→ Morgan defined linkage as follows
All the gens present on a chromosome have the tendency to maintain original combination and to enter one and the same gamete

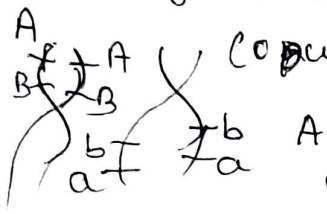


→ The tendency of two alleles to stay together is called coupling

→ The tendency of two alleles to avoid one another is called Repulsion.

* If the two alleles, such as A and B come from the same parent they tend to enter the same gamete & transmit together (Copuling phase)

* If the same alleles come from different parent they tend to enter in to diff^{n} gamete. (Repulsion phase)



Coupling phase

AABB x aabb

Cis

Repulsion phase

AAbb x aaBB

Trans

SUTTON DUE of Linkage

→ Sutton in 1903 predicated that each chromosome contains a gene during meosis chromosome move in to gamete as unit.

→ Hence all the gene which are situated in the same chromosome will be linked together as a result each species would have a specific number of groups corresponds with the number of chromosome

* Sc Batson and punnet

coupling and Repulsion hypothesis

→ B.P while working on sweet pea observe that flower colour and pollen shape tend to remain together & do not asort independently

Blue flower long pollen. X Red flower Round pollen

Blue long	Blue Round	Red long	Red Round
7	1	1	7

→ Batson and punett suggested that a gene comes from parents tends to same gamete & to be inherited togather

→ This phenomenon is called coupling similarly the gene comes from 2 diff^{n} parent tends to enter diff^{n} gamets and to be inherited separetly & independently this phenomenon is known as Repulsion.

CHROMOSOMAL THEORY of LINKAGE

proposed by Morgan and castel (1911)
According to this theory

- Gene thats show in linkage are situated on same chromosome. (in parental combination, except for crossing over)
- Linkage gene are arranged in liniex order
- The distance bet^{n} the linked genes in the chromosome determines the strength of the linkage.
- The closely located genes show greater linkage then the distant genes.
- Linkage genes depend on the original combination during inheritance.
- The linked genes show two types of arrangement
  Cis and Trans.

Cis - arrangement - Dominant alleles of both the gene are present on the chromosome while their recessive alleles are present over the its homologous chromosome

Trans - arr^{n} - presence of dominant alleles of one gene and recessive allele of the other gene on one chromosome (reverse arr^{n} of this genes present over its homologue.

TYPES OF LINKAGE

There are two types of Linkage

(1) Complete Linkage

(2) Incomplete Linkage

COMPLETE LINKAGE

→ Linkage in which gene always show parental combination. It never forms new combination

→ Crossing over is absent in it because gene are also located very closely on chromosome. (Reason)

* When the two or more genes remain together closely for a number of generations. the linkage is said to be complete.
* It produce only parental combination
* It is very rare and found in only male Drosophila & female silkworm moth

ex-

→ A Red eyes normal wings (RRWW) female Drosophila is crossed with male drosophilla have purple eye and vestigial wings (rrww)

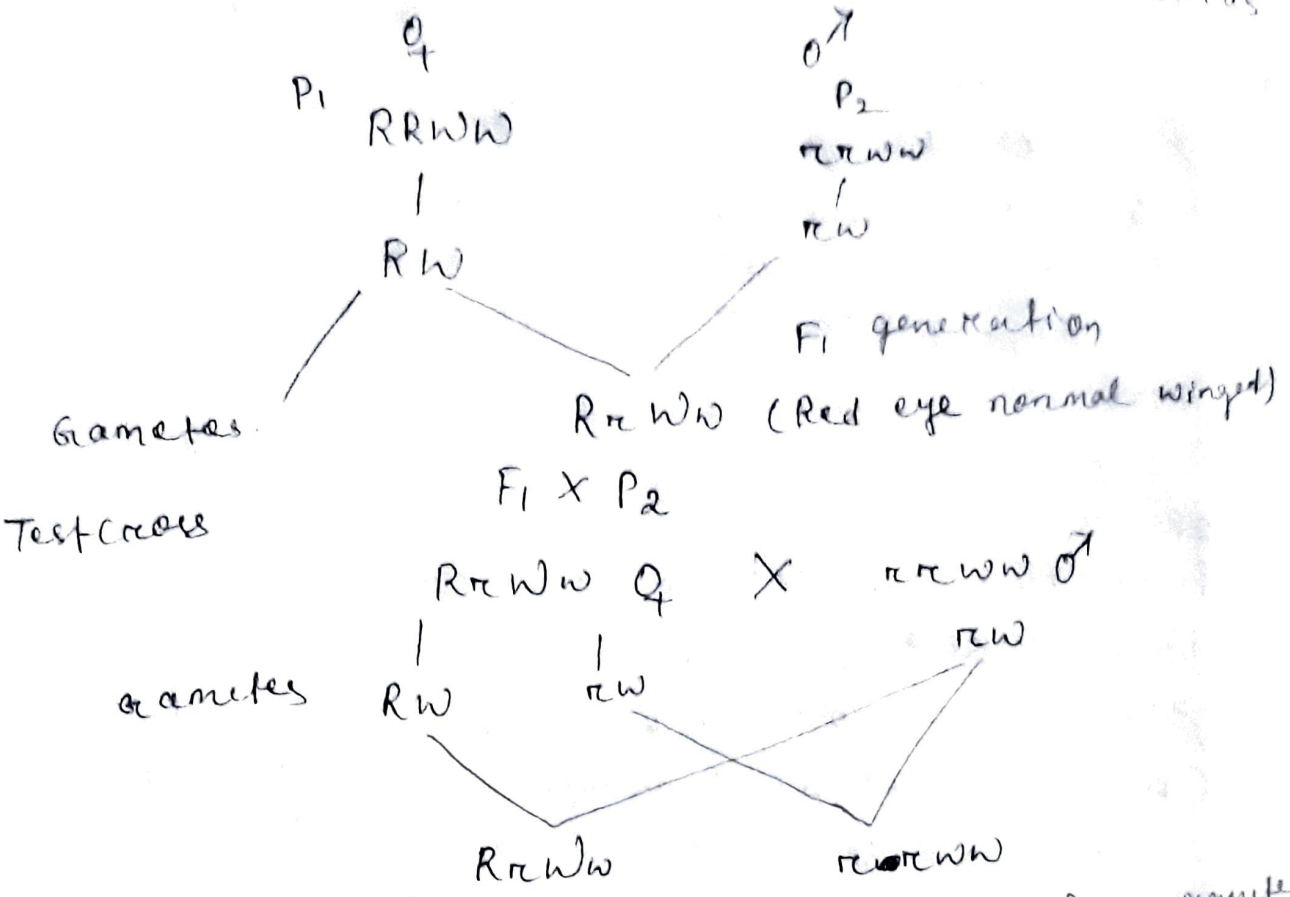
→ In f_1 generation ofspring are (RrWw) Heterozygous Red eyed & normal winged.

→ Now Heterozygous female fly (RrWw) is test crossed with a (rrww) Drosphilla male (Having P.E and V.W)

→ In f_2 generation red eye, normal wings (50%) and vestigial wings, purple eye (50%) in the ratio of 1:1

→ No recombinant types are formed because linkage is complete & no crossing over occurs.

Parents Red eyed, normal wings ♀ Purple eye, vestigial wings ♂



Due to complete linkage, instead of four gametes only two gametes are formed.

Test cross progeny	(R.E, N.W)	(P.E, V.W)
Ratio	1	1
Recombinants	Nill	

→ However, test cross between blue and long (BBLL) and double recessive (bbll) give blue long (Hybrid) (+3.7)

Red round (+3.7%)

Blue round (6.3%)

Red long (6.3%)

→ The parental combination are 93.7% are due to linkage in genes on two homologous chromosome.

→ While in case of new combinations (13.6%) the genes get separated due to breaking of chromosome at the time of crossing over in prophase-1 of Meosis

→ New combination due to incomplete linkage

SIGNIFICANCE OF LINKAGE

- Linkage plays an important role in determining the nature of scope of hybridization and selection programmes
- It holds the parental character together and also restricts the appearance of new recombination
- It helps in maintaining the valuable traits of newly developed variety
- It disallows the plant and animal breeding to combine all the desirable traits in a single variety.

CROSSING OVER

- Crossing over is the exchange of chromosomal part between non-sister chromatids of a homologous pair resulting in recombination of gene
- The non-sister chromatids in which exchang of segments takes place are known as cross overs or recombinants while other chromatids not involved in exchange of segments are called non-crossover or parental type
- The term crossing over was first introduced by T. H. morgan and castell (1912) & defined it as the separation of linked gene ~~cross~~
- The chiasma were first observed by Janssens (1909)
- The no of chisma is variable. min one chisma/ bivalent is the rule The highest number of chismata in long chromosomes of vicia faba has been observed to be 12/ bivalent

There are two types of crossing over depending on the cell types

(a) meiotic crossing over / germinal cross over

(b) Mitotic crossing over / somatic cross over

(i) Meiotic / germinal crossing over

→ It occurs in all sexually reproducing organisms when the undergo meiosis during gametogenesis.

→ It is primarily responsible for variation among the individuals of a species.

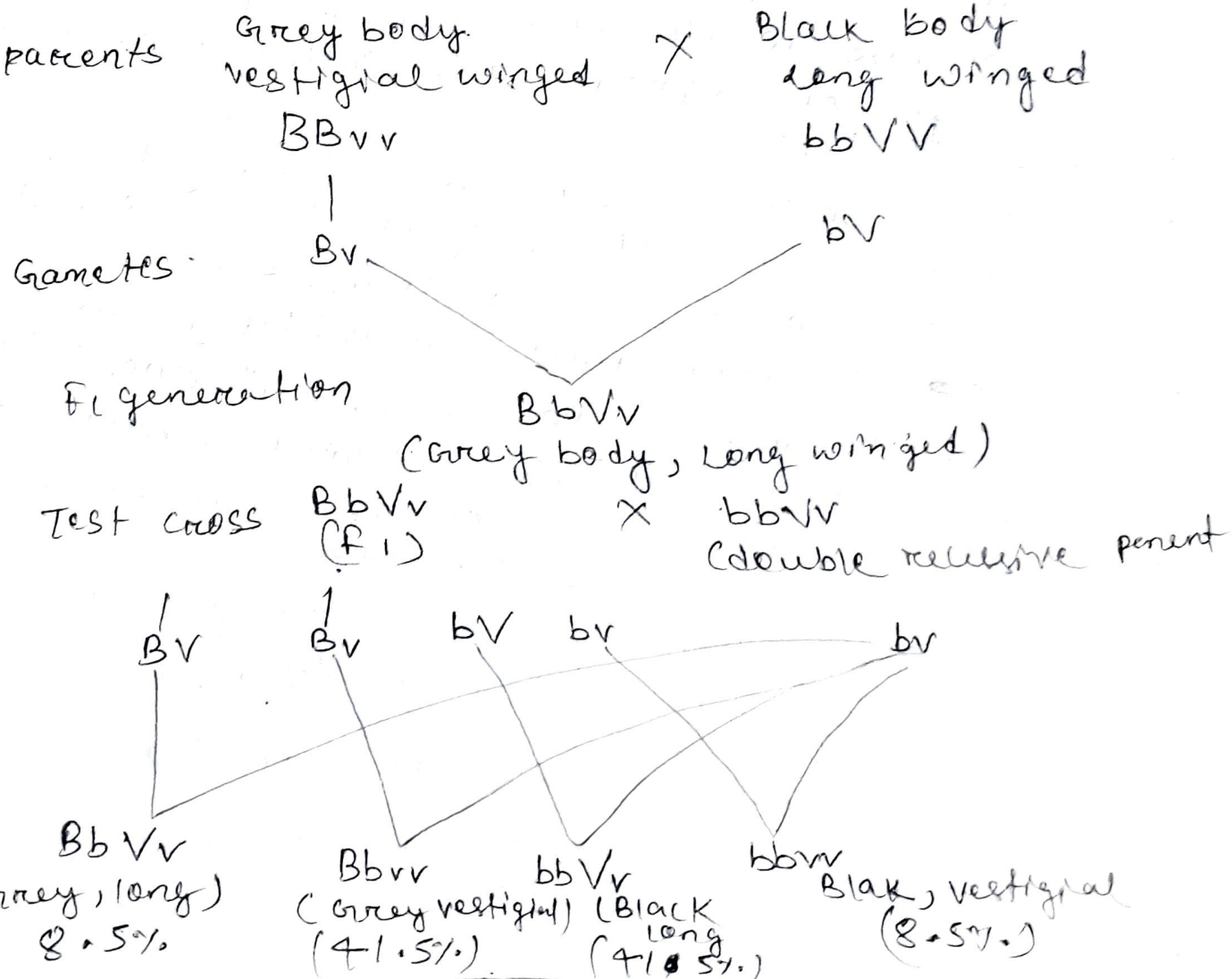
(ii) Mitotic / somatic crossing over

→ It is rare occurance in somatic cell during mitotic cell division.

→ It has no significance from the point of view of inheritance.

→ It is observed in Drosophilla and Aspigillus nedulence.

* Crossing over is absent in female silk worm and male Drosophila during sperm formation by ex- Crossing over was reported in Drosophila by T. H. Morgan



~~Part~~ in F_1 generation show (BbVv) Grey body, long wing drosophilas

parental combination Bbvv (Grey, vestigial) (41.5%) bbVv (Black, long) (41.5%)

Recombinant combination BbVv (Grey, long) (8.5%) bbvv (Black, vestigial) (8.5%)

frequency of crossing over

→ $\frac{\text{no. of recombinant progeny in the test cross}}{\text{Total no. of progeny in the test cross}}$

OR

$C\% = \frac{\text{no. R. progeny in t.c}}{\text{Total no R.P in t.c}} \times 100$

MECHANISMS OF CROSSING OVER

Crossing over occurs during meiosis of gametogenesis

1. Synapsis
2. Duplication Chromosome
3. Exchange of chromosomal part
4. Terminalisation

Synapsis (meiosis)

→ During the zygotene stage of prophase-I the homologous chromosome move towards the each other and come to present side by side longitudinally This pairing of homologous chromosome is synapsis

→ The paired chromosome are called bivalent.

→ In some organism, a network of filamentous str appears betn two chromosome during the process during the process of pairing called synaptonemal complex help in the synapsis

DUPLICATION of CHROMOSOME

→The bivalent undergoes duplication during pach pachytene stage.

→Each two homologous chromosems splits longitudi in to chromatids.
Hence 4 chromatids are produce & called tetrad stag

→The two chromatids of a chromosome are attachi to a single centromere so called sister chromatid

Exchange of chromosomal part / crossing over

→The non-sister chromatids of a chomologous chromosome intercross to each other at certain point called as chiasmata (~~centromere~~)

→At the chiasma, the chromatids break by endonuclease enzyme.

→The broken segregate of non-sister chromatids are exchanged and fused with the other chromatids in presence of an enzyme ligase.

→The exchange of chromosomal segment between non-sister chromatids is called crossing over

TERMINALIZATION

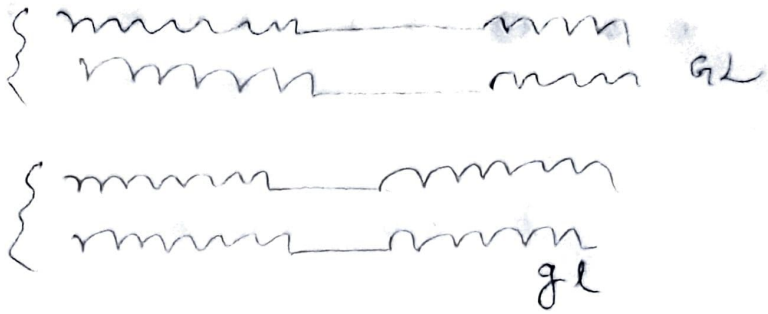
-> After the exchange of the chromosomal segment the non-sister chromatids repel each other

-> The separation begins from the centromere and moves towards the end of chromosome

-> During separation of chromosome, the chismata move towards end of the chromosome. This process is called terminalisation.

1) One bivalent

2) One Tetrad



Significance of crossing over

→ Crossing over provides direct proof for the linear arrangement of gene.

→ The segment of homologous chromosome are interchanged through crossing-over. Hence crossing over provides origin of new character and genetic variation.

→ Crossing over leads to construction of linkage Map and genetic maping of chromosome.

→ Crossing over plays an important role in the field of breeding to improved the varities of animals and plants.

characterestic of sex-linked inheritance

→ Individual showing a recessive sex-linked treat is noticeable Higher in heterogametic sex (male Drosophila & human & female birds) the homogametic sex (female Drosophilla & humans & male birds)

→ In male Human & Drosophila the sex linked traits are not transmited directly male parents to their male progeny.

→ In male human or Drosophila transmits its sex linked gene to all its daughters. These daughter transmitted this gene to half of their male progeny

→ Hence a sex-linked gene passes from male to female then back to male. This inheritance pattern is known as criss-cross inheritance

Casese

→ The inheritance is cause by mainly two reson.
a) The location of a gene in the X chromosome
b) The absence of its allele in the y chromosome

partical sex linkage

The human x and Y chromosome are morphologically distinct But they pair during meiosis in male cell the pairing occurs in the 2 telomeric region, which are called psedoautosomal regions (PAR).

There are 2 types
① PAR1
② PAR 2

→ The genes located in PAR1 & PAR2 are also present in the X chromosome. But these genes do not show the typical inheritance patterns for sex-linkage
Because these genes have alleles in the y chromosome as well.
→ As a result inheritance process responsible that of autosomal genes. These phenomenon is called partial sex-linkage and the chromosome region involved in it are reffered to as pseudoautosomal regions

Factor influenced crossing over

① sex - In drosophilla crossing over is completely supressed in male but very high in female. There is a tendency of reduction of crossing over in male mammals
2- Mutation- Gower first discovered that mutation reduced crossing over in all the chromosomes of drosophila
3- Inversion- crossing over is suppressed due to inversion
4- Temperature - plough shown that when a drosophilla is subjected to high & low temperature variation, The percentage of crossing over in certain parts of the chromosome is increased
5- X-ray effect - muller demonstrated that X-ray radiation increases crossing over near centromere.
6- Age- Bridges demonstrated when the female drosophilla becomes older, the rate of crossing-over increases
7- Nutrition- High calcium diet in young drosophilla decrease crossing over but diet deficient in calcium increase crossing over
8- Heterochromatin- It decreases crossing over.
(Dark/Deep colour of chromosome strains)

Chromosome maps →

The phenomenon of linkage and crossing over has established following facts

① The genes are arranged in a linear order in a chromosome

(ii) The linkage group in an organism are equivalent to the number of chromosome pairs.

(iii) Frequency of crossing over or recombination bet genes depends upon the distance between of crossing over are more betn 2 distinctly placed genes similarly the change of crossing over are less betn 2 closely placed genes.

→The strength of linkage is inversely proportional to the distance betn linked gene

→The position of gene is very definite in chromatids Basing the following observation Sturtevast in 1913 developed the idea the frequency of crossing over can be caused as a title for determination of relative distance betn the genes in a linkage groups.

Chromosome maps

→The chromosome map is the graphic representation of the relative distance betn the linked genes expressed in the percentage of recombination among the genes in a linkage group.

construction of chromosome maps (linkage maps):-

The construction of chromosome map includes following process.

① Determination of linkage group:-

The exact no. of chromosome of a given species is determined. The total no. of genes are determined by hybridisation experiment in betn wild & mutant strain.

→The no. of phenotypic trait which remain always linked is determined. The different linkage group of that species are found out.

② % Determination of map distance:-

The distance betn genes is determined by a unit called "morgan unit" or "map unit"

1 morgan unit represent 100% crossing over

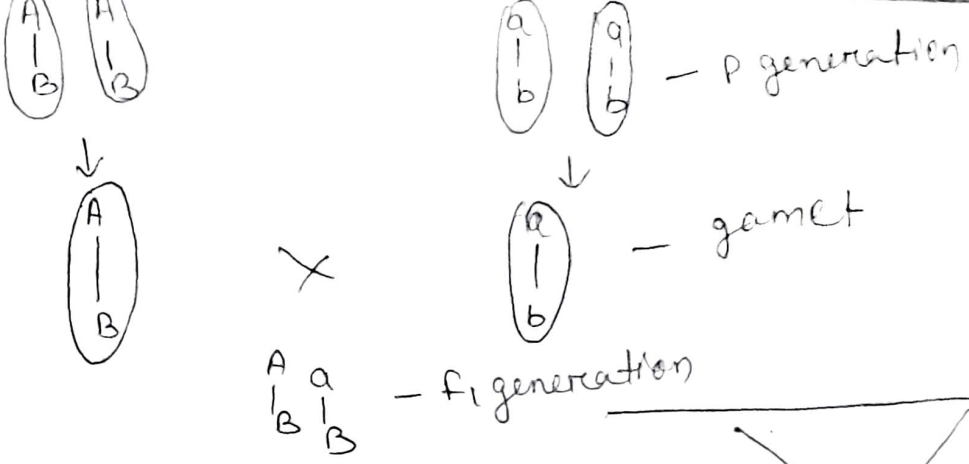
1 crossing over is expressed in 1 centimorgan or 1 map unit.

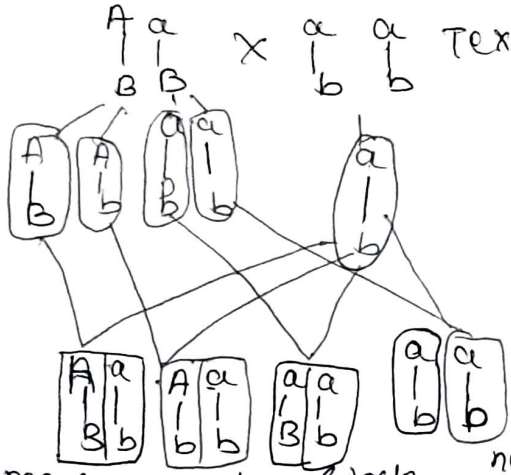
Expt -suppose the percentage of crossing over betn gene A & B is 26%. then the distance betn A & B is 26 cm or map unit.

③ 2 point of test cross:-

The percentage of crossing over betn linked gene is capa

by test cross





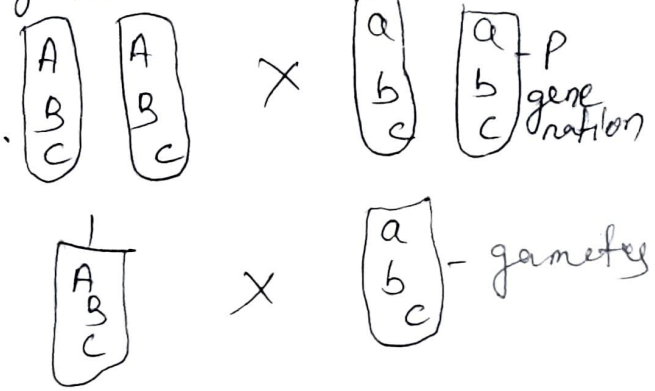
Total single cross betn A & B
= 13% + 13%
= 26%

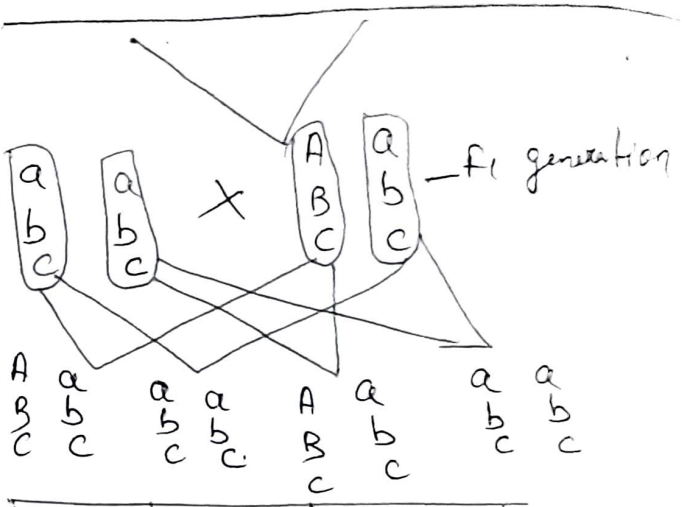
These distance betn A & B
= 36

Double crossing over don't occur betn the genes in which the distance 5cm & less

4) Three point test cross

A Three point of test cross-ing over (involving 3 genes) gives the accurate information about the distance betn the gene





36%	36%	9%	9%	4%	4%	2%	1%

Non-crossing over (C.O) = 72%
Total single C.O betn A & B = 18%
Total single C.O betn B & C = 8%
Total double C.O betn B & C = 2%
Distance betn A & B =
Total single C.O +
Total double C.O betn A & B
= 18% + 2% = 20%
Distance betn B & C =
Total single C.O +
Total double C.O betn B & C
= 8% + 2% = 10%
10 cm or map unit

5—Determination of gene order

Distance bet^n A & C = single c.o + single c.o between A & B + double crossing over

= 20 % + 10 % − 2 (2 %)

= 30 % − 4 % = 26 %

= 26 or map unit

5

Determination of gene order

After knowing the relative distance bet^n the genes of linkage group, it becomes easy to place in their proper linear order

Suppose the distance bet^n the genes

A − B = 12 Cm

B − C = 7 Cm

A − C = 5 Cm

Case-I Let gene A is in the middle (B-A-C)

B 12 A | A 5 C = 17 = 7

B 7 C | The distance B-C are not equiable

Case-II Let gene 'B' is in the middle (A-B-C)

A 12 B | B 7 C

A 5 C

The distance A-C are not equible

Case III

A 5 C | C 7 B

A 12 B

The distance bet^n A-B are equiable Therefore (C) must be in middle.

Combine map segment

Finally the different segments of a complete genetic map.

A 5 C 7 B'

D 4 E 8 F

A 20 C

Interferance

The Tendency of one crossing over (C.O) to interference with the c.o is called Interferance

→ Because one chismata form reduced production adjacent chismata

→ The strength of interferance is expressed in the form of co-efficient of co-incidut

co-efficient of coincidance = % actual double c.o / % expected double c.o

EXP-

Suppose expected double c.o are 2 % or 0.2 % & observed c.o is 1 %.

The co-efficient of coincidance = 1 % / 0.02 % = 0.5 % or 50 %.

co-efficient of interferances = 1.0

Genetics

unit-11

No-1 (1×10 - 10)

1- The Linkage was first discovered by _____ and _____

2- Linkage is exception of _____ principle.

3- Crossing over is absent _____ type of linkage.

4- Crossing over is exchang of _____ part

5- The genes are arcranged in linear orders in a _____

6- The strength of linkage is inversely proportional to the distance between _____.

7- The distance bet^n genes is determined by a unit called _____.

8- Who is the father of Linkage _____.

9- New combination is occurs in _____ type of Linkage

10- The x and y chromosome are pair during _____ Divisio.

No-2 Short note (3×5 - 15)

1 - Crossing over

2 - Coincidance

3 - Interference

4 - Chromosome

5 - Cis and Trans- arcrangement of gene.

No-3 Long question (8×5 - 40)

1- Briefly Describe the linkage & its significance.

2- Explaination of complete & incomplete linkage.

3- What is the chromosomal Theory of linkage

4- Describe the two factor & 3 factor crosses.

5- Cromosome maps

6- Describe the characterestic of sex-linked inheritance.