

## LINKAGE AND CROSSING OVER.

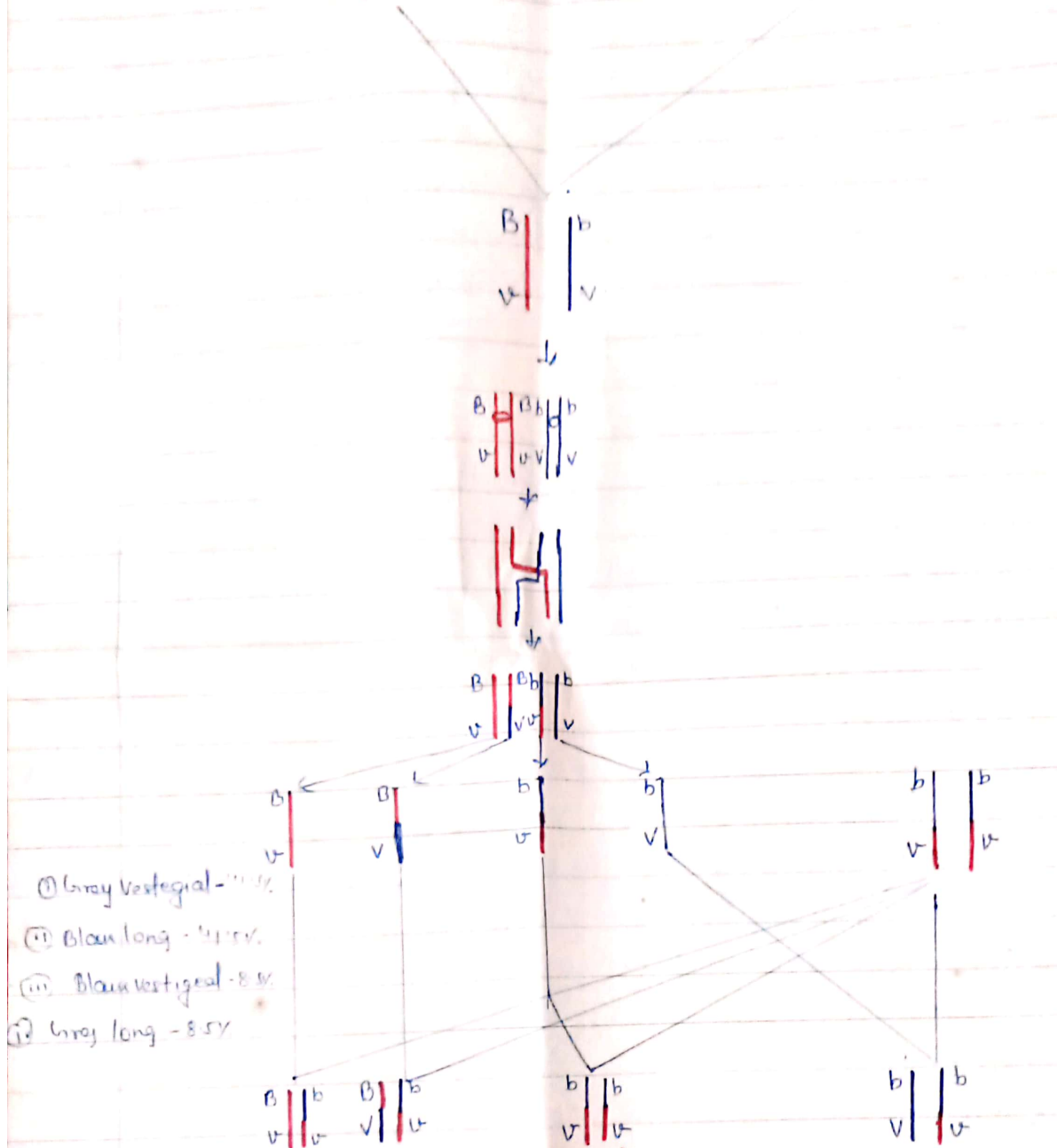
**INTRODUCTION:-** According to the theory of T.H. MORGAN linkage is caused by linked genes being carried in the same chromosome. If the chromosomes remain intact inheritance then the genes located in the same chromosome should remain together in all cases. In other words linkage should be complete. This is not what actually happens for the linked genes. Sometimes there is separation. In other words the linkage is incomplete. MORGAN describes the recombination of linked genes due to interchange of parts between homologous chromosomes, which he called "crossing-over". But on what causes could this linkage be explained. This was the problem of cytologists as well as geneticists, obviously the clue of the problem was sought in the process of Meiosis.

**EXAMPLE:-** While crossing a grey bodied and vestigial winged male *Drosophila* to a black bodied and long winged female *Drosophila*; MORGAN found that their  $F_1$  generation possess all grey bodied and long winged flies. But when these  $F_1$  female hybrids are crossed with double recessive gametes (i.e. black bodied and vestigial winged male) four expected types are produced as follows:-

Grey - Vestigial = 41.5% } Non cross over.  
Black - long = 41.5% } 83%.

Black - Vestigial = 8.5% }  
Grey - long = 8.5% } - cross over.  
17%.

B-grey } Grey Vestigial  
 v-vestigial }  
 B-brown } Brown long  
 V-long }



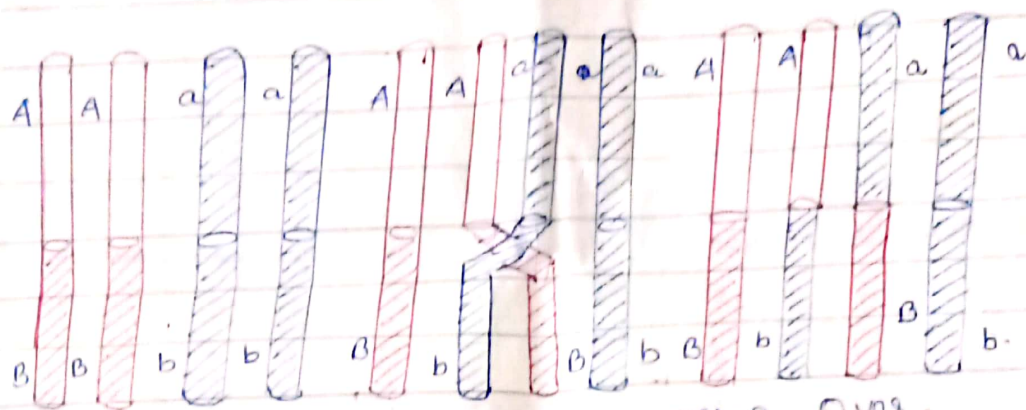
- (i) Grey Vestigial - 1/16
- (ii) Brown long - 1/16
- (iii) Brown Vestigial - 8/16
- (iv) Grey long - 8/16

**MECHANISM OF CROSSING OVER:-**

Observations of behaviour of chromosomes at meiosis have disclosed a process that represents a physical mechanism needed to understand the behaviour of linked genes during this phase. During the prophase of meiosis the homologous chromosomes (maternal and paternal) come close together and pair during zygotene stage. STRASBURGER regarded that it

region of synapsis was to facilitate the interaction of homologous units

of Meiosis each paired chromosome split into two chromatids so that the bivalent now consists of four chromatids. During diplotene when paired chromosomes start splitting, the chromatids remain in contact at one or more points and thus establishes one or more exchanges per bivalent. The points of contact are known as chiasma.



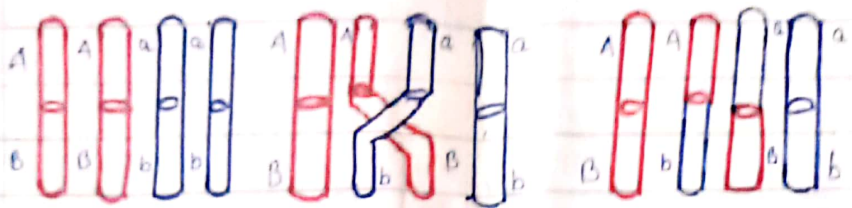
Mechanism of crossing over.

Several thoughts have arisen about chiasma formation. SARC advocated that the formation of chiasma is the result of cross over not the cause of it. But according to DARLINGTON (1937) there is first the formation of chiasma then the crossing over. At each chiasma two chromatids of the bivalent break and rejoin with the exchange of segment, so that the new chromatids are the compound of section of the original one. The essential feature of crossing over is that usually two of the four chromatids cross over while the other two chromatids one from each chromosome preserve their original continuity. The crossing over takes place in between

only two nearest chromatids.

**TYPES OF CROSSING OVER:-** According to the number of chiasma following types of crossing over have been described:

(i) **SINGLE CROSSING OVER:-** The occurrence of only one chiasma is responsible for the types of single crossing over.



(ii) **DOUBLE CROSSING OVER:-** when in the same chromosome the chiasma occurs at two points, it is known as double crossing over. It has two types of chiasma:-

(a) **Reciprocal chiasma:-** In this chiasma the same two chromatids are involved in the second chiasma as in the first. Thus the second chiasma restores the order which was changed by the first chiasma and it produces two non-cross-over chromatids.

(b) **Complementary chiasma:-** when

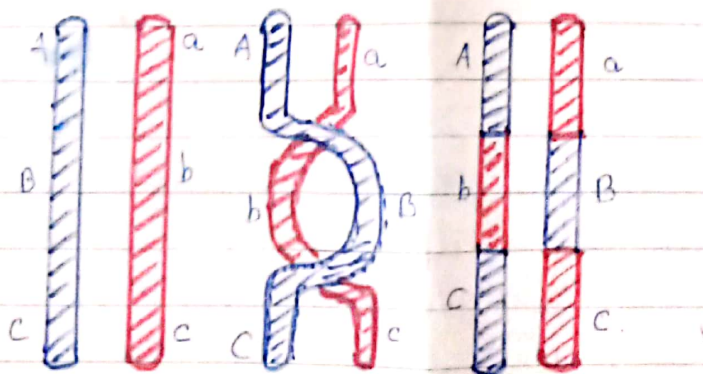


Fig- showing double Crossing over.

when both the chromatids taking part in the second chiasma are different from the chromatids involved in the first chiasma, the chiasma is known as Complementary chiasma.

number

- ii) Multiple crossing over:- when crossing over takes place at more than two places in the same chromosome pair then it is known as multiple crossing over. It occurs rarely.

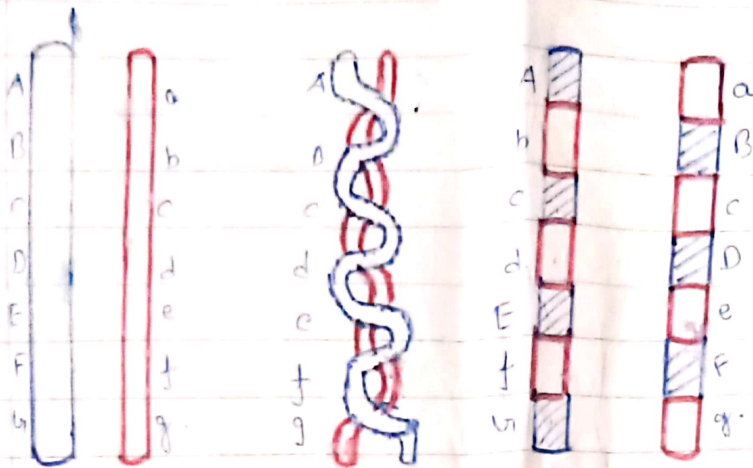


Fig: Multiple crossing over.

### THEORIES ABOUT MECHANISM OF CROSSING OVER:-

The following theories have been put forward:-

- (i) Belling's Hypothesis:- According to T Belling the crossing over is brought about due to novel attachment formed between newly synthesized genes.
- (ii) Copy choice Theory:- According to I. Lederberg (1955) it is speculated that a newly synthesized daughter chromatid is derived due to copying of one homologous chromosome upto a certain distance and then switching to the other homologous chromosome for copying the remaining distance of the chromosome.
- (iii) Break and exchange theory:-

According to this theory the crossing over breaks occur in the non-sister chromatids of the tetrad and between the non-sister chromatids the exchange of chromosomal segments occurs. The cytological finding of Stein and Hottey (1969) have shown that crossing over performed

by two nuclear enzymes namely endonuclease helps in breaking the chromatids and ligase restores the broken segments to the broken non-sister chromatids.

### SIGNIFICANCE OF CROSSING OVER:

- (i) Because of the linked genes a good variety may be maintained to perpetuate the individual's race.
- (ii) Because the crossing over the independent assortment of characters are possible. This is the factor very essential for the mechanism of evolution.
- (iii) By the crossing over the chromosomal maps are prepared which give the better understanding of hereditary mechanism.
- (iv) Crossing-over creates an enormous amount of genetic variation.