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LINKAGE AND CROSSING OVER

LINKAGE CAN BE DEFINED AS THE TENDENCY OF GENES TO REMAIN TOGETHER IN THEIR ORIGINAL COMBINATION DURING INHERITANCE IS CALLED LINKAGE.

MENDEL'S LAW OF INDEPENDENT ASSORTMENT STATES THAT THE SEGREGATION OF ALLELES OF ONE GENE IS INDEPENDENT OF ALLELES OF ANOTHER GENE. THIS LAW ALWAYS HOLDS TRUE FOR GENES THAT ARE LOCATED ON DIFFERENT CHROMOSOMES, BUT FOR GENES THAT ARE ON THE SAME CHROMOSOME, IT DOES NOT ALWAYS HOLD TRUE.

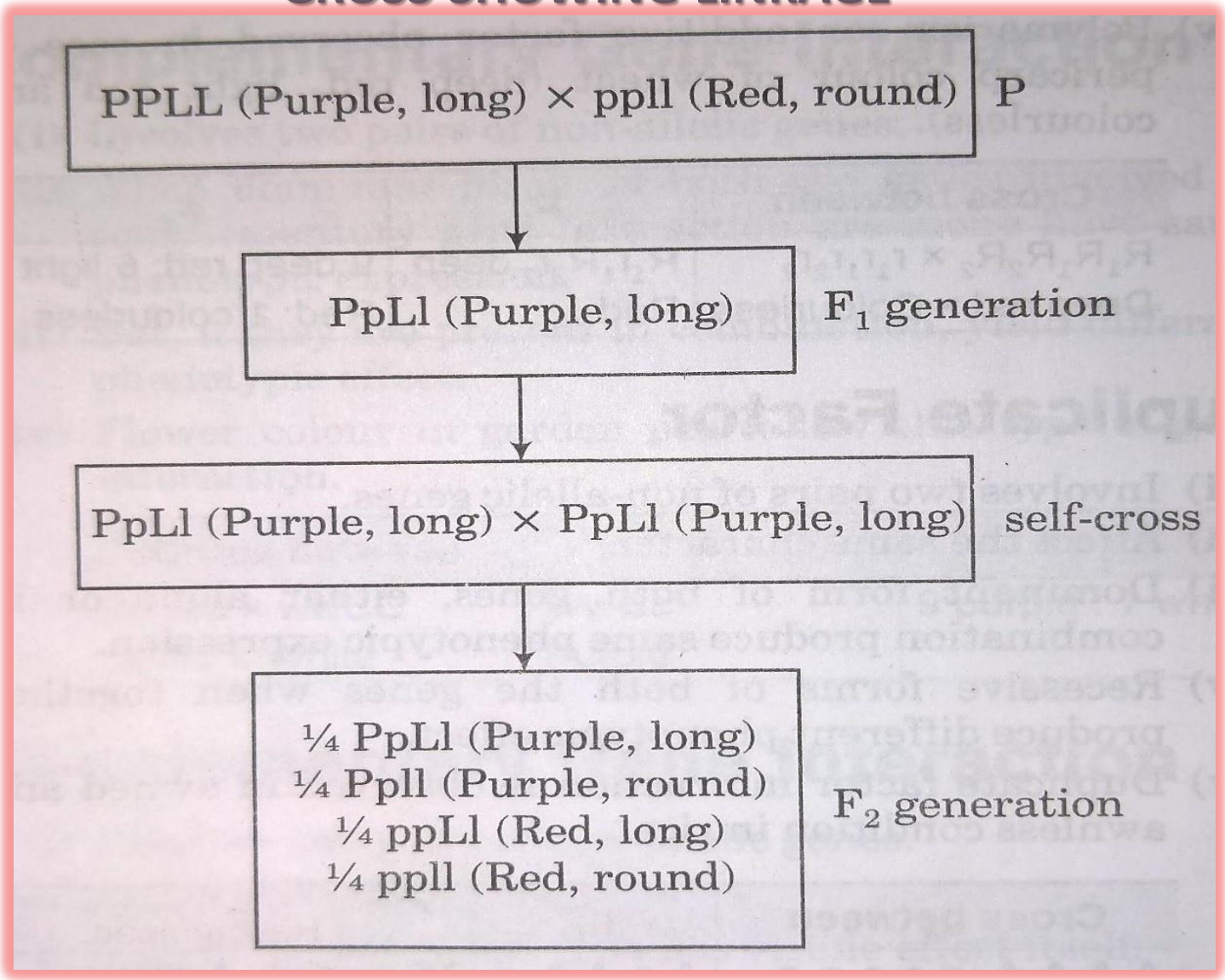
- GENES PRESENT ON A SINGLE CHROMOSOME IS SAID TO BE BELONGING TO ONE LINKAGE GROUP. THEREFORE,THERE ARE AS MUCH LINKAGE GROUP AS THE NUMBER OF HAPLOID CHROMOSOMES.
- LINKAGE WAS DISCOVERED THROUGH A CLASSIC EXPERIMENT BY WILLIAM BATESON AND REGINALD PUNNET.THEY WERE STUDYING

  THE INHERITANCE PATTERN OF THE GENE FOR FLOWER COLOUR

  (P-PURPLE AND p-RED) AND THE GENE AFFECTING THE SHAPE OF POLLEN GRAINS (L-LONG AND l-ROUND).

  THEY CROSSED THE PURE LINES PPLL AND ppll AND THEN SELF CROSSED THE RESULTING PpLl LINES. THE OBSERVED FREQUENCY DIFFERED FROM THE EXPECTED 9:3:3:1 RATIO OF PL:Pl:pL:pl. THEY OBSERVED AN INCREASED FREQUENCY OF PL AND pl AND A DECREASED FREQUENCY OF Pl AND pL .

CROSS SHOWING LINKAGE



Cross showing linkage

Phenotype and Genotype	Observed	Expected from 9:3:3:1 Ratio
Purple, long (PpLl)	284	216
Purple, round (Ppll)	21	72
Red, long (ppLl)	21	72
Red, round (ppll)	55	24

- THEIR EXPERIMENT REVEALED LINKAGE BETWEEN THE P AND L ALLELES AND THE p AND l ALLELES.THE FREQUENCY OF POCCURING TPGETHER WITH L AND WITH p OCCURING TOGETHER WITH l IS GREATER THAN OF THE RECOMBINANT Pl AND pL.
- GENES PRESENT ON THE SAME CHROMOSOME IS THEORETICALLY LINKED TO EACH OTHER, BUT MOST OF THE TIME THEY SHOW INDEPENDENT ASSORTMENT AS OBSERVED BY MENDEL. THIS PHENOMENON IS DIRECTLY RELATED TO THE DISTANCE BETWEEN THE TWO GENES IN QUESTION. THE MORE THE DISTANCE BETWEEN THE TWO GENES THE GREATER PROBABILITY OF THEIR INDEPENDENT ASSORTMENT, THAT IS THEY WILL BE SEPARATED DURING GAMETE FORMATION. THIS PHENOMENON IS FACILITATED BY THE PROCESS CALLED CROSSING OVER.

CROSSING-OVER CAN BE DEFINED AS THE EXCHANGE OF GENETIC MATERIAL BETWEEN THE NON-SISTER CHROMATIDS OF A HOMOLOGOUS CHROMOSOME. THE MOST IMPORTANT FEATURES OF CROSSING OVER CAN BE SUMMARIZED AS FOLLOWS:

- THE GENES ARE LOCATED ON A CHROMOSOME IN A LINEAR SEQUENCE AT

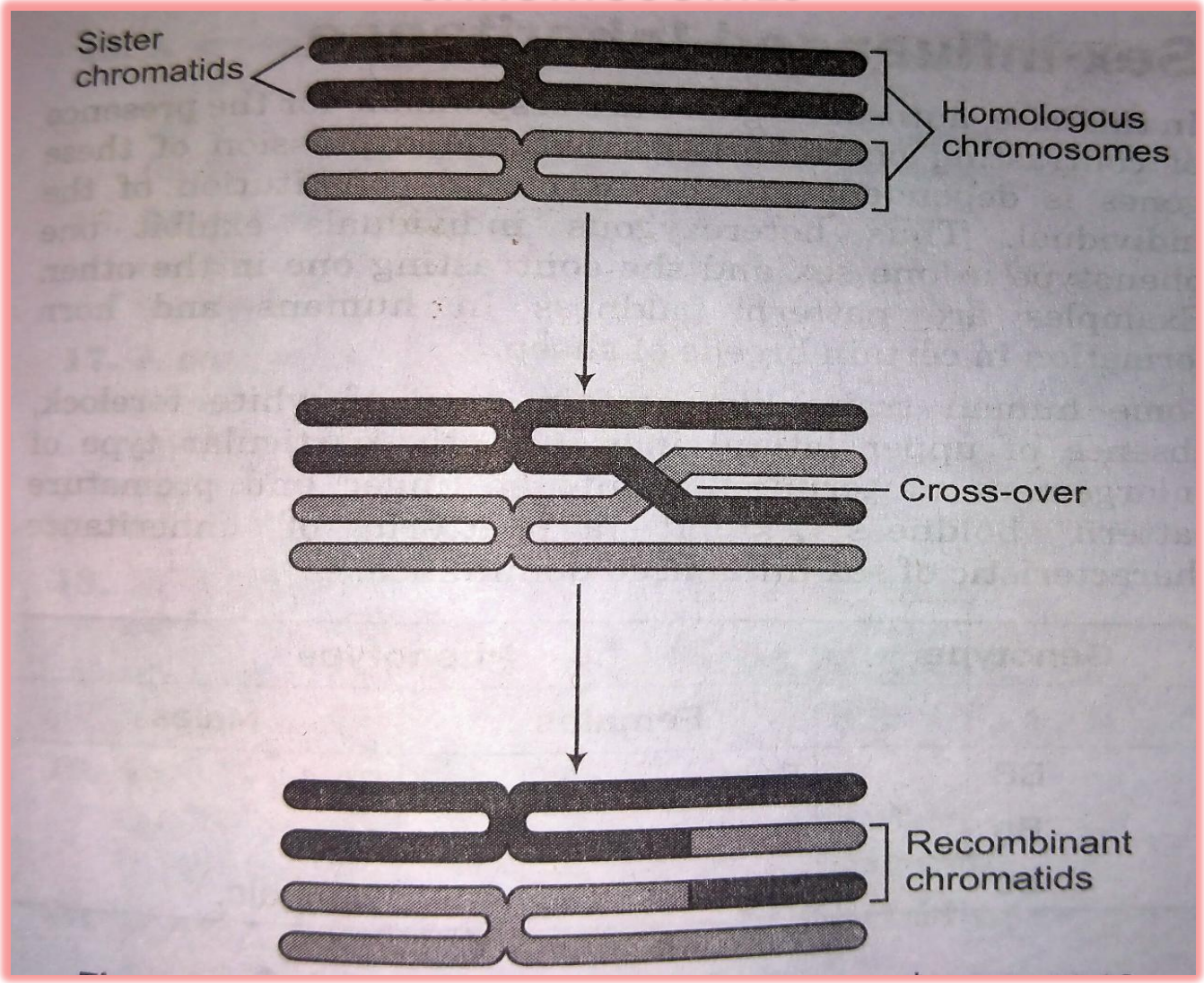
  DIFFERENT LOCI.
- THE TWO ALLELES OF A GENE IN A HETEROZYGOTE OCCUPY CORRESPONDING POSITIONS IN THE HOMOLOGOUS CHROMOSOMES.
- CROSSING-OVER INVOLVES THE BREAKAGE OF EACH OF TWO NON-SISTER CHROMATIDS OF THE HOMOLOGOUS CHROMOSOMES

- CROSSING-OVER OCCURS AT PACHYTENE STAGE AFTER SYNAPSIS OF THE HOMOLOGOUS CHROMOSOMES HAS OCCURED IN PROPHASE 1 OF MEIOSIS.
- CHROMOSOMES WITH RECOMBINANT COMBINATIONS OF LINKED GENES ARE FORMED BY THE OCCURRENCE OF CROSSING-OVER IN THE REGION BETWEEN THE TWO LOCI.

A CROSS-SHAPED STRUCTURE IS FORMED DURING CROSSING-OVER IN WHICH TWO OF THE FOUR CHROMATIDS OF HOMOLOGOUS CHROMOSOME PAIRS APPEAR TO EXCHANGE MATERIAL. THIS STRUCTURE IS CALLED CHIASMA.

TH MORGAN WAS THE FIRST TO HYPOTHESIZE THE RELATION BETWEEN LINKAGE AND SEGREGATION OF HOMOLOGOUS CHROMOSOMES AND THE OCCURRENCE OF CROSSIONG-OVER BETWEEN HOMOLOGOUS CHROMOSOMES DURING MEIOSIS.

Crossing over between homologous chromosomes



TYPES OF LINKAGE

GENERALLY IT IS OF THREE TYPES---

- 01.CROSSING-OVER
- 02.GENES INVOLVED AND
- 03.CHROMOSOMES INVOLVED.

01.BASED OF CROSSING OVER

IT IS OF TWO TYPES:-

- (A)COMPLETE LINKAGE:-IT IS KNOWN IN CASE OF MALES OF DROSOPHILA AND FEMALES OF SILKWORMS,WHERE THERE IS COMPLETE ABSENCE OF RECOMBINANT TYPES DUE TO ABSENCE OF CROSSING OVER.

(B)INCOMPLETE /PARTIAL LINKAGE:-IF SOME FREQUENCY OF CROSSING OVER
ALSO OCCURS BETWEEN THE LINKED GENES, IT IS KNOWN AS INCOMPLETE /PARTIAL LINKAGE. .IN COMPLETE LINKAGE HAS BEEN OBSERVED IN MAIZE, PEA, DROSOPHILA FEMALE AND SEVERAL OTHER ORGANISMS.

02.BASED ON GENES INVOLVED

- BASED ON GENES INVOLVED :-DEPENDING ON WHETHER ALL DOMINANT OR SOME DOMINANT AND SOME RECESSIVE ALLELES ARE LINKED TOGETHER ,LINKAGE CAN BE CATEGORIZED INTO
- (a)COUPLING PHASE AND
- (b)REPULSION PHASE.
- (a)COUPLING PHASE:-DOMINANT ALLELES PRESENT ON THE SAME CHROMOSOME AND RECESSIVE ALLELES PRESENT ON SAME CHROMOSOME SHOWS COUPLING PHASE
- TR tr
- ----- ----- COUPLING PHASE
- TR tr

(b)REPULSION PHASE:- DOMINANT ALLELES OF SOME GENES ARE LINKED WITH RECESSIVE ALLELES OF OTHER GENES ON SAME CHROMOSOMES SHOWS REPULSION PHASE

Tr tR

--- ---- REPULSION PHASE

Tr tR

03.BASED ON CHROMOSOMES INVOLVED:-

BASED ON THE LOCATION OF GENES ON THE CHROMOSOMES, LINKAGE IS CATEGORIZED INTO

(a)AUTOSOMAL LINKAGE:-IT REFERS TO LINKAGE OF THOSE GENES WHICH ARE LOCATED IN AUTOSOME (OTHER THAN SEX CHROMOSOMES)

(b)ALLOSOMAL LINKAGE /SEX LINKAGE:-IT REFERS TO LINKAGE OF GENES WHICH ARE LOCATED IN SEX CHROMOSOMES i.e. EITHER "X" OR "Y"(GENERALLY "X").

LINKAGE GROUPS

- LINKAGE GROUP REFERS TO A GROUP OF GENES WHICH ARE PRESENT IN ONE CHROMOSOME. IN OTHER WORDS ALL THOSE GENES WHICH ARE LOCATED IN ONE.
- CHROMOSOME CONSTITUTE ONE LINKAGE GROUP. THE NUMBER OF LINKAGE GROUPS IS LIMITED IN EACH INDIVIDUAL. THE MAXIMUM NUMBER OF LINKAGE GROUPS IS EQUAL TO THE HAPLOID CHROMOSOME NUMBER OF AN ORGANISM.

  E.g.- FOR EXAMPLE THERE TEN LINKAGE GROUPS IN CORN (2n=14), FOUR IN *DROSOPHILA MELANOGASTER* (2n=8) IN MAN (2n=46).

THANK YOU