Crossing over

Crossing over is the exchange of genetic material between non sister chromatids of homologous chromosomes during meiosis which results in new allelic combinations in the daughter cells.

Each diploid cell contains two copies of every chromosomes, one derived from the maternal gamete and the other from the paternal gamete. These pairs of chromosomes each derived from one parent, are called homologous chromosomes, when diploid organisms undergo sexual reproduction, they first produce haploid gametes through meiosis. During prophase I of meiosis, homologous chromosome align with each other and exchange genetic material, so that some of the resultant chromosomes are recombinants, containing a mixture of genes derived from the maternal as well as the paternal chromosomes.

Prophase I - Meiosis occurs in two stages - Meiosis I and meiosis II. meiosis I is also known as reduction division, is the series of events that results in the formation of two haploid daughter cells. At the end of reduction division, the number of chromosomes is halved and each of the daughter cells have only one complete set of duplicated chromosomes.

During meiosis I, particularly in prophase I a number of events occur, making it one of the longest phases in meiosis I

1) Condensation of chromosomes.
2) Formation of homologous chromosomes which are similar in centromere position formation of
3) Synaptonemal complex.

3/ Exchange of chromosomal material between non sister chromatids having a tetrad structure.
4/ Repelling of homologous chromosomes.
5/ Disappearance of ~~chromosomal~~ nuclear envelop and beginning of metaphase of meiosis. I.

Mechanism of crossing over -

On a molecular level, crossing over begins with a double strand break in one of the DNA molecules. This double strand break can occur naturally through agents like specific protein, radiation and exonucleases. enzyme that remove nucleotides from the 5' > 3' orientation from both the strands. This leads to two hanging single stranded regions that get coated with proteins catalyzing recombination called recombinase. These enzymes catalyze the invasion of single strand regions into sequences suitable for base pairing. The close proximity of non sister chromatids during prophase I allows this single stranded region to use the sequence on the homologous chromosomes. The first invading strand behaves like a primer and synthesize a double stranded region for itself using one strand of its non sister chromatid as a template. This leads to its complementary strand getting displaced and base pairing with the second single stranded region that was initially generated by the exonuclease. Ultimately this results in two strands being exchanged with the formation of cross like structure called Holliday junction (Chiasmata). Holliday junctions are stabilized and resolved through proteins that modulate genomic manipulation which are called MSH4 and MSH5

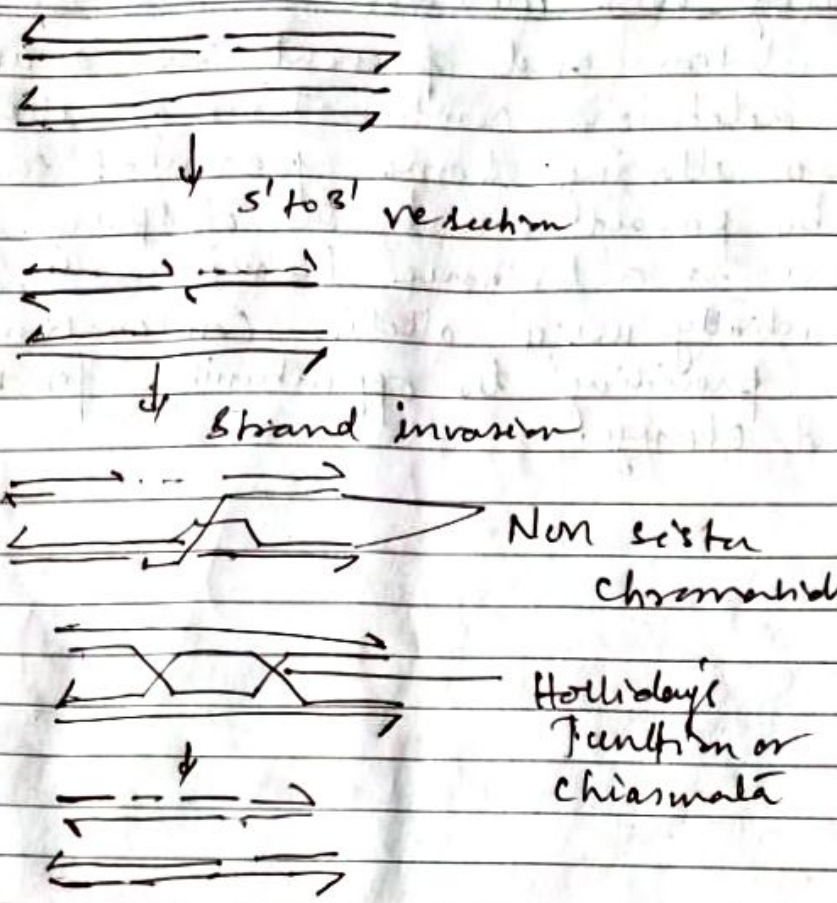

fig showing process of crossing over

Functions of crossing over -

Organisms that divide only asexually without the chance of such recombination suffer from a condition called Muller's Ratchet. That is each generation of that species contains at least one as many genetic mutations as the previous generation, if not more. In other words, when all the progeny are genetically identical to one another, there is no scope of genetic errors to be corrected or for new and beneficial combinations to arise.

Crossing over increases the variability of a population and prevents the accumulation of deleterious combinations of alleles, while also allowing some parental combinations to be passed on to the offspring. This way there is a balance between maintaining potentially useful allelic combinations as well as providing the opportunity for variation and change.