Course- B.Sc. (Botany Honours), Part -3

Paper-VI (Group-A), Cytogenetics

Topic- Crossing over

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Binod Kumar Pandey

Assistant Professor & HOD, Botany Department,

Ram Ratan Singh College, Mokama, Patna.

E.mail- binodkp14@gmail.com

Crossing over

Crossing over refers to the interchange of parts between non-sister chromatids of homologus chromosomes during meiotic prophase (pachytene). In other words, crossing over results from exchange of genetic material between non-sister chromatids involving breakage and reunion at precise point. The term crossing over was first used by Morgan and Cattell in 1912.

Feature of Crossing Over:

The main features of crossing over are given below:

1. Crossing over takes place during meiotic prophase, i.e., during pachytene. Each pair of chromosome has four chromatids at that time.

2. Crossing over occurs between non-sister chromatids. Thus one chromatid from each of the two homologus chromosomes is involved in crossing over.

3. It is universally accepted that crossing over takes place at four strand stage.

4. Each crossing over involves only two of the four chromatids of two homologus chromosomes. However, double or multiple crossing over may involve all four, three or two of the four chromatids, which is very rare.

5. Crossing over leads to re-combinations or new combinations between linked genes. Crossing over generally yields two recombinant types or crossover types and two parental types or non-crossover types.

6. Crossing over generally leads to exchange of equal segments or genes and recombination is always reciprocal. However, unequal crossing over has also been reported.

7. The value of crossover or recombinants may vary from 0-50%.

8. The frequency of recombinants can be worked out from the test cross progeny. It is expressed as the percentage ratio of recombinants to the total population (recombinants + parental types). Thus,

$$\text{Crossing over frequency (\%)} = \frac{\text{No. of recombinants}}{\text{Total progeny}} \times 100$$

Types of Crossing Over:

Depending upon the number of chiasmata involved, crossing over may be of three types, viz., single, double and multiple as described below:

i. Single Crossing Over:

It refers to formation of a single chiasma between non-sister chromatids of homologous chromosomes. Such cross over involves only two chromatids out of four.

ii. Double Crossing Over:

It refers to formation of two chiasmata between non-sister chromatids of homologous chromosomes. Double crossovers may involve either two strands or three or all the four strands. The ratio of recombinants and parental types under these three situations are observed as 2:2:3:1 and 4 : 0, respectively.

iii. Multiple Crossing Over:

Presence of more than two crossovers between non-sister chromatids of homologous chromosomes is referred to as multiple crossing over. Frequency of such type of crossing over is extremely low.

Factors Affecting Crossing Over:

The frequency of crossing over is influenced by several factors which are briefly discussed below:

i. Distance:

The distance between genes affects the frequency of crossing over. Greater the distance between genes higher is the chance of crossing over and vice versa.

ii. Age:

Generally crossing over decreases with advancement in the age in the female Drosophila.

iii. Temperature:

The rate of crossing over in Drosophila increases above and below the temperature of 22°C.

iv. Sex:

The rate of crossing over also differs according to sex. There is lack of crossing over in Drosophila male and female silk moth.

v. Nutrition:

Presence of metallic ions like calcium and magnesium in the food caused reduction in recombination in Drosophila. However, removal of such chemicals from the diet increased the rate of crossing over.

vi. Chemicals:

Treatment with mutagenic chemicals like alkylating agents was found to increase the frequency of crossing over in Drosophila female.

vii. Irradiation:

Irradiation with X-rays and gamma rays was found to enhance the frequency of crossing over in Drosophila females.

viii. Structural Changes:

Structural chromosomal changes especially inversions and translocations reduce the frequency of crossing over in the chromosomes where such changes are involved.

ix. Centromere Effect:

Generally genes that are located adjacent to the centromere show reduced frequency of crossing over.

x. Cytoplasmic Genes:

In some species cytoplasmic genes also lead to reduction in crossing over. For example, Tifton male sterile cytoplasm in pearl millet.

Significance of Crossing Over:

Crossing over is useful in three principal ways, viz:

(1) Creation of variability,

(2) Locating genes on the chromosomes, and

(3) Preparing linkage maps

i. Creation of Variability:

Crossing over leads to recombination or new combination and thus is a potential genetic mechanism for creating variability which is essential for improvement of genotypes through selection.

ii. Locating Genes:

Crossing over is a useful tool for locating genes in the chromosomes.

iii. Linkage Maps:

Crossing over plays an important role in the preparation of chromosome maps or linkage maps. It provides information about frequency of recombination's and sequence of genes which are required for preparation of linkage maps.