BIOLOGY

Bio- Botany – Chapter – 3

Linkage Groups

- The groups of linearly arranged linked genes on a chromosome are called **Linkage groups**.
- In any species the number of linkage groups corresponds to the number haploid set of chromosomes. Example:

Linkage groups in some organisms

Name of organism	Linkage groups
Mucor	2
Drosophila	4
Sweet pea	7
Neurospora	7
Maize	10

- Linkage and crossing over are two processes that have opposite effects.
- Linkage keeps particular genes together but crossing over mixes them.
- The differences are given below.

Differences between linkage and crossing over

Linkage	Crossing over
1. The genes present on chromosome stay close together	It leads to separation of linked genes

2. It involves same chromosome of homologous chromosome	It involves exchange of segments between non-sister chromatids of homologous chromosome.
3. It reduces new gene combinations	It increases variability by forming new gene combinations. lead to formation of new organism

Crossing Over

- Crossing over is a biological process that produces new combination of genes by inter-changing the corresponding segments between non-sister chromatids of homologous pair of chromosomes.
- The term 'crossing over' was coined by **Morgan (1912).**
- It takes place during pachytene stage of prophase I of meiosis.
- Usually crossing over occurs in germinal cells during gametogenesis.
- It is called meiotic or germinal crossing over.
- It has universal occurrence and has great significance.
- Rarely, crossing over occurs in somatic cells during mitosis.
- It is called somatic or mitotic crossing over.

Mechanism of Crossing Over

- Crossing over is a precise process that includes stages like synapsis, tetrad formation, cross over and terminalization.

(i) Synapsis

- Intimate pairing between two homologous chromosomes is initiated during zygotene stage of prophase I of meiosis I.

- Homologous chromosomes are aligned side by side resulting in a pair of homologous chromosomes called **bivalents**.
- This pairing phenomenon is called **synapsis or syndesis.** It is of three types,

1. **Procentric synapsis:** Pairing starts from middle of the chromosome.
2. **Proterminal synapsis:** Pairing starts from the telomeres.
3. **Random synapsis:** Pairing may start from anywhere.

(ii) Tetrad Formation

- Each homologous chromosome of a bivalent begin to form two identical sister chromatids, which remain held together by a centromere.
- At this stage each bivalent has four chromatids. This stage is called **tetrad stage**.

(iii) Cross Over

- After tetrad formation, crossing over occurs in pachytene stage.
- The non-sister chromatids of homologous pair make a contact at one or more points.
- These points of contact between non-sister chromatids of homologous chromosomes are called **Chiasmata** (singular-Chiasma).
- At chiasma, cross-shaped or X-shaped structures are formed, where breaking and rejoining of two chromatids occur.
- This results in reciprocal exchange of equal and corresponding segments between them.
- A recent study reveals that synapsis and chiasma formation are facilitated by a highly organised structure of filaments called **Synaptonemal Complex (SC)**.
- This synaptonemal complex formation is absent in some species of male ***Drosophila*** hence crossing over does not takes place.

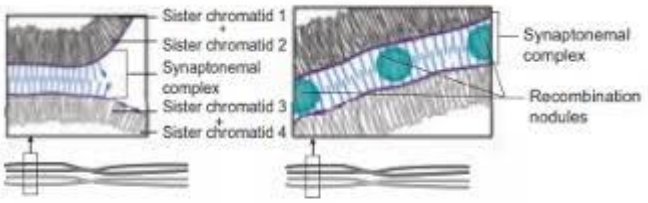

Figure 3.9: Structure of Synaptonemal Complex

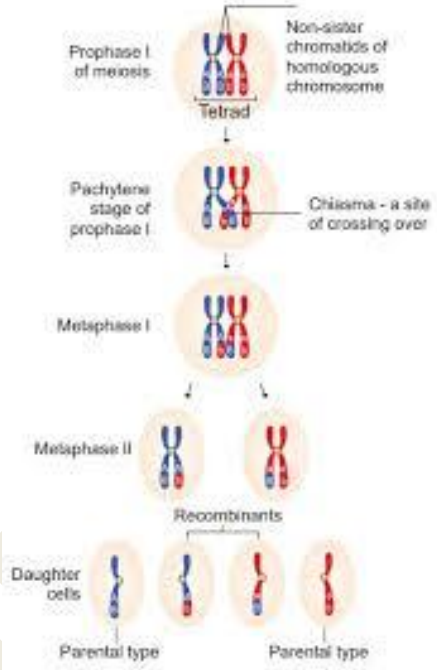

Figure 3.10: Mechanism of crossing over

(iv) Terminalisation

- After crossing over, chiasma starts to move towards the terminal end of chromatids.
- This is known as **terminalisation**.
- As a result, complete separation of homologous chromosomes occurs.