Notes

Programme: Bachelor of Science (Third Year – VI Semester)

Subject: Botany

Paper Code: BOC 108

Paper Title: Cytogenetics and Plant Breeding.

Unit IV: Linkage, crossing over and chromosome mapping

Module Name: Cytological basis of crossing over.

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Cytological basis for crossing over

Crossing over is the interchange of chromosomal segments between homologous chromosomes during meiosis. It occurs during the tetrad stage of meiosis.

Direct cytological evidence that homologous chromosomes exchange parts during crossing over -

1. C. Stern's experiment (working with *Drosophila*)
2. H.B.Creighton and McClintock (working with maize)

Stern's experiment

He used a mutant strain where the female *Drosophila* showed the following genetical features of the X chromosomes.

1. **Deletion** in one X chromosome containing the recessive mutant genes *car* (carnation) for eye colour and another dominant mutant allele *B* (bar) for eye shape (short in height)

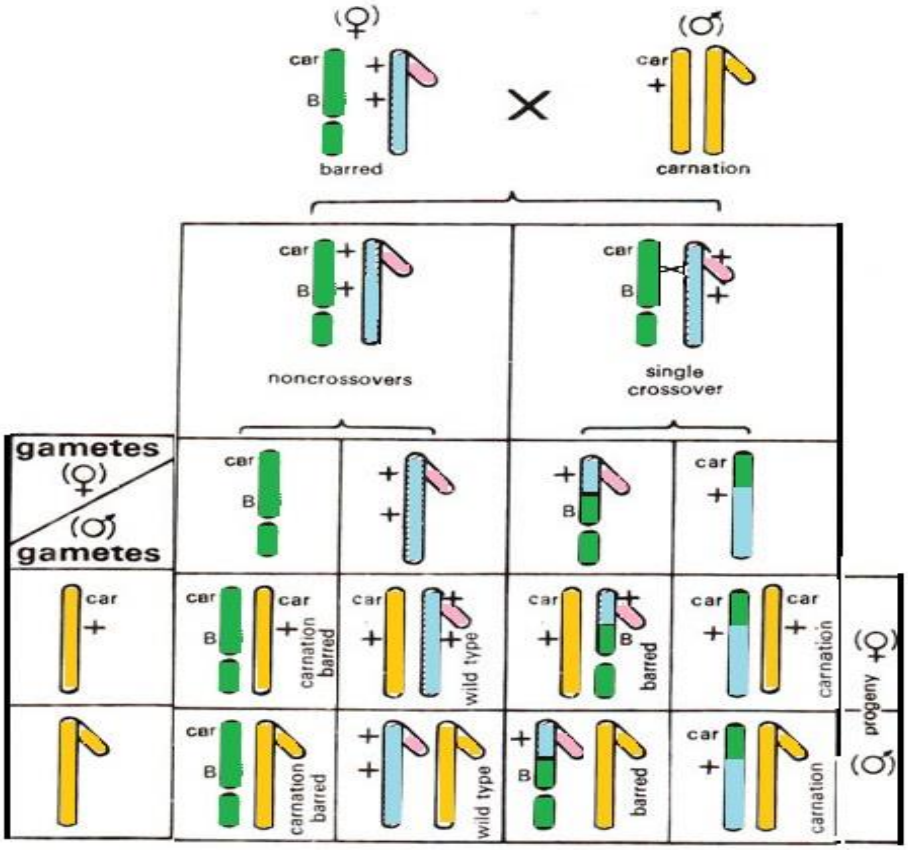
2. Second X chromosome with dominant genes *Car*$^{+}$ (red eye colour) and *B*$^{+}$ (round eyes) exhibit **translocation** (has a piece of Y chromosome attached to it).

3. . The female flies used, carried the allele pairs in the *cis* – configuration.

Under the microscope, the two X-chromosomes in the female fly could be distinguished from each other, and also from normal X-chromosome.

Stern crossed two strains of *Drosophila* flies –

Female *Drosophila* flies from the mutant strain were crossed with male having carnation coloured, round eyes.



✓ The flies which are classified as crossovers (recombinants) on the basis of phenotype i.e., carnation (with normal eye shape) and barred (with normal red eye colour) were studied cytologically.

✓ It was found that carnation flies did not have any fragmented X-chromosome, but rather had normal X-chromosomes of equal length.

- ✓ On the other hand, in red, bar flies, one X-chromosome was normal and other was fragmented.
- ✓ The fragmented X-chromosome also had attached part of Y-chromosome.
- ✓ Such chromosome combination in red bar is possible only through exchange of segments between non-sister chromatids of homologous chromosomes.
- ✓ This has proved that genetic crossing over is the result of cytological crossing over i.e. interchange of chromosomal material takes place between the homologous chromosomes.

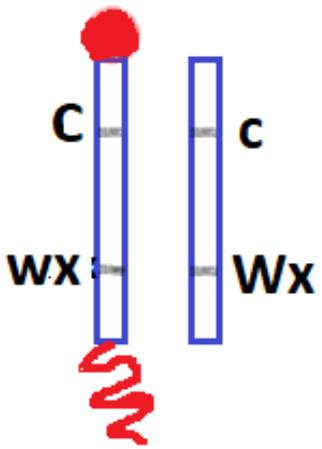
<u>Creighton and McClintock's experiment in maize</u>

Creighton and McClintock proved experimentally the exchange of chromatids during crossing over in maize.

They used 2 strains of maize which showed differences in the 9^{th} chromosomes.

In one strain, the 9^{th} chromosomes had a densely staining knob at one end and an extra (translocated) piece (cell marker) at the other end.

The second strain had no knob or cell marker.



In addition, the following two genetical markers (characters) were selected.

1. **Kernel colour**

✓ coloured kernel (***CC***)– dominant;

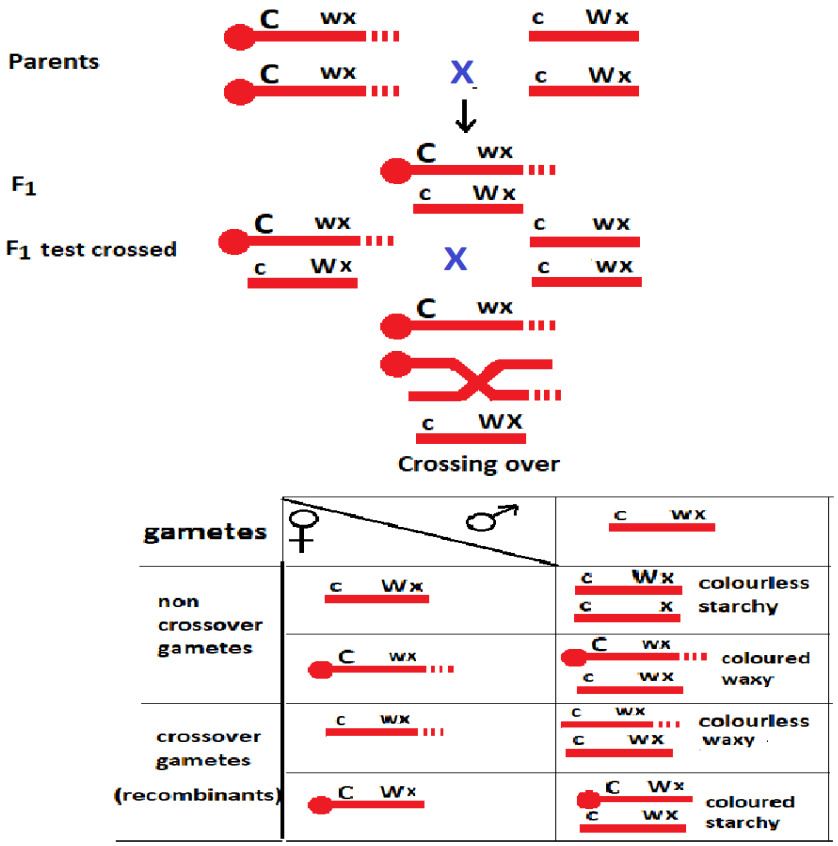
✓ colourless kernel (***cc***) - recessive

2. **Nature of endosperm**

✓ starchy endosperm (***Wx***) - dominant

✓ waxy endosperm (***wx***) - recessive

A Maize with **knobbed chromosome**, with cell marker, **coloured kernel** and **waxy endosperm** (*C wx / C wx*) was crossed with another Maize with **no knob**, **no cell marker**, **colourless kernel** and **starchy endosperm** (*c Wx / c Wx*).



Diagrammatic representation of parallelism between cytological and genetic crossing over, explaining the phenotypes of aleurone and endosperm of F1 maize grains and chromosome morphology and genotypes for microspore mother cells produced by F1 plants.

F1 hybrid plants - heterozygous for coloured kernel and waxy endosperm; carried these genes in repulsion phase i.e., *Cwx/cWx.*

Cwx - carried on the knobbed chromosome and *cWx* on the knobless chromosome.

These **F1 hybrid plants** were testcrossed with plants homozygous recessive for both characters i.e., colourless and waxy *(cwx/cwx).*

The experiment showed the following new combinations.

- ✓ All coloured, starchy plants have knobbed chromosomes. The knob of this chromosome is received from the parent plant, knobbed, coloured, waxy, by crossing over.
- ✓ The colourless, waxy plants have knobless chromosomes with cell markers. The cell marker is received from the parent plant, knobbed, coloured and waxy by crossing over.