Rearrangements

Reading: Chapter 14, pp489-508 for two lectures
Problem set for two lectures

We will consider four types of rearrangements.

A B C D E F G

Deletions: CD deleted

A B E F G

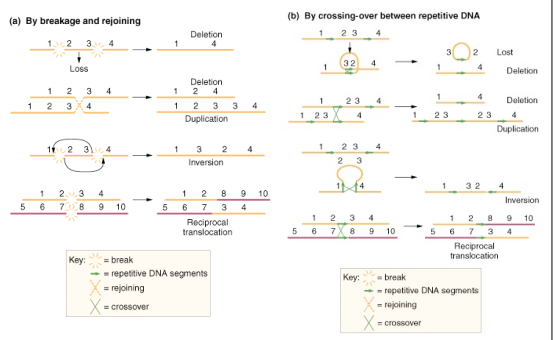
Tandem duplications: CD duplicated

A B C D C D E F G

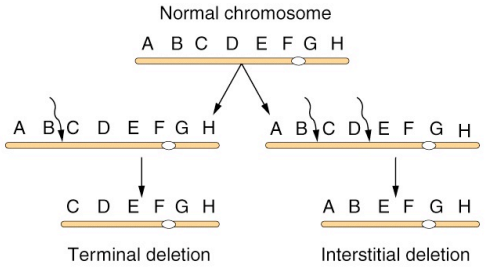
Inversions: CDE inverted

A B E D C F G

Reciprocal Translocations

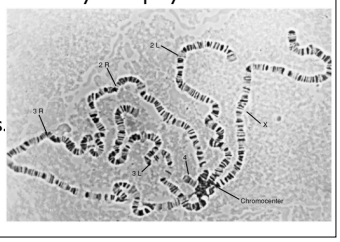


Deletions

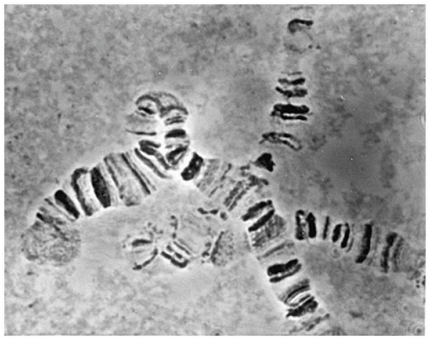


Secretory tissues of dipteran insects, like Drosophila, have polytene chromosomes.

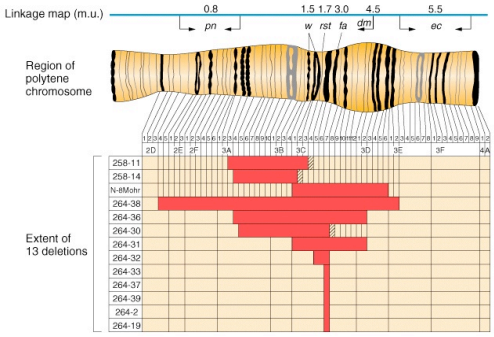
DNA undergoes rounds of replication without separating into separate chromosomes. While Drosophila has four pairs of chromosomes, it has only four polytene chromosomes.
Therefore, all of the copies of both homologs align in polytene chromosomes.



Deletions (deficiencies) can be observed in polytene chromosomes.



Calvin Bridges generated maps that defined the physical extents of deletions.



Deficiencies can be used to map genes.

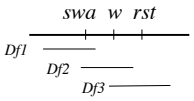
swa, w and *rst* map to X chromosome

Df/+ female X *swa, w* and *rst* male

↓

Score F1 phenotypes

Female genotype	male genotype: *swa*/Y	*w*/Y	*rst*/Y
Df1/+	**mutant**	wt	wt
Df2/+	**mutant**	**mutant**	wt
Df3/+	wt	**mutant**	**mutant**

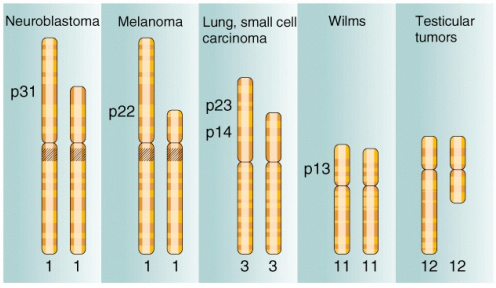


Df mapping can be used to order genes

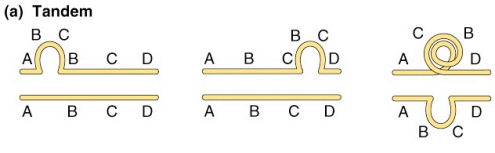
Calvin Blackman Bridges, 1927.
Photo courtesy of Cold Spring Harbor Laboratory Archives.

Using 3-factor mapping, Df mapping, and characterizing the physical extent of Dfs, Bridges showed the order of genes defined by genetic mapping represented the physical order of genes on the chromosome.

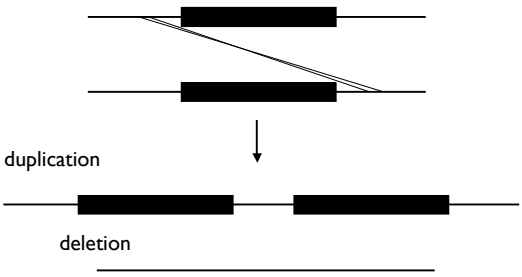
Deletions are often found in tumor cells.



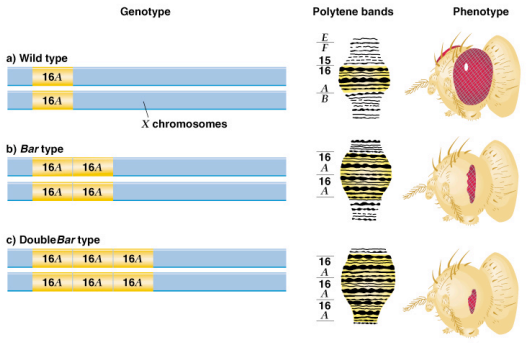
Duplications



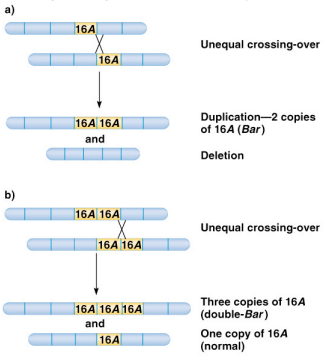
Tandem duplications can be generated by asymmetric pairing and crossing over.



Tandem dublication results in the Bar phenotype.



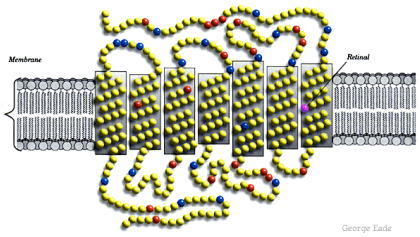
Asymmetric pairing and crossing over can generate multiple copies of DNA segments.



Asymmetric pairing and duplication of genes is thought to generate gene families.

The red and green genes on the X chromosome are thought to have arisen from an ancestral photoreceptor gene.

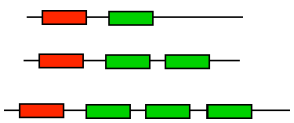
Opsin genes: rhodopsin



The gene for rhodopsin is located on chromosome 3. This was the first opsin gene to be discovered. Because of the similarity in structure, and hence sequence, of rhodopsin to the color opsins, the remaining opsin genes were isolated based on their similarity to rhodopsin. Above is a molecular structure of the rhodopsin protein, which is embedded in the rods cell's outer membrane. Because of their similarity, the color opsins adopt a similar structure.

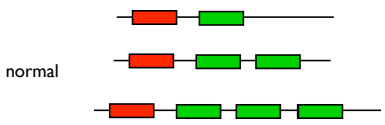
Color opsin genes

The blue opsin gene is on chromosome 7.



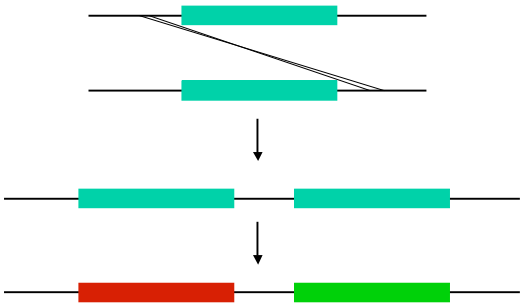
Both red and green opsin genes are on the X chromosome. There is usually one red gene and one to three green genes. The genes are next to each other and arranged head to tail relative to one another.

Most red-green colorblind males lack green genes!

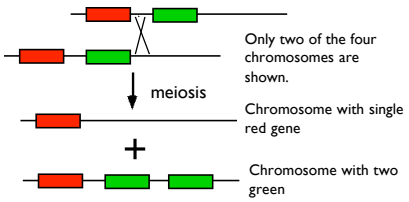


But how did this happen?

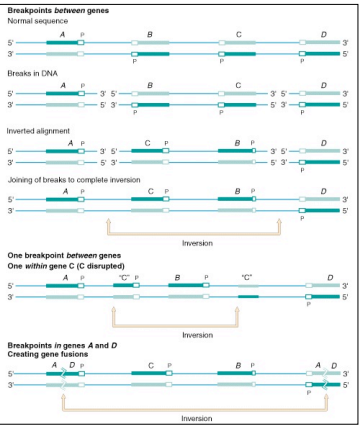
Asymmetric pairing and unequal crossing over of a ancestral gene led its duplication and evolution into red and green genes.



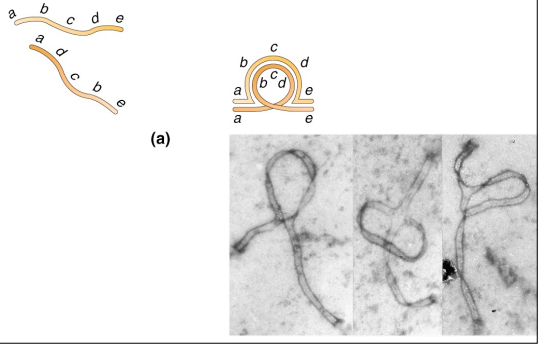
The extra green genes and the single red found in red-green colorblind individuals could have been generated by unequal crossing over.



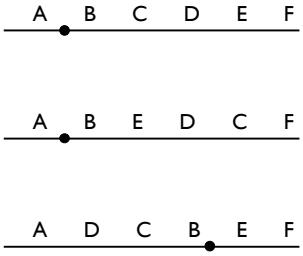
Inversions can affect gene function.

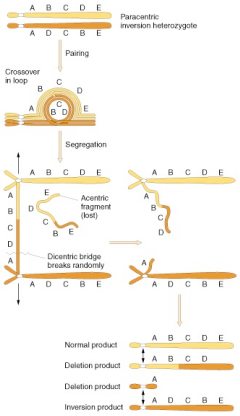


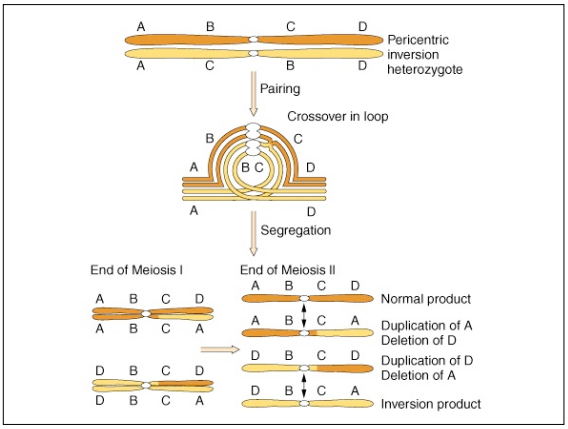
Homolog pairing of inversion heterozygotes during meiosis or in polytene chromosomes results in inversion loops.



Two types of inversions







The consequence of crossing over in the inversion loop is the production of unbalanced gametes.

Semisterility in plants
Zygotic inviability in animals

How are lethal mutations and deficiencies maintained?

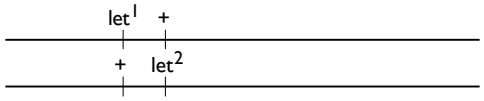
Df/+ (or lethal) female X Df/+ (or lethal) male

↓

1/4 +/+
1/2 Df/+ } Survive
1/4 Df/Df Die

If cross the survivers, 1/3 will lack Df. Eventually will loose the Df if don't have a simpler way to keep track of it.

Could "balance" mutation with another!

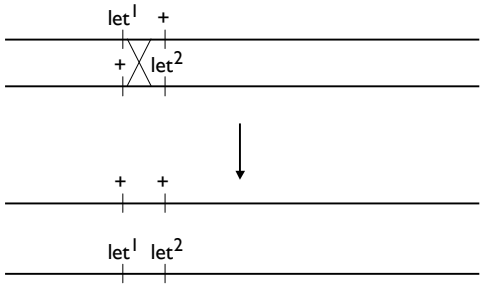


let^1 +/ + let^2 X let^1 +/ + let^2

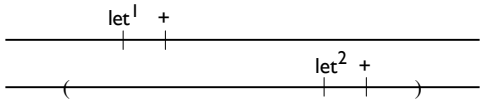
↓

1/2 let^1 +/ + let^2 Survive
1/4 let^1 +/ let^1 +/ } Die
1/4 let^2 +/ let^2 +/

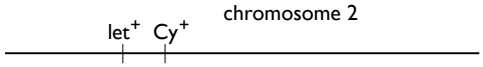
But will get recombiants



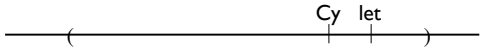
Inversions used so don't get recombinant progeny.



Deficiencies and mutations that lead to a lethal phenotype can be maintained using balancer chromosomes.



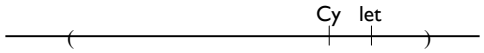
CyO is a Drosophila chromosome 2 balancer



All that has been added is a dominant curly wing marker to be able to know Balancer chromosome is present.

Good balancer chromosomes usually have:

1. A recessive marker -usually one or more lethal mutations (let), so that animals homozygous for this chromosome die.
2. A dominant marker to defect animals that carry the chromosome (Cy-curly wings)
3. An inversion or multiple inversions () to ensure that recombinant progeny are not produced.

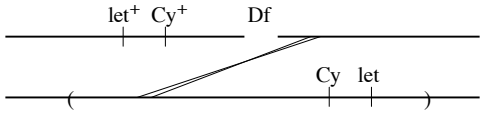


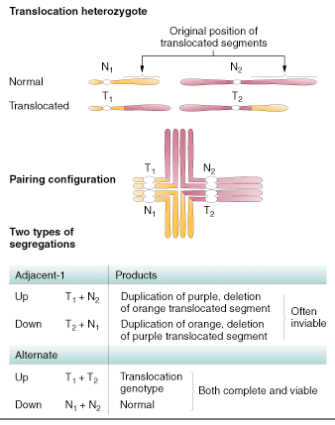
The Df or lethal can be maintained stably over a balancer.

Df/CyO female X Df/CyO male

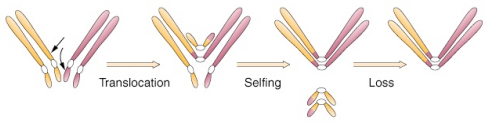
1/4 CyO/CyO Die
1/2 Df/CyO Survive, curly wings
1/4 Df/Df Die

Recombinants that generate a normal chromosome lacking the Df are genetically dead.





Robertsonian Translocation



A 14-21 Robertsonian chromosome produces an inherited form of Down syndrome.