Duplications: source of evolutionary novelty?

Duplication is a source of new genes over evolutionary time: e.g., gene families like globins and MHC genes

- ____________
- ____________
- ____________
- ____________

Structural Changes

- Deletions (deficiencies)
- Duplications
- Inversions
- Translocations
Inversions Suppress Recombination

Organisms carrying an inversion tend to undergo little crossing over in the inversion region in both inverted and non-inverted chromosomes.

If there is crossing over, half the chromatids involved in crossing over will produce non-viable gametes.

Can be a cause of ________
Inversions and evolution

If loci inside an inversion affect a single trait (or suite of related traits), this means they'll be inherited together and allele combinations won’t be broken up by recombination.

A suite of tightly linked loci that affect a single trait is collectively known as a **SUPERGENE**.

- mimicry coloration in some species of butterflies
- snail shell color pattern (some species)

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**Structural Changes**

- Deletions (deficiencies)
- Duplications
- Inversions
- Translocations

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![Diagram](https://via.placeholder.com/150)
Robertsonian Translocation: **Familial Down Syndrome**

**Position Effect**

- In some translocation mutations, the new position of the gene can affect the rate of its transcription and translation.

- For example, if a highly-transcribed gene is translocated to a region close to tightly coiled, inactive heterochromatin, it can sometimes be partially engulfed by that heterochromatin. This will result in a failure of the gene to be expressed in the cells where the heterochromatin coils over the translocated gene.

- This can be seen in "position effect variegation" in our old pal *Drosophila*:

**Chromosome Evolution:**

<table>
<thead>
<tr>
<th></th>
<th>2n</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human</td>
<td>46</td>
<td>23</td>
</tr>
<tr>
<td>Chimpanzee</td>
<td>48</td>
<td>24</td>
</tr>
<tr>
<td>Horse</td>
<td>64</td>
<td>32</td>
</tr>
<tr>
<td>Cat</td>
<td>38</td>
<td>19</td>
</tr>
<tr>
<td>Chicken</td>
<td>78</td>
<td>39</td>
</tr>
<tr>
<td>Geometrid moth</td>
<td>224</td>
<td>112</td>
</tr>
<tr>
<td><em>Drosophila mel</em></td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>Ant (<em>Myrecia pilosula</em>)</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Tomato</td>
<td>24</td>
<td>12</td>
</tr>
<tr>
<td>Horsetail</td>
<td>216</td>
<td>108</td>
</tr>
<tr>
<td>Pink bread mold</td>
<td>14</td>
<td>7</td>
</tr>
</tbody>
</table>
Evolutionary change in chromosome number

- Centromere fusion: two acrocentric chromosomes become fused at or near their terminal centromeres, creating a single, large chromosome.
  **Result:**
  Often evidence of this in closely related species. Compare the NF (fundamental number): the number of chromosome arms visible at metaphase. Or compare sequence data.

- Centromere fission. In this case, the chromosome splits at the centromere, creating two chromosomes from one.
  **Result:**

**Synteny**
Polyploidy

Autopolyploidy
Allopolyploidy

Many plants are polyploids

- > _____ of flowering plants are of polyploid origin.

- In many genera, different species will have different ploidy levels (multiples of a base number) representing a series of polyploids. In the genus *Chrysanthemum*, different species have chromosome numbers of 2n = 18, 36, 54, 72, 90, and 198 - all multiples of a base chromosome number of 9.
Some autopolyploids

- Winesap apples
- Commercial bananas
- Seedless watermelons
- Cultivated tiger lily

Allopolyploidy

Results from hybridization between different species

Bread wheat, oats, cotton, tobacco, strawberries, coffee

Xenopus frogs
Speciation by Polyploidization

Some species are sufficiently closely related that their genes, when combined in a hybrid individual, provide the necessary information for a viable organism—but not for that organism to undergo normal meiosis.

Homo sapiens 2n - 46
Pan troglodytes 2n - 44
Hybrid between the two would be 2n = 45.
(BUT THIS HAS NOT HAPPENED, DESPITE WHAT THE WEEKLY WORLD NEWS WILL TELL YOU.)

Artificially-Produced New Species!

- Brassica oleracea (_______) x Raphanus sativa (______)
- Both species 2n = 18; n = 9, chromosomes not homologous.
- _______ X ______ --> hybrid has 18 chromosomes, but meiosis is abnormal.
- Nondisjunction in a meristematic cell --> 36 chromosomes.
- The cell is said to be allopolyploid (allotetraploid).
- Normal meiosis!
- These plants are self-fertile, so can produce offspring, even if there is only one such individual.
- New “genus/species” was named Raphanobrassica.
- Unfortunately, the hybrid combines the root of a cabbage with the flower head of a radish, rather than the reverse!
**Polyploidy in Animals**

Animals can also produce allopolyploids (e.g. horse x donkey → mule; lion x tiger → liger or tigon).

In mammals, these crosses tend to be sterile, but many fish and reptile species are thought to have arisen as polyploids (e.g. ________________________).

**Why less common in animals?**

Many animals have chromosomally determined sex, and polyploidy interferes with this.

Most animals have several isolating mechanisms (geographic, temporal, behavioral etc.) that tend to prevent natural interbreeding between species.

Many plants have meristematic tissue throughout their lives and are self-fertile: In plants, about 5 out of every 1000 gametes produced is diploid!