Sexual Reproduction: Meiosis Chapt. 9

Meiosis

- Cell division process in which the number of chromosomes is cut in half...
- Results in the formation of gametes such as eggs and sperm
- Gametes have ½ chromosomes of adult
  - Fusion of an egg and sperm results in a zygote
  - Zygote now has the same number of chromosomes as adult

Plants too...Reproduce Sexually

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As a comparison:  
**In Mitosis..**  
- All chromosomes are passed to each new cell...as chromatids  
- Each chromosome splits at its centromere region  
- In this example: 46 chromatids go to each new cell

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**In Meiosis:**

During the first stage of Meiosis- 
Only one of each pair will go to each new cell  
This is called the separation of Homologous chromosomes  
Each new cell will then have 23 chromosomes

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**Haploid vs. Diploid**

- Typically, each cell of your body has 46 chromosomes..23 from each parent  
- So, you have what we call a **Diploid** value of 46  
- Or, referred to as 2N = 46  
- Your gametes, however, have 1N values  
- 1N = 23....This is a **Haploid** condition  
- **All your normal body cells are diploid, only your gametes are haploid**
Diploid numbers of some organisms

<table>
<thead>
<tr>
<th>Organism</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Homo sapiens (human)</td>
<td>46</td>
</tr>
<tr>
<td>Mus musculus (house mouse)</td>
<td>40</td>
</tr>
<tr>
<td>Zea mays (corn or maize)</td>
<td>20</td>
</tr>
<tr>
<td>Drosophila melanogaster (fruit fly)</td>
<td>8</td>
</tr>
<tr>
<td>Xenopus laevis (South African clawed frog)</td>
<td>36</td>
</tr>
<tr>
<td>Caenorhabditis elegans (microscopic roundworm)</td>
<td>12</td>
</tr>
<tr>
<td>Saccharomyces cerevisiae (budding yeast)</td>
<td>12</td>
</tr>
<tr>
<td>Canis familiaris (domestic dog)</td>
<td>78</td>
</tr>
<tr>
<td>Arabidopsis thaliana (plant in the mustard family)</td>
<td>10</td>
</tr>
<tr>
<td>Muntiacus reevesi (the Chinese muntjac, a deer)</td>
<td>23</td>
</tr>
<tr>
<td>Muntiacus muntjac (its Indian cousin)</td>
<td>8</td>
</tr>
<tr>
<td>Myrmecia pilosula (an ant)</td>
<td>2</td>
</tr>
<tr>
<td>Mammalian equus var. univalens (parasitic roundworm)</td>
<td>2</td>
</tr>
<tr>
<td>Cambarus clarkii (a crayfish)</td>
<td>200</td>
</tr>
<tr>
<td>Equisetum arvense (field horsetail, a plant)</td>
<td>216</td>
</tr>
</tbody>
</table>

The complete set of chromosomes in the cells of an organism is its **karyotype**.

**Mitosis vs. Meiosis**

- **Mitosis**: each division gives 2 identical products
  
  \[2N \text{ Cell} \rightarrow 2(2N) \text{ Cells} \rightarrow 4(2N) \text{ Cells}\]

- **Meiosis**: 2 division steps which reduce the number of chromosomes in half
  
  \[2N \text{ Cell} \rightarrow 4(1N) \text{ Cells}\]

**The Process of Meiosis: 2 Separate Steps**

- **Meiosis I**: Homologous chromosomes line up and then separate. In Meiosis 1, chromosomes in a diploid cell resegregate, producing four haploid daughter cells. It is this step in Meiosis that generates genetic diversity.

- **Meiosis II**: Similar process to mitosis.
**Meiosis I**  4 Stages

- **Prophase I** Replicated chromosomes condense and homologs join together in a foursome
  - Text pg. 171
- Homologs may exchange entire regions of genes...**Crossing over**
- Human female eggs remain in Meiosis I until puberty... 12-13 years

**Prophase I in Meiosis**

Prophase I in Meiosis has a unique event -- the pairing of homologous chromosomes. Synapsis is the process of linking of the replicated homologous chromosomes. The resulting chromosome is termed a tetrad, being composed of two chromatids from each chromosome, forming a thick (4-strand) structure.

- Crossing-over may occur at this point.
- During crossing-over chromatids break and may be reattached to a different homologous chromosome.

**Late Prophase I**

- The nuclear membrane disappears.
- One kinetochore forms per chromosome rather than one per chromatid,
- The chromosomes attached to spindle fibers begin to move.
**Meiosis I: Metaphase I**

- Each homologous set of chromosomes line up along cell center
- Orientation on the metaphase plate is random...with either parental homologue on a side. This means that there is a 50-50 chance for the daughter cells to get either the mother's or father's homologue for each chromosome.

**Meiosis I: Anaphase I**

- Homologs are pulled apart to opposite poles
- Chromosomes, each with two chromatids, move to separate poles.
- Each of the daughter cells is now haploid (23 chromosomes), but each chromosome has two chromatids.
- Text pg. 168

**Meiosis I: Telophase I**

- Homologous chromosomes have fully separated
- Results in a Haploid (1N) set of chromosomes at each pole
- Nuclear envelopes may reform, or the cell may quickly start meiosis 2.
- Text pg. 169

http://www.biology.arizona.edu/cell_bio/tutorials/meiosis/page3.html
Meiosis II:

- Essentially a mitotic division of the products of Meiosis I that now separates the chromatids.
- Meiosis 2 is similar to mitosis. However, there is no “S” phase. The chromatids of each chromosome are no longer identical because of recombination.
- Meiosis II separates the chromatids producing two daughter cells each with 23 chromosomes (haploid), and each chromosome has only one chromatid.

http://www.biology.arizona.edu/cell_bio/tutorials/meiosis/page3.html

Meiosis II: Prophase II

- During Prophase II, nuclear envelopes (if re-formed during Telophase I) dissolve, and spindle fibers reform.
- All else is as in Prophase of mitosis. Indeed Meiosis II is very similar to mitosis.

- Text pg. 168

Meiosis II: Metaphase II

- Metaphase II is similar to mitosis metaphase, with spindles moving chromosomes into the equatorial area and attaching to the opposite sides of the centromeres in the kinetochore region.
- Chromosomes align along center
- Text pg. 168
**Meiosis II: Anaphase II**

- During Anaphase II, the centromeres split and the former chromatids are segregated into opposite sides of the cell.
- Text pg. 168

**Meiosis II: Telophase II**

- Telophase II is identical to Telophase of mitosis. Cytokinesis separates the cells.
- End up with 4 haploid (1N) products
- Text pg. 169

**Meiotic Products**

- Final products of meiotic division are:
- 4 cells containing a haploid set (1N) of chromosomes
- These 1N cells become gametes in animals
- But, in plants, they may grow into new 1N individuals.
- Text pg 166
Meiosis Overview

Why Sex??
- Crossing over…generates new gene combinations
- But, new combinations can just as often be bad as good…
- May also provide a backup set of information for DNA repair

Gametogenesis
Gametogenesis is the process of forming gametes (haploid, 1n) from diploid cells of the germ line.
Spermatogenesis is the process of forming sperm cells by meiosis. In spermatogenesis all 4 meiotic products develop into gametes and human males produce 200,000,000 sperm per day.
Oogenesis is the process of forming an ovum (egg) by meiosis in specialized gonads known as ovaries. Human females female produce one egg (usually) each menstrual cycle.
Genes are located on Chromosomes

How can we determine where, and on what Chromosome a gene resides?

FISH Technique

This image from David Ward’s lab shows the spots on two chromosomes where the human gene encoding a specific enzyme (glycogen phosphorylase) is located.

A fluorescent molecule (green) was attached to a piece of DNA containing the gene sequence for this enzyme and when the labeled DNA piece was allowed to combine with human chromosomes, the complementary sequences found and bound each other.

This produced a fluorescent spot close to the centromere of each sister chromatid on chromosome #11.