A. **Plan:** Finish mitosis (see 9/12/06 notes) and discuss meiosis

B. **Reading assignment for lecture:**

**Interesting additional material (brief) in Human Genetics textbook:**
- Stem cells: p39-43
- Animal cloning: p58-59 Bioethics Box
- Twins: p60-62
- Birth defects: p64-69

Following material adapted from THE BIOLOGY PROJECT Univ. of Arizona at:
http://www.biology.arizona.edu/cell_bio/tutorials/meiosis/page1.html

and your Human Genetics textbook by Ricki Lewis

**Asexual (vegetative) reproduction and somatic cell division**
- A form of cell duplication using **mitosis**
- Produces genetically identical offspring or cells
- Offspring are **clones** - each is an exact copy of the original cell
- Since the daughter cells are identical, there is no mechanism for introducing diversity

**Sexual reproduction**
- Formation of new individual from two **haploid sex cells (gametes)**
- **Fertilization** - combination of genetic information from two separate cells that each have one half the original genetic information
- Gametes for fertilization usually come from separate parents
  - Female - produces an **egg**
  - Male produces **sperm**
- Both gametes are **haploid**, with a single set of chromosomes
- The new individual is called a **zygote**, with two sets of chromosomes (diploid)
- **Meiosis** is a process that converts a diploid cell to haploid gametes, and the process provides opportunities that increase genetic diversity in the offspring.

**Number of chromosomes in a human cell**
- Human cells have a diploid or 2n number of chromosomes = 46 (23 pairs)
  - **Autosomes** - one from each parent (22 pairs in humans)
  - **Sex chromosomes** - one from each parent (humans have 2 sex chromosomes)
    - Female - sex chromosomes are homologous (XX)
    - Male - sex chromosomes are non-homologous (XY)
**Ploidy** - refers to the number of sets of chromosomes in a cell
- Haploid (n) = one set chromosomes
- Diploid (2n) = two sets chromosomes
  - Most plant and animal adults are diploid (2n)
  - Eggs and sperm are haploid (n)

**Meiosis** - produces gametes that have one half the number of chromosomes (haploid or 1n) from diploid cells (2n) and generates diversity because different combinations of chromosomes can be formed in the 4 daughter cells.

Meiosis requires two divisions of the genetic material
- the **reduction division** or **meiosis I** and
- the **equational division** or **meiosis II**

**Overview of meiosis** Figure 3.3 Human Genetics 6th and 7th ed.
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During **meiosis I**, the homologous pairs of chromosomes pair forming a **bivalent** (may also be called quartet or tetrad) - this process is called **synapsis**. The junction between the chromosomes is called a **chiasma** or **chiasmata**. **Crossing over** (homologous recombination) or gene swapping occurs between the paired chromosomes - this generates **genetic diversity**. This step is called **early prophase I** (or **prophase I**).
**Figure 3.5 Human Genetics 6th and 7th ed.**

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![Diagram of homologous pair of chromosomes](image)

**Figure 3.4 Meiosis I Human Genetics 6th and 7th ed.**

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**MEIOSIS I**

- **Prophase I (early)**
  - Synapsis and crossing over occurs.

- **Prophase I (late)**
  - Chromosomes condense, become visible. Spindle forms. Nuclear envelope fragments. Spindle fibers attach to each chromosome.

- **Metaphase I**
  - Paired homologous chromosomes align along equator of cell.

- **Anaphase I**
  - Homologous chromosomes separate to opposite poles of cell. Cytokinesis divides cell into two.

- **Telophase I**
  - Nuclear envelopes partially assemble around chromosomes. Spindle disassembles.
• A spindle forms (late prophase I or prometaphase), one kinetochore forms per chromosome and the chromosome bivalents line up (metaphase I) and then the pairs separate to opposite poles of the cell (anaphase I). During metaphase I and anaphase I, the chromosomes from the parents can align and assort randomly - this step generates genetic diversity - called independent assortment.

• When the pairs reach the poles, the spindle is dissolved, the nuclear membrane reforms partially (telophase I) and cytokinesis divides the cell into two - but we are not done yet!!!!

**Figure 3.4 Meiosis II Human Genetics 6th and 7th ed.**

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**During meiosis II** - (prophase II, metaphase II, anaphase II, telophase II)

• The nuclear membrane in the each of the two new cells dissolves, a new spindle forms, and the chromosomes separate again. At the chromosome separation step, called metaphase II, the chromosomes assort randomly - this generates genetic diversity. Meiosis results in the formation of 4 cells each with a haploid or 1n number of non-identical chromosomes (non-identical - because of crossing over and independent assortment).
It is important to understand that during meiosis:

1. Recombination events called **CROSSING OVER** involving the homologous pairs of chromosomes create new gene combinations. Crossing over generates recombinant chromosomes, unlike those in either parent, and this increases genetic diversity.

2. During metaphase I & anaphase I and metaphase II & anaphase II, the chromosomes align and assort randomly - called **independent assortment**.

**Independent assortment generates genetic diversity.**

3. **LINKAGE**: Two genes that lie near each other on the same chromosome tend to segregate together or stay together, thus they are called **LINKED**. (Linkage reduces the potential types of gamete that can be formed).

| Table 3.1 |
| Comparison of Mitosis and Meiosis |

<table>
<thead>
<tr>
<th>Mitosis</th>
<th>Meiosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>One division</td>
<td>Two divisions</td>
</tr>
<tr>
<td>Two daughter cells per cycle</td>
<td>Four daughter cells per cycle</td>
</tr>
<tr>
<td>Daughter cells genetically identical</td>
<td>Daughter cells genetically different</td>
</tr>
<tr>
<td>Chromosome number of daughter cells same as that of parent cell (2n)</td>
<td>Chromosome number of daughter cells half that of parent cell (1n)</td>
</tr>
<tr>
<td>Occurs in somatic cells</td>
<td>Occurs in germine cells</td>
</tr>
<tr>
<td>Occurs throughout life cycle</td>
<td>In humans, completes after sexual maturity</td>
</tr>
<tr>
<td>Used for growth, repair, and asexual reproduction</td>
<td>Used for sexual reproduction, producing new gene combinations</td>
</tr>
</tbody>
</table>