Lab 8 Mitosis and Meiosis

Introduction:

All new cells come from previously existing cells. New cells are formed by karyokinesis (the process in cell division that involves replication of the cell’s nucleus) and cytokinesis (the process in cell division that involves division of the cytoplasm). There are two types of nuclear division; mitosis and meiosis. Mitosis, cell division of non-reproductive cells, results in new somatic cells (2n) that are genetically identical to the parent cell. Mitotic cell division is involved in the formation of an adult organism from a fertilized egg, asexual reproduction, regeneration, and maintenance or repair of body parts. Meiosis results in the formation of gametes in plants, fungi, and animals. These cells have half the chromosome number of the parent cell (1n).

Mitosis, cell division, is best observed in cells that are growing at a rapid pace, such as in the whitefish blastula or onion root cell tips. Root tips contain a growth region called the apical meristem, where the highest percentage of cells are undergoing mitosis. The whitefish blastula is formed immediately after the egg is fertilized, a period of rapid growth and numerous cell divisions when mitosis can be observed.

Mitosis consists of several stages, with an additional stage before and after mitosis. Interphase precedes mitosis. During interphase, the cell will have a distinct nucleus with one or more nucleoli that is filled with a network of threads of chromatin. DNA replication occurs during interphase. After duplication, the cell is ready to begin mitosis. Prophase is when the chromatin thickens until condensed into distinct chromosomes. The nuclear envelope dissolves and chromosomes are in the cytoplasm. The first signs of the microtubule-containing spindle also begin to appear in prophase. Next, the cell begins metaphase. During this phase, the centromere of each chromosome attaches to the spindle and are moved to the center of the cell. This level position is called the metaphase plate. The chromatids separate and pull to opposite poles during the start of anaphase. Once the two chromatids are separate, each is called a chromosome. The last stage of mitosis is telophase. At this time, a new nuclear envelope is formed and the chromosomes gradually uncoil, forming the fine chromatin network seen in interphase. Cytokinesis may occur forming a cleavage furrow that will form two daughter cells when separated.

Meiosis is more complex than mitosis and involves two nuclear divisions called Meiosis I and Meiosis II. These divisions result in the production of four haploid gametes and allow for genetic variation due to crossing over of genetic material. Prior to the process, interphase involves replication of the DNA. During prophase I, the first meiotic stage, homologous chromosomes move together to form a tetrad and synopsis begins. This is the stage in which crossing over occurs, resulting in the recombination of genes. In metaphase I, the tetrads move to the metaphase plate in the middle of the cell as in mitotic metaphase. Anaphase I brings the tetrads back to their original two-stranded form and moves them to opposite poles. During telophase I, the cell prepares for a second division. In Meiosis II, in prophase II, centrioles move to opposite ends of the chromosome group. In metaphase II, the chromosomes are positioned at the center of each daughter cell.
**Anaphase II** involves the centromere and separation of chromatids. **Telophase II** occurs when the divided chromosomes separate into different cells, known as haploid cells.

![Meiosis Diagram]

**Spermatogenesis and Oogenesis**

Meiosis, the process by which gametes are formed, can also be called **gametogenesis** (= “creation of gametes”). The specific type of meiosis that forms sperm is called **spermatogenesis**, and the formation of egg cells, or ova, is called **oogenesis**. The most important thing to remember about both processes is that they occur through meiosis, but there are a few specific distinctions between them.

**Spermatogenesis**

The male testes have tiny tubules containing diploid cells called **spermatogonia** that mature to become sperm. The basic function of **spermatogenesis** is to transform each diploid spermatogonium into four haploid sperm cells. This quadrupling is accomplished through meiotic cell division as detailed in the last section. During interphase, before Meiosis I, each spermatogonium’s 46 single chromosomes are replicated to form 46 pairs of sister chromatids. Sister chromatids exchange genetic material through synopsis before the first meiotic division. In Meiosis II, the two daughter cells go through a second division to yield four cells containing a unique set of 23 single chromosomes that, ultimately, mature into four sperm cells. Starting at puberty, a male will produce literally millions of sperm every single day for the rest of his life.
Oogenesis

Similar to spermatogenesis, oogenesis involves the formation of haploid cells from an original diploid cell, the **primary oocyte**, through meiosis. The female ovaries contain primary oocytes. There are two major differences between the male and female production of gametes. First, oogenesis only leads to the production of one ovum, or egg cell, from each primary oocyte (this is in contrast to the four sperm that are generated from every spermatagonium). Of the four daughter cells that are produced when the primary oocyte divides, three are much smaller than the fourth. These three smaller cells, called **polar bodies**, eventually disintegrate to leave only the last ovum as the final product of oogenesis. The production of one egg cell via oogenesis normally occurs only once a month, from puberty to menopause.

**Hypothesis:**

The stages of mitosis can be examined in whitefish blastula and onion root cell tips by using a microscope. The process of crossing over and the stages of meiosis only occur during the creation of gametes and spores.

**Materials:**

*Exercise 3A*

The materials necessary for this exercise are a light microscope, prepared slides of whitefish blastula, onion root cell tips, a pencil, and paper.

**Methods:**

*Exercise 3A.1: Observing Mitosis*

During this exercise, prepared slides of whitefish blastula and onion root tips should be observed under the 10X and 40X objectives of a light microscope. A cell in each stage of mitosis should be identified and sketched.

*Exercise 3A.2: Time for Cell Replication*

In this section of the lab, use the high-power objective to observe and count every cell in the field of view. Cells should be counted according to the stage of mitosis. At least 200 cells and 2 fields of view should be examined and counted. The percentage of cells in each stage is recorded and amount of time spent in each phase calculated.

**Timing the Stages of Cell Division**

You've now seen that cell division is a dynamic event. Once you know the approximate duration of a particular cell cycle, it's possible to calculate the amount of time the cell spends in each phase. You can do this even
though you are looking at a slide of cells that have been arrested during the process of division. Follow these steps:

1. Determine the approximate duration of the entire cycle for the cells you are studying. (Your instructor will provide this information.)
2. Looking at the slide, count and record the number of cells in the field of view that are in each phase.
3. Determine the total number of cells counted.
4. Determine the percent of cells that are in each phase.
5. To calculate the time (in minutes) for each phase, multiply the percent of cells in that phase by the number of minutes for the whole cycle.

We will practice with the slide of onion root cells below. Looking at the cells marked with an “X”, count the number of cells in each phase. (In lab, you will count at least 200 cells by moving your slide so that you view several fields.)

The average time for onion root tip cells to complete the cell cycle is 24 hours = 1440 minutes. To calculate the time for each stage:

% of cells in stage x 1440 minutes = number of minutes in the stage

Calculate the time for each stage and fill in the table below; then check your answer.

Exercise 3B: Observing Meiosis

Using the computers go to the interactive genetics folder and complete the reviews of Mitosis and Meiosis.

Results:

Exercise 3A
Why is it more accurate to call mitosis "nuclear replication" rather than "cellular division"?

Explain why the whitefish blastula and onion root tips are selected for a study of mitosis.
Table 1: Number of Cells in Each Stage of Mitosis and Amount of Time Spent in Each Stage

<table>
<thead>
<tr>
<th>Number of Cells</th>
<th>Field 1</th>
<th>Field 2</th>
<th>Total</th>
<th>Field 1</th>
<th>Field 2</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interphase</td>
<td>71</td>
<td>101</td>
<td>172</td>
<td>73.2%</td>
<td>1054.0</td>
<td></td>
</tr>
<tr>
<td>Prophase</td>
<td>13</td>
<td>15</td>
<td>28</td>
<td>12.0%</td>
<td>171.6</td>
<td></td>
</tr>
<tr>
<td>Metaphase</td>
<td>12</td>
<td>13</td>
<td>25</td>
<td>10.6%</td>
<td>153.2</td>
<td></td>
</tr>
<tr>
<td>Anaphase</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>1.3%</td>
<td>18.4</td>
<td></td>
</tr>
<tr>
<td>Telophase</td>
<td>3</td>
<td>4</td>
<td>7</td>
<td>3.0%</td>
<td>42.9</td>
<td></td>
</tr>
<tr>
<td>Total Cells</td>
<td></td>
<td></td>
<td>235</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Counted</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

If your observations had not been restricted to the area of the root tip that is actively dividing, how would your results differ?

Based on the data in Table 1, what can you infer about the relative length of time an onion root-tip cell spends in each stage of cell division?

**Exercise 3B**

List three major differences between the events of mitosis and meiosis. Compare mitosis and meiosis with respect to each of the following.

Table 2: Comparing Mitosis and Meiosis

<table>
<thead>
<tr>
<th>Topic Being Compared</th>
<th>Mitosis</th>
<th>Meiosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chromosome number of Parent Cells</td>
<td>Diploid (2n)</td>
<td>Diploid (2n)</td>
</tr>
<tr>
<td>Number of DNA Replications</td>
<td>Once</td>
<td>Once</td>
</tr>
<tr>
<td>Number of Divisions</td>
<td>One</td>
<td>Two</td>
</tr>
<tr>
<td>Number of Daughter Cells</td>
<td>Two</td>
<td>Four</td>
</tr>
<tr>
<td>Chromosome Number of Daughter Cells</td>
<td>Diploid (2n)</td>
<td>Haploid (n)</td>
</tr>
<tr>
<td>Purpose</td>
<td>Growth and repair</td>
<td>Production of gametes or spores</td>
</tr>
</tbody>
</table>
How are Meiosis I and Meiosis II different?

How do oogenesis and spermatogenesis differ?

Why is meiosis important for sexual reproduction?

Error Analysis:

Because the results gathered in the lab were based mostly on observations and sketching, chances of error are slim. However, when either counting the number of or identifying cells in specific stages in Exercise 3A, mistakes could have occurred.

Discussion and Conclusion:

The stages of mitosis were observed and timed in Exercise 3A. These stages are prophase, metaphase, anaphase, and telophase. Prophase is the most time-consuming phase, while anaphase is the least time-consuming. Mitosis is just one portion of a cell’s life. The longest time of a cell’s life (73% to be exact) is spent in interphase, the phase just prior to prophase. During this phase, DNA replication takes place. Prophase involves the first signs of cell division with a thickening of the chromatin threads until the chromatin is condensed into chromosomes. In metaphase, the centromere attaches to the spindle and chromosomes move to the center of the cell. During anaphase, the chromatids are separated and move to opposite ends of the poles. The final stage, telophase, involves condensing of the chromosomes and the formation of a new nuclear envelope. Following telophase, cytokinesis may occur and the cytoplasm will be divided into two cells.