

Mitosis and Meiosis

1. Pre-Lab Preparation

Chapter 10 Sections 1 and 2 (10.1 and 10.2) “Cell Division” and “The Cell Cycle”
Biology2e, OpenStax College

Chapter 11 “Meiosis and Sexual Reproduction” Biology2e, OpenStax College

2. Purpose and Objectives

The purpose of this lab is to become familiar with the stages of cell division and to understand how mitosis and meiosis distribute genetic material to daughter cells.

Upon completion of this lab, you should be able to:

1. Describe the four stages of the cell cycle and the phases of mitosis and meiosis.
2. Identify the stages of the cell cycle and mitosis in plant cells.
3. Distinguish between sister chromatids and homologous chromosomes.
4. Explain how mitosis and meiosis differ.
5. Describe how meiosis contributes to genetic diversity in offspring during sexual reproduction.

3. Background Information

Mitosis and meiosis are both forms of nuclear division in eukaryotes. Before either takes place, the chromosomes within the nucleus are duplicated. The two processes differ in how the chromosomes are distributed in the daughter nuclei. In mitosis, the duplicated chromosomes are separated to form two genetically identical

daughter nuclei. Usually mitosis is followed by **cytokinesis**, the division of the cell's cytoplasm. For many unicellular organisms, mitosis followed by cytokinesis constitutes an asexual form of reproduction. In many sexually reproducing organisms, mitosis occurs after fertilization has formed a single **diploid** cell called a **zygote**. All the cells of a multicellular adult organism are products of the repeated mitotic divisions that began with the zygote. The diploid cells that result and comprise the body of the adult organism are called **somatic cells**.

In sexual reproduction, a reduction of the duplicated chromosomes occurs in **germ-line cells**, cells that give rise to **haploid** gametes. This type of nuclear division is called **meiosis**. Not only are the duplicated chromosomes separated from one another, but homologous chromosomes are separated as well in a series of two chromosomal divisions. This results in four daughter cells that each have half the number of chromosomes of the parent cell. These haploid cells are referred to as **gametes**. When a male and female gamete fuse (fertilization) a diploid cell results (zygote) and the diploid number of chromosomes is reestablished.

4. Mitosis in Plant Cells

In most eukaryotic cells, the process of growth and division is repeated and referred to as the **cell cycle**. The cycle consists of four phases: G₁ (first gap), S (synthesis), G₂ (second gap), and M (mitotic). The G₁, S and G₂ phases are collectively called **interphase**. Primary growth occurs in G₁, the chromosomes are replicated in S and preparations for chromosomal separation are made during G₂. Mitosis and cytokinesis occur during the M phase. In interphase, the DNA exists as extended fibers called **chromatin** that are not distinguishable under the light microscope. The nucleus looks homogeneous, is bounded by the nuclear membrane and contains a nucleolus. Once cells enter mitosis, obvious changes in the nucleus are evident.

The M phase consists of five phases: prophase, prometaphase, metaphase, anaphase and telophase. In **prophase**, chromosomes (appearing as two identical sister chromatids) condense and become visible and the nucleolus disappears. Fibers of the

mitotic spindle, made of microtubules and associated proteins, begin to form and **centromeres** start moving apart. The nuclear envelope fragments in **prometaphase** and microtubules from the centromeres extend through the cell's center. **Kinetochores** are now present on each sister chromatid and microtubules begin attaching to the kinetochores. In **metaphase**, chromosomes line up on the **metaphase plate**, an imaginary plate located between the spindle's two poles. Sister **chromatids** separate in **anaphase** and begin to move away from the metaphase plate. By **telophase**, the chromosomes gather at the poles and new nuclei begin to reappear. You will be able to see two nuclei within a cell that is about the same size as the other cells. The nuclei may be separated by the cell plate which forms as **cytokinesis** occurs.

Procedure

1. Obtain a slide of onion root tip cells. Examine the slide first under low power (40x) and eventually under high power (400x). Look for dividing cells near, but not at, the very tip of the root. Avoid the cells in the very center.
2. Determine the mitotic index of the root tip cells: Move the slide to an area with dividing cells. Working with your partner, record the stage of the cell cycle (interphase, prophase, metaphase, anaphase, or telophase) in 100 cells. Record the results in the table. The easiest procedure is to:
 - a) place the pointer on a column of cells
 - b) read the stage to your partner as you go down the column. Skip cells where neither the nucleus nor chromosomes are visible because of the section.

When you have counted about 50 cells wipe down the microscope, switch places with your partner, move the slide to a new location and let your partner count the rest.

3. Calculate the mitotic index from your data. The mitotic index is the percentage of cells in the M phase (that is, in any phase of mitosis).

4. Determine the percentage of cells in each stage of mitosis and in interphase.
5. Onion root tip cells take about 16 hours to complete the cell cycle. Multiply the percentage of cells in each phase by 16 hours to determine the time required for each stage of the cycle (interphase, prophase, metaphase, anaphase, and telophase).

5. Meiosis: Reebops

As mentioned in the background information, meiosis is a type of reductive division that takes place in sexual reproduction to form haploid cells called gametes. Distribution of homologous chromosomes during meiosis is random; a gamete can end up with any combination of chromosomes from the parent cell, some of maternal and some of paternal origin. This increases genetic variation from one generation to the next and contributes to **independent assortment**, the observation that many traits are inherited independently of each other. In this simulation, you will be a Reebop parent and reproduce to create a new generation of Reebop offspring. A Reebop is an unusual organism made of marshmallows, push pins, toothpicks, pipe cleaners, thumbtacks and pins. You will work with a partner for this activity.

Procedure

1. Observe the phenotypes of the parent Reebops created prior to lab. Female Reebops have a pink tail while males have a blue tail.
2. Open the envelope containing your chromosomes and group homologous chromosomes together. The letters on the chromosomes represent alleles for the various Reebop traits. **How do you determine which chromosomes are homologous?**
3. Table 1 provides the key to the Reebop traits. Record both the genotype and phenotype of your Reebop.

4. **Reebop replication: gamete formation.** Turn the chromosomes over so the letters are face down. Remove one chromosome from each homologous pair at random and place in the center of the table. This represents gamete formation. Your partner should do the same.
5. Combine your Reebop gamete's chromosomes with your lab partner's set to represent fertilization.
6. The resulting collection of chromosomes represents the genetic makeup of one of your offspring (F_1 generation). Turn the chromosomes over and record the genotype and phenotype. This represents your Reebop baby.
7. **Proud Parents!** Take back your chromosomes and repeat steps 4 and 5 and create a second offspring. Now assemble the Reebop babies from the materials provided.
8. Once the entire class has assembled the first Reebop generation (F_1), survey all the offspring. Are any two alike? Do any offspring look exactly like the parents?
9. Reebops reach sexual maturity rapidly. Using the genotype of one of your F_1 offspring, work with another group in the lab and create a second generation (F_2) of Reebops by following steps 4-6. Record the genotype and phenotype and assemble this Reebop. Place with the other F_2 Reebops and compare.

Table 1: Key to Reebop Traits

Trait	Homozygous dominant	heterozygous	recessive
Antenna (A,a)	1 antenna	2 antenna	3 antenna
Antenna color (B,b)	white	yellow	no antenna
Green humps (M,m)	1 hump	2 humps	3 humps
Nose color (Q,q)	Red nose	Orange nose	Yellow nose
Tail shape (T,t)	curly	curly	Straight
Number of eyes (E,e)	2	2	1
Leg color (L,l)	red	green	white
Body segments (D,d)	3	3	2

6. Conclusion and Summary

1. In what ways does your Reebop offspring (first generation) resemble its parents? In what ways is it different?
2. Survey the first Reebop generation (F₁) offspring. Are any two alike? Do any offspring look exactly like the parents?
3. Did any of the class Reebops in the F₂ generation look exactly like the parents? grandparents?
4. Explain how segregation of chromosomes in meiosis results in differences in the phenotypes of the Reebop babies when compared to their parents.

5. Interphase takes longer than any of the stages of mitosis. What are two time-consuming processes that happen during interphase?

6. How does cytokinesis in plant cells differ from that in animal cells? (Consult your text to answer this question.)

Resources:

http://www.pbs.org/wgbh/nova/baby/divi_flash.html

<http://www.lewport.wnyric.org/jwanamaker/animations.htm>

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