LAB 7 - MITOSIS AND MEIOSIS

I. INTRODUCTION

Eukaryotic cells use 2 types of division: mitosis and meiosis. In this lab you will review the structure and organization of the genetic material in eukaryotic cells. Then you will draw 4 sets of diagrams to illustrate how the genetic material is transmitted from parent cell to daughter cells during both mitosis and meiosis. Before you begin the lab, make sure you have completed all video and computer assignments for Unit 3, Topic 3A: *Cell Division*.

II. DR. TAVORMINA'S BIONOTES

A. Read and study *Dr. Tavormina's BioNotes* on "The Cell Cycle." A link to this resource can be found on the Home Page for BIOL 1408 [http://www.austincc.edu/tav/1408].

After studying these notes, as the first part of your lab report, write out the answers to the following questions. Answers should be written using complete sentences, but you do not need to re-write each question.

1. Distinguish between chromosome, chromatid, centromere, and chromatin.
2. Distinguish between identical chromosomes and homologous chromosomes
3. Distinguish between gene, gene locus, and allele.
4. Identify the stages of the eukaryotic cell cycle and explain what happens during each stage.

B. Read and study *Dr. Tavormina's BioNotes* on "Meiosis." A link to this resource can be found on the Home Page for BIOL 1408 [http://www.austincc.edu/tav/1408].

After studying these notes, as the second part of your lab report, write out the answers to the following questions. Answers should be written using complete sentences, but you do not need to re-write each question.

1. Distinguish between synapsis and crossing-over, and identify the stage of meiosis when synapsis and crossing-over take place.
2. Describe the main differences between mitosis and meiosis.
3. Explain the role that mitosis, meiosis, and fertilization play in the life cycle of eukaryotic organisms.

III. COMPUTER EXERCISES ON MITOSIS AND MEIOSIS

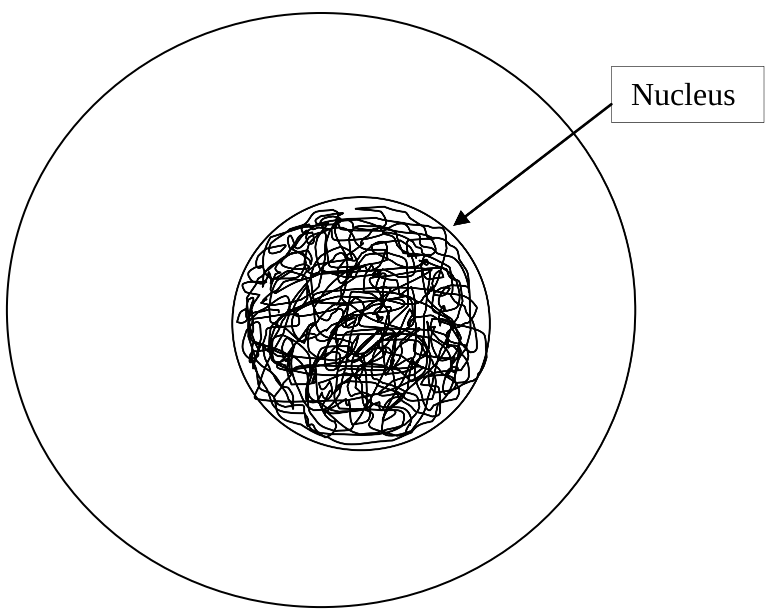
Review the following computer exercises from unit 2 of *The Process of Science*, and make sure you can correctly answer all of the quiz questions in these 2 exercises:

The Cell Cycle and Mitosis
Meiosis

IV. A REVIEW OF CHROMOSOME STRUCTURE AND NUMBER

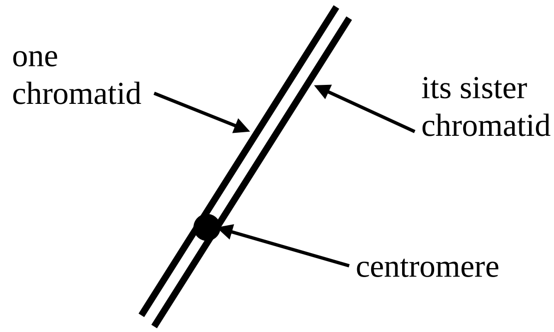
The nucleus of almost every eukaryotic cell contains several to many **chromosomes**. Each chromosome consists of a single long DNA molecule which is wrapped, at regular intervals, around clusters of histone proteins. The sequence of base pairs in the DNA molecule of a chromosome is a code which directs the production of polypeptides made by the cell. By controlling which polypeptides are made, DNA controls all of the activities and characteristics of the cell. A segment of the DNA molecule that contains the code for making a single polypeptide is called a **gene**.

During most of the cell cycle, chromosomes are in an uncoiled state and are too thin to be seen as individual structures. During this stage, which is called **interphase,** the nucleus will look, more or less, like a solid circle with dense granules (called chromatin) in areas where the chromosomes are tightly coiled. We can diagram a cell in interphase as follows:

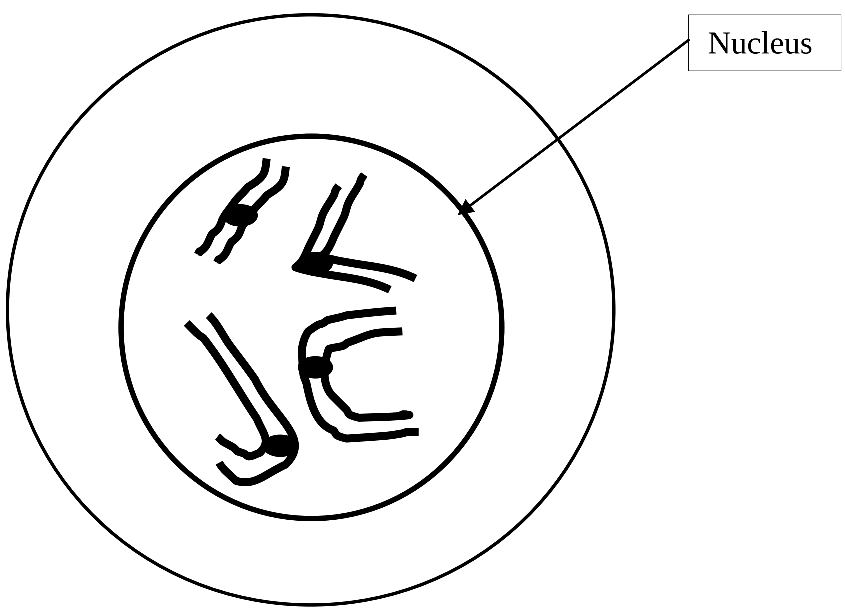


Although individual chromosomes cannot be seen during interphase, this is when they actually **replicate** in preparation for cell division. During replication, each DNA molecule makes an identical copy of itself and the two copies remain attached at a point called the **centromere**. After replication, each chromosome (still not visible) consists of 2 identical DNA molecules which are wrapped around histone proteins and joined at the centromere.

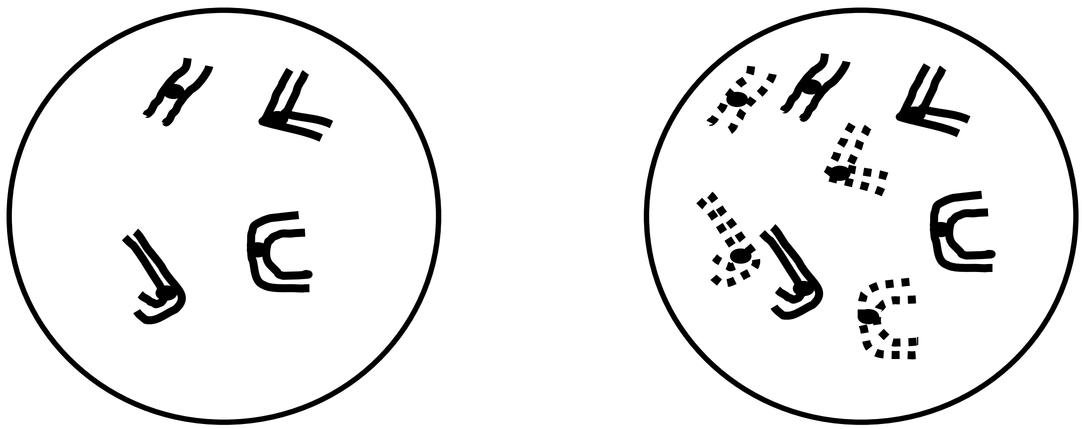
After the chromosomes have replicated, they will coil into short, dense, rod-like structures. This allows the chromosomes to move around within the cell without getting tangled up. Because of replication, each chromosome will be seen to consist of 2 **identical** chromatids (called **sister chromatids**) joined by a **centromere**. You can represent one duplicated chromosome in your diagrams as follows:



Once the chromosomes are condensed (tightly coiled), we can actually see the size and shape of the individual chromosomes and count the number present in each cell. Careful counts of chromosome numbers have revealed that each species has its own characteristic number of chromosomes that make up a complete set. A complete set of chromosomes contains all of the genes needed to code for all the proteins produced by a species. The chromosomes that make up a complete set can vary in size, structure, and location of the centromere. In your diagrams, you should use different shapes to represent the different chromosomes that make up a set. **Use shapes that are easily distinguished from each other**. For example, a complete set of chromosomes in the fruit fly *Drosophila* contains 4 chromosomes. If we are drawing duplicated chromosomes, we can represent these 4 chromosomes within the nucleus as follows:

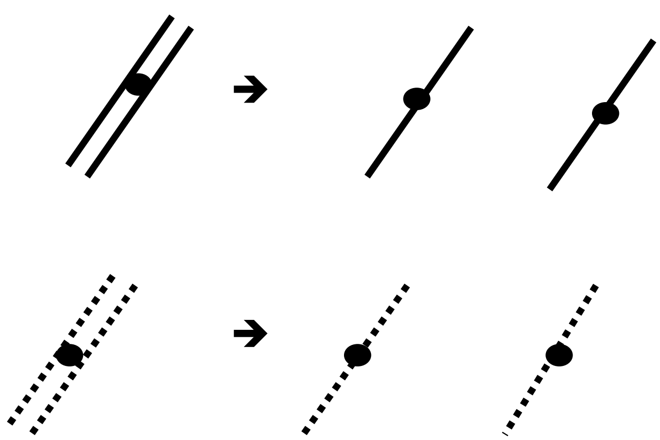


While studying the number of chromosomes in eukaryotic cells, scientists have found that in most species some cells have one set of chromosomes (these are **haploid cells**) while other cells have two sets (these are **diploid cells**). The number of chromosomes in a haploid cell is represented by the symbol N, while the number of chromosomes in a diploid cell is represented by the symbol 2N (in the fruit fly *Drosophila*, N=4 and 2N=8.) In the diagrams below, solid lines are used to represent one set of chromosomes, while dotted lines are used to represent the second set (if present). Note that in diploid cells there are 2 chromosomes with each shape (in the diagram below, one is shown as solid, the other as dotted.) The 2 members of each pair are called **homologous chromosomes -** they have the same shape and control the same traits, but they are not identical because they may code for different forms of those traits.



Haploid Nucleus   Diploid Nucleus

Finally, during cell division the centromere of each chromosome eventually splits, changing each duplicated chromosome into 2 separate but **identical** unduplicated chromosomes. The diagram below shows how you should represent unduplicated chromosomes in your diagrams (except you will use different colors instead of solid and dotted lines when 2 sets of chromosomes are present). Keep in mind that the actual number, shape, location, and color of the chromosomes in each cell will depend on the number of chromosomes in each set, whether you started with a haploid or diploid cell, and the stage of cell division you are drawing.



one duplicated chromosome ➔ two unduplicated chromosomes

V. DIAGRAMMING THE STAGES OF MITOSIS

Note: When you draw your diagrams, refer to Unit 2 of the *Process of Science* CD-ROM for descriptions and diagrams of the different stages of mitosis. Keep in mind that your diagrams will not look exactly like those on the CD because the number, shape and color of the chromosomes that you draw will be different from the chromosomes shown on the CD.

1. On a sheet of paper, draw labeled diagrams showing the 4 stages of **mitosis** (prophase, metaphase, anaphase and telophase) for a **diploid cell** where 2N=6. Use 3 different shapes to represent the different chromosomes in each set, and use 2 different colors to represent the 2 sets of chromosomes. Make sure you show the number, shape, color and location of the chromosomes at each stage of division . Remember, in some stages the chromosomes will be duplicated and in some stages they will not be duplicated. Also include the spindle apparatus and nuclear membrane when appropriate.

2. On a second sheet of paper, draw labeled diagrams showing the 4 stages of **mitosis** (prophase, metaphase, anaphase and telophase) for a **haploid cell** where N=4. Use 4 different shapes to represent the different chromosomes that make up a complete set. Make sure you show the number, shape, color and location of the chromosomes at each stage of division . Remember, in some stages the chromosomes will be duplicated and in some stages they will not be duplicated. Also include the spindle apparatus and nuclear membrane when appropriate.

VI. DIAGRAMMING THE STAGES OF MEIOSIS

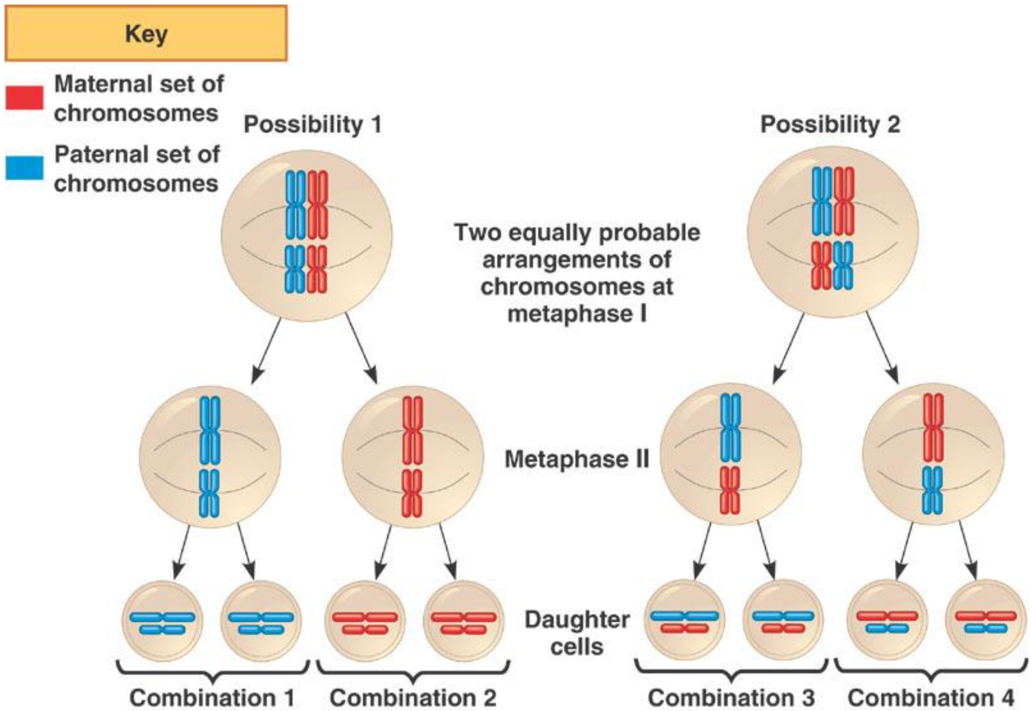
Note: When you draw your diagrams, refer to Unit 2 of the *Process of Science* CD-ROM for descriptions and diagrams of the different stages of meiosis. Keep in mind that your diagrams will not look exactly like those on the CD because the number, shape and color of the chromosomes that you draw will be different from the chromosomes shown on the CD.

1. On a third sheet of paper, draw labeled diagrams showing the 8 stages of **meiosis** (prophase I, metaphase I, anaphase I, telophase I, prophase II, metaphase II, anaphase II, and telophase II) for a **diploid cell** where 2N=6. Use 3 different shapes to represent the different chromosomes in each set, and use 2 different colors to represent the 2 sets of chromosomes. Make sure you show the number, shape, color and location of the chromosomes at each stage of division . Remember, in some stages the chromosomes will be duplicated and in some stages they will not be duplicated. Also include the spindle apparatus and nuclear membrane when appropriate.

VII. INDEPENDENT ASSORTMENT OF CHROMOSOMES DURING MEIOSIS

Diploid cells have 2 sets of chromosomes, one set inherited from the mother (maternal set) and one set inherited form the father (paternal set). During Prophase I of meiosis, homologous chromosomes pair up. Each homologous pair consists of one maternal chromosome and one paternal chromosome. During Metaphase I of meiosis, the homologous pairs line up down the middle of the cell. The orientation of the 2 chromosomes in each homologous pair relative to the two poles of the cell is completely random. Therefore, for each homologous pair there is a 50% chance that the maternal chromosome will be on the left side of the cell with the paternal chromosome on the right, and a 50% chance that the maternal chromosome will be on the right side of the cell with the paternal chromosome on the left. Further, the orientation of one pair of chromosomes is independent of the orientation of the other pairs. This is referred to as **Independent Assortment**. (This is similar to a situation where you toss 3 coins. Each coin has a 50% chance of coming up heads and a 50% chance of coming up tails. The way one coin lands does not affect how the other coins land. The outcome for each coin is independent of the other coins.)

The diagram below shows the different possible arrangements of chromosome pairs during Metaphase I in an organism where 2N=4. The darker chromosomes represent the maternal set and lighter chromosomes represent the paternal set. The orientation of each homologous pair of chromosomes along the middle of the cell during Metaphase I is a matter of chance, like flipping a coin. The way one pair lines up is independent of the way the other pair lines up. The orientation of the chromosome pairs during Metaphase I determines which chromosomes will be packaged together in the gametes. Note that when there are 2 pairs of chromosomes, there are 4 possible chromosome combinations in the gametes produced.



1. On a fourth sheet of paper, draw a diagram which shows the different possible arrangements of chromosome pairs during Metaphase I in an organism where 2N=6. Use one color to represent the maternal chromosomes and a different color to represent the paternal chromosomes. For each chromosome arrangement during Metaphase I, show the resulting chromosome combinations in the gametes produced at the end of meiosis. Your diagram should be similar to the diagram above, except that you will be dealing with 3 pairs of chromosomes instead of 2 and, consequently, there will be more possible arrangements of the chromosome pairs.

VIII. REPORT

For your lab report on mitosis and meiosis, turn in the following 3 items:

- answers to questions on "The Cell Cycle" from section II
- answers to questions on "Meiosis" from section II
- 4 pages of diagrams showing the stages of mitosis, the stages of meiosis, and independent assortment as described in sections V, VI, and VII

