



A PILOT DVD PROJECT

MODELING MEIOSIS

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□ **Activity:** Modeling Meiosis: Pop Beads

○ **Timeframe:** 1.5-2 hours

○ **Materials:** 60 pop beads of one color, 4 centrioles, 60 pop beads of another color, 8 magnetic centromeres

○ **Teacher Directions**

- Tell students that meiosis takes place in all organisms that reproduce sexually.
- Tell students that in animals, meiosis occurs in special cells of the gonads; in plants, in special cells of the sporangia.
- Tell students that meiosis consists of two nuclear divisions, meiosis I and II, with an atypical interphase between the divisions during which cells do not grow and synthesis of DNA does not take place. This means that meiosis I and II result in four cells from each parent cell, each containing half the number of chromosomes, one from each homologous pair.
- Tell students that cells with only one of each homologous pair of chromosomes are haploid (n) cells. The parent cells, with pairs of homologous chromosomes, are diploid ($2n$). The haploid cells become sperm (in males), eggs (in females), or spores (in plants).
- Tell students that one advantage of meiosis in sexually reproducing organisms is that it prevents the chromosome number from doubling with every generation when fertilization occurs.
- Watch Lecture 1 Chapter 26 (stop DVD after discussion of consequences of meiosis)
- Define chromatids, homologous chromosomes (homologs), gametes, diploid, and haploid.
- What are the two consequences of meiosis?
- Discuss gene swapping (recombination) and division of chromosomes.
- Describe the stages of meiosis.
- Watch Lecture 1 Chapter 31 Animation: Meiosis

○ **Student Directions and Evaluation:**

Lab Study A. Interphase

Working with another student, you will build a model of the nucleus of a cell in interphase before meiosis. You and your partner should discuss activities in the nucleus and chromosomes in each stage. Go through the exercise once together and then demonstrate the model to each other to reinforce your understanding.

Procedure

1. Build the premeiotic interphase. Have two morphologically distinct pairs of chromosomes ($2n = 4$). Have one member of each pair of homologues be one color, the other a different color.
2. To represent G1 (gap 1), pile your four chromosomes in the center of your work area. The chromosomes are decondensed.

In G1, are chromosomes single-stranded or double-stranded?

3. Duplicate the chromosomes to represent DNA duplication in the S (synthesis) phase. Recall that in living cells the centromeres remain single, but in your model you must use two magnets. *What color should the sister chromatids be for each pair?*
4. Duplicate the centriole pair.
5. Leave the chromosomes piled in the center of the work area to represent G2 (gap 2). In G2 the cell prepares for meiosis by synthesizing proteins and enzymes necessary for nuclear division.

Lab Study B. Meiosis I

Meiosis consists of two consecutive nuclear divisions, called meiosis I and meiosis II. As the first division begins, the chromosomes coil and condense.

Procedure

1. Meiosis I begins with the chromosomes piled in the center of your work area. As chromosomes begin to coil and condense, prophase I begins. Each chromosome is double-stranded, made up of two sister chromatids. Two pairs of centrioles are located outside the nucleus.
2. Separate the two centriole pairs and move them to opposite poles of the nucleus. The nuclear envelope breaks down and the spindle begins to form.
3. Move each homologous chromosome to pair with its partner. You should have four strands together. Early in prophase I, each chromosome finds its homologue and pairs in a tight association called the synaptonemal complex. The process of pairing is called synapsis. Because the chromosomes are double-stranded, this means that each paired doubled chromosome complex is made of four strands. This complex is called a tetrad.

How many tetrad complexes do you have in your cell which is $2n = 4$?

4. Represent the phenomenon of crossing over by detaching and exchanging identical segments of any two nonsister chromatids in a tetrad. Crossing over takes place between nonsister chromatids in the tetrad. In this process a segment from one chromatid will break and exchange with the exact same segment on a nonsister chromatid in the tetrad. The crossover site forms a chiasma (plural, chiasmata).

Note: If you are having difficulty envisioning the activities of chromosomes in prophase I and understanding their significance, discuss these events with your lab partner and, if needed, ask questions of your lab instructor before proceeding to the next stage of meiosis I.

5. Move your tetrads to the equator, midway between the two poles.
Late in prophase I, tetrads move to the equator.
 6. To represent metaphase I, leave the tetrads lying at the equator.
During this phase, tetrads lie on the equatorial plane. Centromeres do not split.
 7. To represent anaphase I, separate each double-stranded chromosome from its homologue and move one homologue toward each pole. (In our model, the two magnets in sister chromatids represent one centromere holding together the two sister chromatids of the chromosome.)
 8. To represent telophase I, place the chromosomes at the poles. You should have one long and one short chromosome at each pole, representing a homologue from each pair.
Two nuclei now form, followed by cytokinesis. *How many chromosomes are in each nucleus?*
- Note:** The number of chromosomes is equal to the number of centromeres. In this model, two magnets represent one centromere in double-stranded chromosomes.
- Would you describe the new nuclei as being diploid (2n) or haploid (n)?*
9. To represent meiotic interphase, leave the chromosomes in the two piles formed at the end of meiosis I. The interphase between meiosis I and meiosis II is usually short. There is little cell growth and no synthesis of DNA. All the machinery for a second nuclear division is synthesized, however.
 10. Duplicate the centriole pairs.

Lab Study C. Meiosis II

Meiosis I results in two nuclei with half the number of chromosomes as the parent cell, but the chromosomes are double-stranded (made of two chromatids). The events in meiosis II must change double-stranded chromosomes into single-stranded chromosomes. As meiosis II begins, two new spindles begin to form, establishing the axes for the dispersal of chromosomes to each new nucleus.

Procedure

1. To represent prophase II, separate the centrioles and set up the axes of the two new spindles. Pile the chromosomes in the center of each spindle.
In each new cell the centrioles move to the poles, nucleoli break down, the nuclear envelope breaks down, and a new spindle forms. The new spindle forms at a right angle to the axis of the spindle in meiosis I.
2. Align the chromosomes at the equator of their respective spindles.
As the chromosomes reach the equator, prophase II ends and metaphase II begins.
3. Leave the chromosomes on the equator to represent metaphase II.
4. Pull the two magnets of each double-stranded chromosome apart.
As metaphase II ends, the centromeres finally split and anaphase II begins.

5. Separate sister chromatids (now chromosomes) and move them to opposite poles.

In anaphase II, single-stranded chromosomes move to the poles.

6. Pile the chromosomes at the poles.

As telophase II begins, chromosomes arrive at the poles. Spindles break down. Nucleoli reappear. Nuclear envelopes form around each bunch of chromosomes as the chromosomes uncoil. Cytokinesis follows meiosis II.

* *What is the total number of nuclei and cells now present?*

* *How many chromosomes are in each?*

* *How many cells were present when the entire process began?*

* *How many chromosomes were present per cell when the entire process began?*

* *How many of the cells formed by the meiotic division just modeled are genetically identical? (Assume that alternate forms of genes exist on homologues.)*

- Web Connections

- <http://www.dartmouth.edu/~cbbc/courses/movies/meiosis.html>
- <http://www.iacr.bbsrc.ac.uk/notebook/courses/guide/movie/meiosis/htm>
- http://highered.mcgrawhill.com/sites/0073031216/student_view0/exercise14/meiosis_movie.html