NAME _____

DATE _____

Carolina BioKits™

Chromosome Simulation

Mitosis Activity

Mitosis is a continual process in which the phases progress from one to the next gradually. However, for the purposes of this discussion and to facilitate modeling, we will designate events in the process of mitosis as separate phases. During this activity, you will manipulate the materials at your lab station in order to visualize the events that occur during each phase. For each step of the Procedure, read the description of the events in the phase, and then follow the directions to model the step using the model materials provided.

Materials

40 red beads
40 yellow beads
4 magnetic centromeres
2 red plastic centrioles
clear adhesive tape (shared)
masking tape (shared)
string (shared)

Procedure

1. Build two chromosomes (a homologous pair).
   a. Make four strands of 10 yellow beads and four strands of 10 red beads.
   b. Connect two red strands to one magnetic centromere to create a 20-bead strand with the centromere in the center.
   c. Repeat Step 1b with the remaining strands of red beads.
   d. Connect two yellow strands to one magnetic centromere to create a 20-bead strand with the centromere in the center.
   e. Repeat Step 1d with the remaining strands of yellow beads.
   f. Place the two long red strands together, and allow them to join at the magnetic centromeres. This entire, combined structure represents one chromosome.
   g. Allow the two long yellow strands to come together and join at the magnetic centromeres. This entire structure represents another chromosome, in this case, the homolog of the red chromosome. Together, the models represent a homologous pair of chromosomes.
2. Build a nuclear membrane.
   a. Acquire six lengths of masking tape, each approximately 12 inches long.
   b. Use two pieces of tape to create a closed circle or hexagon shape on the surface of your desk or on a clear space on the floor, as your teacher directs. The tape ring represents the nuclear membrane of the cell. Your entire workspace represents the area inside the cell.
   c. Place the two chromosomes in random orientations inside the nuclear membrane.
   d. Now you are ready to model events in the cell cycle.

3. **Interphase:** Interphase occurs before mitosis as a preparation for nuclear division. It is the longest stage of the cell cycle. During this time, DNA is replicated and the cell rapidly grows and produces organelles. The nuclear membrane and nucleolus are distinct. The nucleolus is made of nucleic acids and proteins.
   a. Position two plastic centrioles outside the nuclear membrane ring, touching at right angles.
   b. Position the chromosomes in a pile inside the nuclear membrane. If you looked at a cell in interphase under a compound microscope, you would not be able to see individual chromosomes, because they are so long and thin. Only when they are condensed are they visible under the microscope, assuming their characteristic "X" shape.
   c. On the Mitosis Sketches page, make a diagram of the chromosome model at this stage of mitosis.
4. **Prophase:** Prophase is the first phase of mitosis. Replicated DNA condenses into chromosomes that consist of two identical sister chromatids bound by a centromere. The nuclear membrane begins to disappear as it breaks down. Centrioles are located on opposite sides of the cell. In later phases, microtubules radiating from the centrioles will attach to each side of the centromere and pull the sister chromatids apart.
   a. Move the centrioles so that they are on opposite sides of the nucleus, about 8 inches from the outside edge of the nuclear membrane.
   b. Use a piece of transparent tape to secure each centriole to the work surface so that the opening of the bead faces the area that was the nucleus.
   c. Break down the nuclear membrane by pulling pieces of tape from the work surface. If you can, keep the tape in strips on the side of your workspace to reuse it later as a new nuclear membrane.
   d. Arrange the chromosomes with arms outstretched to demonstrate that they are condensed. Then, twist the arms of the sister chromatids together.
   e. On the Mitosis Sketches page, make a diagram of the chromosome model at this stage of mitosis.
5. **Metaphase:** Metaphase is the shortest phase of mitosis. The nuclear membrane has completely disappeared. Microtubules radiating from opposite sides of the cell have attached to the centromeres of the chromosomes. Chromosomes line up along the equator of the cell.
   a. Cut four lengths of string, each 3 feet long. Bring them to your workstation.
   b. Using the four pieces of string, tie a loop around each magnetic centromere. When you have finished, each chromatid should have a length of string hanging off it.
   c. The strings represent microtubules that function to move the chromosomes around in the cell. Thread the loose end of the pieces of string through the holes in the centriole bead, such that if you were to pull the strings through the centriole bead, the two parts (chromatids) of the current chromosome would separate. See Figure 2.
   d. Gently pull the strings from one chromosome through the centrioles to that the chromosome moves to the center, but the chromatids remain attached. Pull the strings from the second chromosome to move it to the center also. The two chromosomes should be roughly aligned between the centrioles. This action represents the chromosomes lining up along the metaphase plate.
   e. On the Mitosis Sketches page, make a diagram of the chromosome model at this stage of mitosis.

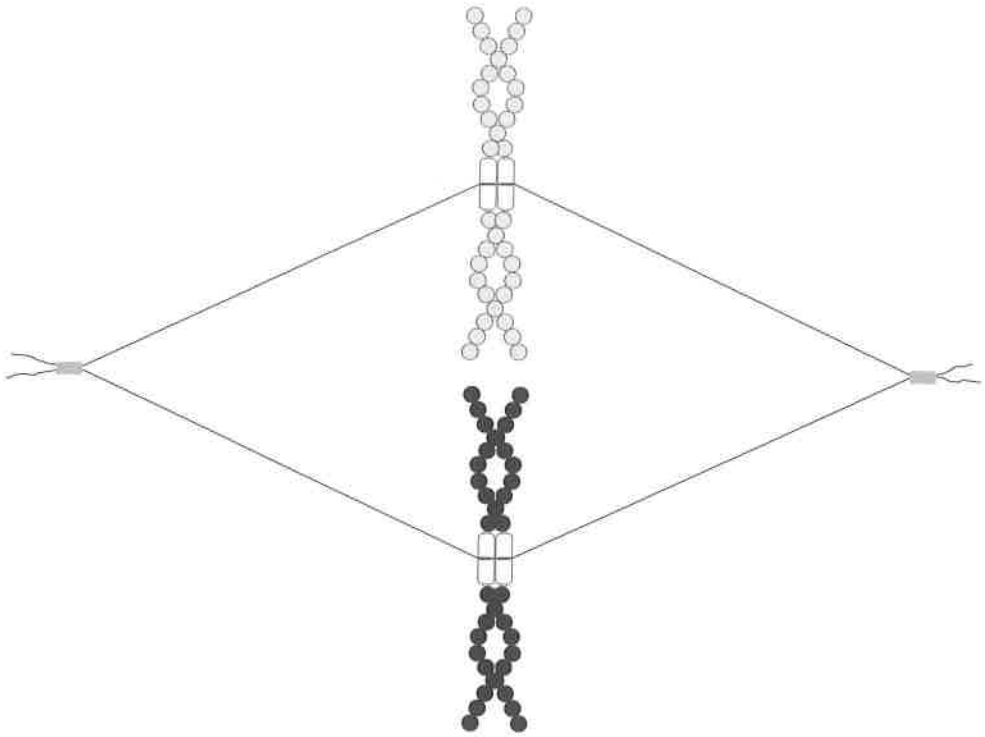
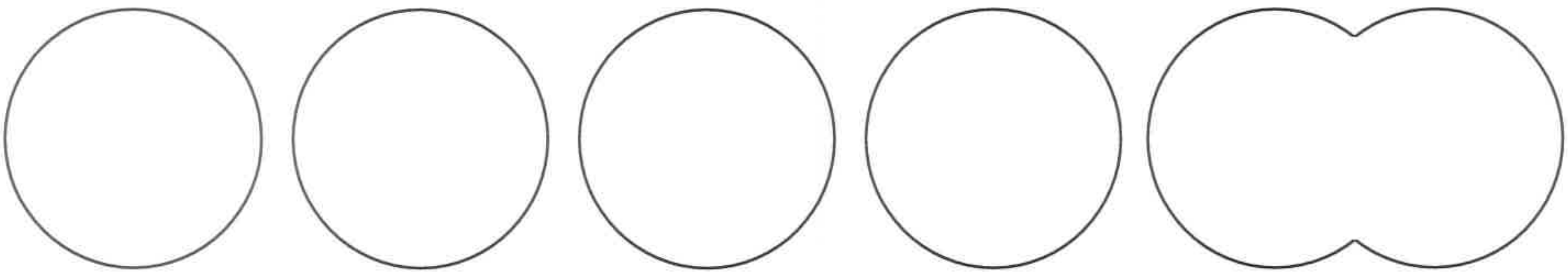


Figure 2. Metaphase of mitosis

6. **Anaphase:** During Anaphase, the microtubules pull sister chromatids toward opposite sides of the cell. Each chromatid is now properly referred to as a chromosome. The cell now has twice the original number of chromosomes. This segregation results in two regions of compact chromosomes that are genetically identical.
   a. Pull the strings through the centriole beads until the chromatids separate.
   b. Continue to separate the chromatids until they are adjacent to the centrioles. Each side of the cell should have one red and one yellow chromosome.
   c. On the Mitosis Sketches page, make a diagram of the chromosome model at this stage of mitosis.
7. **Telophase:** A visible nuclear membrane begins to form around each set of chromosomes. The chromosomes decondense. The nucleoli form in each nucleus, and the microtubules break down.
   a. Remove the string from each chromosome, and set aside the strings.
   b. To represent decondensing, pile the chromosomes beside their closest centriole.
   c. Use the masking tape you set aside to create a new nuclear membrane around each set of chromosomes (or obtain more tape if necessary). This concludes the modeling of mitosis.
   d. On the Mitosis Sketches page, make a diagram of the chromosome model at this stage of mitosis.
   e. Save the pieces of string and the chromosome structures for the next activity.

Cytokinesis is the division of the cytoplasm and its contents into two cells. This stage of the cell cycle may occur at the same time as telophase of mitosis. Cytokinesis in plant cells and in animal cells occurs by different mechanisms. In animal cells, microfilaments form around the cell and contract, forming an indentation called a cleavage furrow. Eventually the parent cell is pinched into two daughter cells. Plant cells develop a cell plate along the equatorial plane outward to the wall to divide the cell; new cell walls form along the cell plate.

Mitosis Sketches



Interphase | Prophase | Metaphase | Anaphase | Telophase