

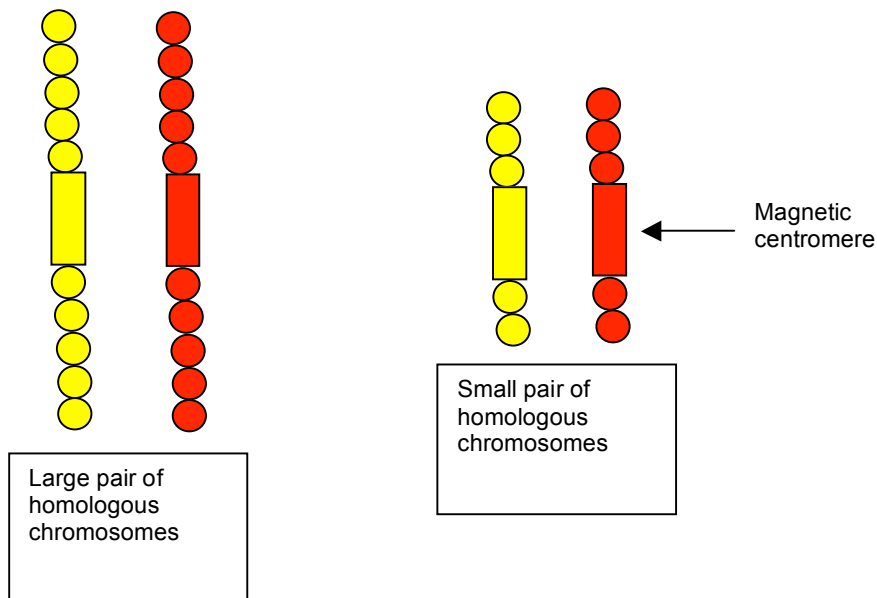
Meiosis simulation with models made of pop-it beads and magnetic centromeres.

Materials needed:

- A supply of pop-it beads of two different colors (available from several vendors including Ward's, Science Kit and Carolina)
- A supply of magnetic centromeres (available from several vendors including Ward's, Science Kit and Carolina)
- A large sheet of paper
- Pencils
- String or thread to simulate spindle fibers
- Scotch tape
- Scissors

Begin with a mother cell containing $2N=4$ chromosomes (2 homologous pairs, one large pair, one small pair). Each lab group constructs the chromosomes as follows:

1. For the large chromosome attach a string of 5 beads of one color to one side of a centromere and repeat for the other side (total of 10 beads for one chromosome).
2. Repeat step one with beads of the other color to make the homolog.
3. Repeat steps one and two for a pair of small chromosomes but use a total of 5 beads per chromosome.



At this point each lab group can proceed to model the steps of meiosis. The large piece of paper will represent the cell. The chromosomes can be arranged on this surface as needed. Students can sketch features such as centrioles. Pieces of string representing spindle fibers can be attached to the centromeres using small pieces of tape. As cytokinesis takes place, the paper can be cut in two.

Each group must show each phase to the teacher before the group can proceed to the next phase. The simulation can be done with or without crossing over, although crossing over

yields much greater variability. Students may use any resource such as texts or web sites to learn about the phases. They must then apply this in creating the model.

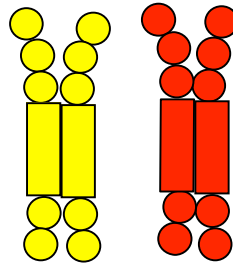
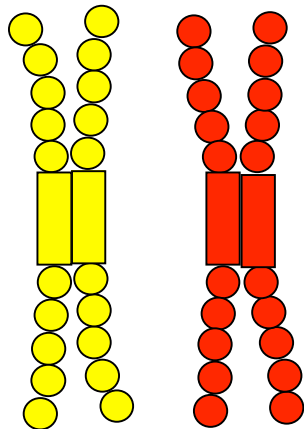
After each group has successfully completed the exercise, the 4 gametes are saved on the lab bench. After all groups are finished, take the class on a “tour” of each of results. Ask students about the diversity in genetic material in the gametes. Which steps in meiosis account for this diversity?

Sexual reproduction can then be simulated by randomly selecting two gametes, one from each of two different groups, and uniting their chromosomes to regain the $2N=4$ diploid number. This may repeated for other gametes and can serve as a basis for a discussion of the importance of sexual reproduction in producing genetic diversity.

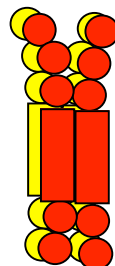
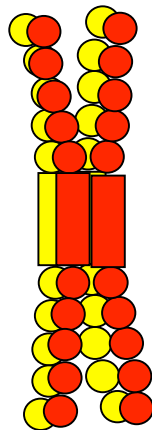
Points to remember:

- Replication of chromosomes prior to prophase 1
- Crossing over in prophase 1 (let students decide where and if crossing over will happen)
- Lining up of homologous pairs on the metaphase 1 plate (independent assortment). Let students decide how to line the chromosomes up.

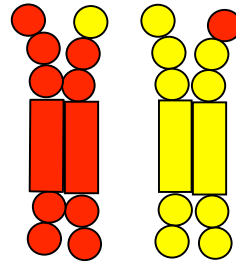
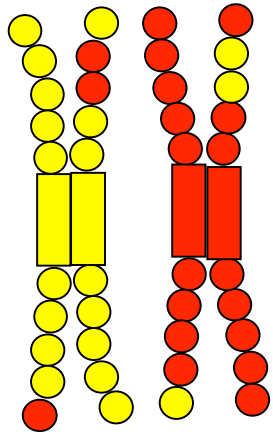
Sample results:



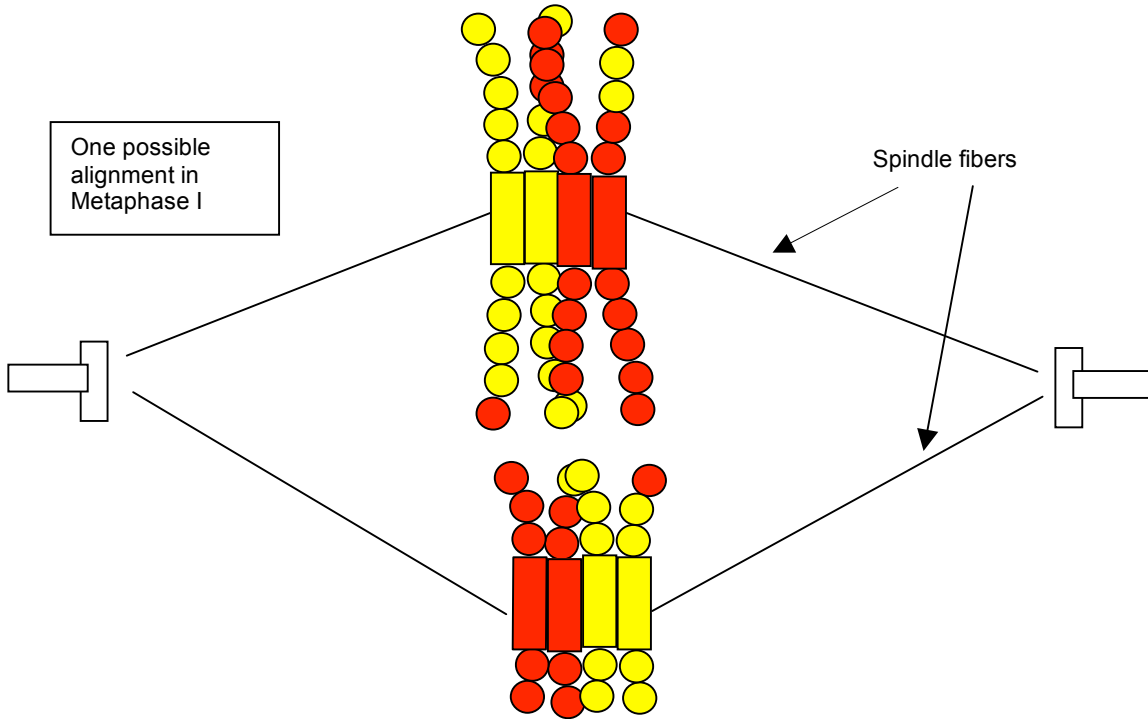
- Chromosomes have replicated.
- Each is composed of two identical sister chromatids.

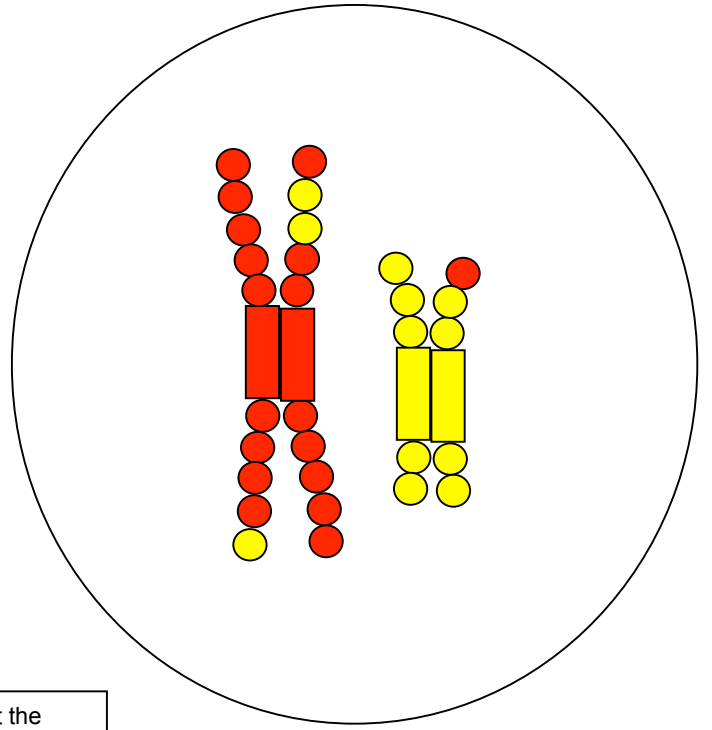
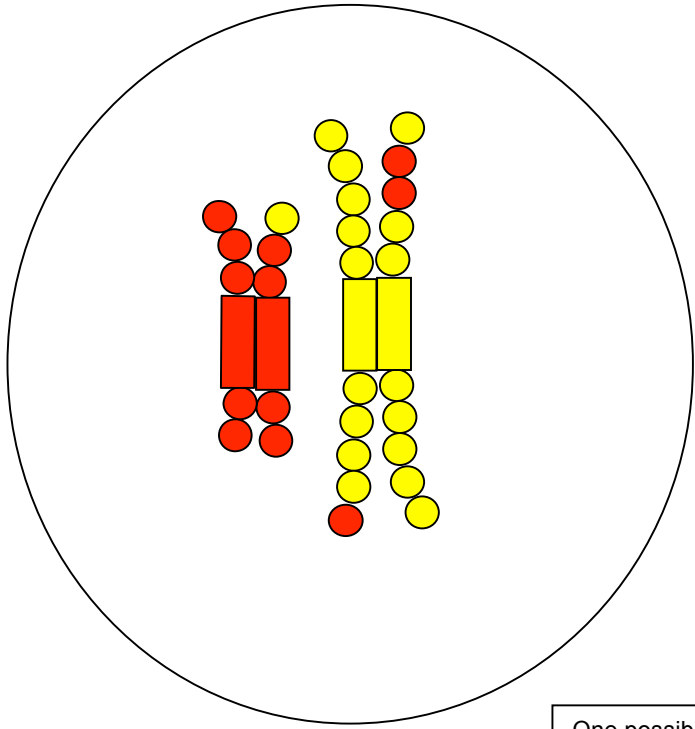


Pairs of homologous chromosomes form tetrads.

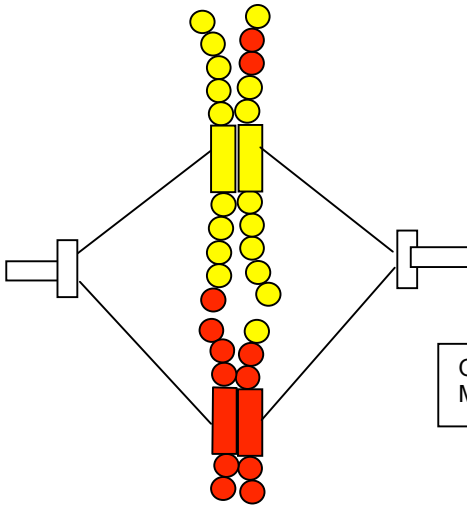


One possible result of crossing over

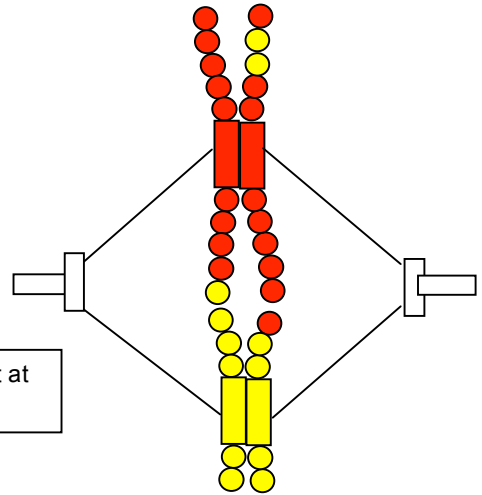




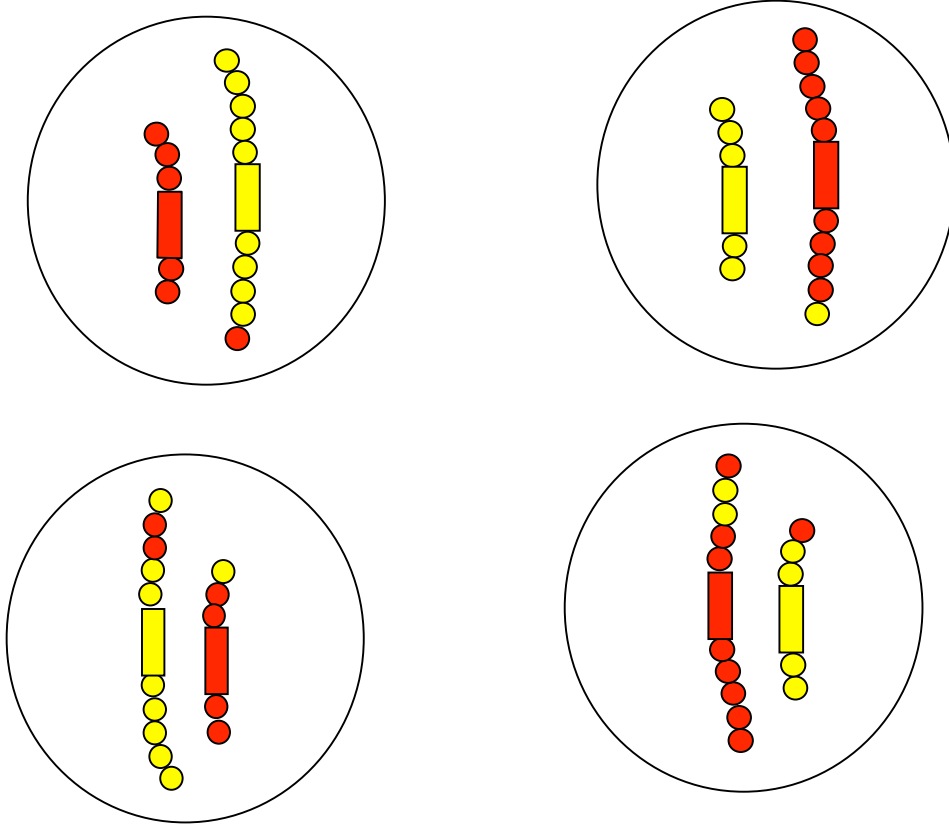
One possible result at the end of Telophase I



One possible alignment at Metaphase II



One potential outcome at the end of Telophase II: Are any of the gametes the same?
Imagine the diversity one can achieve with $2N=46$!



NOTES:

The magnetic centromeres allow the chromosomes to stick any steel surface including most chalkboards and white boards because they are usually metal-mounted. This way the teacher can demonstrate the entire process on the board and freely move the models around as needed, draw in structures like spindles, etc.

As inquiry, this exercise is best done by students with little teacher interference. If groups do not successfully transition from one phase to another, have them consult other groups if needed. If there is still a lack of understanding, then the teacher can intercede to give clues. The more the students figure things out on their own, the better the learning experience.

As a suggestion for assessment, have each group sketch their result. Then have the group repeat the process with the objective of obtaining a different result. The teacher can also ask the groups “what if” questions, e.g. 1. “What if homologous chromosomes fail to separate in meiosis I? Can you illustrate this phenomenon using the model?” 2. “What if crossing over results in an unequal exchange of chromosomal material?”