Sock Mitosis and Meiosis Modeling Activity

Adapted from Wright and Newman, 2011 (1).

Instructor Preparation/Modifications to Wright et al, 2011 for implementation at UMR:

Instructions will include directive to model mitosis as well as meiosis

All students will participate in modeling, rather than only 6 students acting as chromosomes with socks and 2 students acting as centrosomes (8 students total). Rather, we will utilize 4 groups of students, all modeling. We will use N=4, 2N=8 to involve all students. This will affect the correct responses for items in Wright et al., 2011 table II.

1. Instructor will divide students into 4 groups of 11 students each. There will not be parity among males and females (as male students are outnumbered by female students). For each group, 8 students will be given the number 1-4 to represent different chromosomes in the hypothetical genome. Two students with the same number will act as homologous pairs of chromosomes. Two students in each group of 11 will be assigned the role of centrosomes (C). The final student in each group of 11 will serve as the “Reader” and will read the instructions to the group members.
2. Each student with a number 1-4 is given a unique solid-colored sock (with its mate hidden inside) in one of four sizes (adult large, adult small, child, and infant). Students will be directed by their group’s Reader to hold up the sock in one hand. Student volunteers will then “replicate” their DNA by pulling the hidden sock out and will then be instructed to hold both socks in the same hand. Pins with colored beads will be used to represent alleles. Maternal and paternal alleles will be represented by different colored beads for the same gene. Students will be asked to pin a bead of the same color as the parental sock on the newly replicated sock.
3. Students will count the number of chromosomes present in the hypothetical cell.

*Instructions here will diverge depending on if students are modeling mitosis or meiosis.*

1. For mitosis, students will be asked to form alignment along the metaphase plate. The 2 students role playing centrosomes will “rope” the sister chromatids and pull them apart to opposite poles of the cell. Students will count how many chromosomes are present in the daughter cells.

End Mitosis role playing

For meiosis, Student ‘‘chromosomes’’ are then asked by the “Reader” to find their homologous pair.

1. Students will be asked to participate in crossing over between the two homologous chromosomes, involving only one chromatid from each replicated homologous chromosome. Specifically, the “Reader” for the group will instruct students representing homologous chromosomes to link arms to represent the formation of a synaptonemal complex, and perform an exchange of genetic material represented by the beads pinned on the socks.
2. The “Reader” will instruct homologous pairs of chromosomes to align along the metaphase plate. The 2 students role playing centrosomes will “rope” the homologous chromosomes and pull them apart to opposite poles of the cell. Students will be asked to count the number of chromosomes present in each daughter cell, and whether the daughter cells are diploid or haploid.
3. Individual students representing replicated chromosomes (sister chromatids) with 2 socks being held in one hand will be instructed to align along metaphase plate for meiosis II division.

End meiosis role playing

1. Wright LK, Newman DL. 2011. An interactive modeling lesson increases students’ understanding of ploidy during meiosis. Biochem Mol Biol Educ 39:344-351.

**Modeling Mitosis and Meiosis: Reader Handout**

1. Mitosis Modeling
2. Before you begin modeling, consider a diploid organism that has four chromosomes, numbered 1, 2, 3, 4. What is a normal karyotype for a **somatic cell** of this organism?
3. Students in your group either have a chromosome number or a “C.” Students with a chromosome number will need to find their appropriately sized sock (*remember, chromosomes are numbered from largest to smallest*). Students who are assigned a “C” are acting as the centrosomes and will each need a length of yarn.
4. Students who are assigned a chromosome: Hold up your sock in one hand.
5. “Replicate” your DNA chromosome by pulling the hidden sock out and then hold both socks in the same hand. Pins with colored beads will be used to represent alleles. Maternal and paternal alleles will be represented by different colored beads for the same gene. Pin a bead of the same color as the parental sock on the original and newly replicated socks according to the genotype information below:
   * 1. **On chromosome 1 reside genes A and B**:

Gene A alleles: black/white (black is dominant to white)

Gene B alleles: dark blue/light blue (dark blue is dominant to light blue)

***Genotype:*** Your organism is heterozygous for gene A and heterozygous for gene B. Assume the maternal copy of chromosome 1 has dominant alleles for both genes.

1. **On chromosome 2 reside genes C and D.**

Gene C alleles: green/yellow (alleles have codominant relationship)

Gene D: Red (This gene is monomorphic: it only comes in one form!)

***Genotype:*** Your organism is heterozygous for gene C, homozygous for gene D.

1. **On chromosome 3 resides gene E**

Gene E alleles: pink/purple (Pink is dominant to purple)

***Genotype:*** Your organism is homozygous for the recessive allele

1. As a group, count the number of chromosomes present in the hypothetical cell.
2. Form alignment along the metaphase plate. How are the replicated chromosomes (sister chromatids) aligned?
3. The 2 students role playing centrosomes will “rope” the sister chromatids and pull them apart to opposite poles of the cell.
4. As a group, count how many chromosomes are present in the daughter cells.

*End Mitosis role playing*

**B. Meiosis Modeling**

1. Before you begin modeling, consider a diploid organism that has four chromosomes, numbered 1, 2, 3, 4. What is a normal karyotype for a **somatic cell** of this organism?
2. “Replicate” your DNA chromosome by pulling the hidden sock out and then hold both socks in the same hand. Pins with colored beads will be used to represent alleles. *(This will be the same as above, you do not need to pin again)*
3. Pairs of homologous chromosomes will need to form a tetrad (or bivalent) to participate in crossing over (also known as homologous recombination). Students holding replicated chromosome 1s will indicate the formation of a bivalent by linking arms.
4. Perform crossing over for one of the genes on chromosomes 1 and 2.
5. Are there any new allele combinations present after recombination that were not present before recombination? Explain.
6. What does alignment look like for metaphase of meiosis I?
7. Complete meiosis I by having student centrosomes separate bivalents (paternal and maternal homologous chromosomes) to 2 daughter cells.
8. As a group, count the number of chromosomes present in the hypothetical cell.
9. Complete meiosis II by having student centrosomes separate sister chromatids to daughter cells.
10. As a group, count the number of chromosomes present in the hypothetical cell.

*End Meiosis role playing*