IDEA BANK

MEIOSIS AND PLAYING CARDS

Meiosis, the process by which diploid cells divide to produce haploid gametes, is one of the most fundamental concepts of biology; however, it is also one of the most difficult for students to grasp. Therefore, repeated presentations in the form of slides, drawings, and videos are often helpful for teaching meiosis. Levine and Miller (1991) describe meiosis as a shuffling of the chromosomal deck, so what better way of carrying out this analogy than with playing cards?

The following demonstration is a novel way of presenting the concept of meiosis to an introductory biology or genetics class using two partial decks of playing cards. After presenting meiosis to the class in a conventional manner, tell them that you are going to present it in a way that they can practice at home with two decks of playing cards.

Obtain two decks of cards with backs of two different colors, such as red and blue. For a small class, you may perform the trick with two regular decks of cards, but you must be prepared to sacrifice them. Presenting the demonstration to an audience of one hundred or more students could be a nightmare, but problems may easily be circumvented.

Separate the Queen and King of hearts and the Queen and King of clubs from each deck. Photocopy the face sides of these cards on an overhead transparency using a 65 percent reduction. Cut out the "cards" with a pair of scissors. Using a red or blue transparency marker, draw around the edge of each card to represent the color on the reverse side of the original playing cards. The cards can now be projected onto a screen using an overhead projector. Another alternative for large audiences (which works fine for David Copperfield) is to use real cards and a television camera.

Begin with an overhead projector and a blank transparency (you will draw cell membranes on this transparency later). You are now ready to face the class. Explain that you have removed the King and Queen of hearts and the King and Queen of clubs from each deck. Each of these cards represents a chromosome. Red-backed cards are maternal chromosomes and blue-backed cards are paternal chromosomes. For example, the red-backed and blue-backed Queen of hearts are homologous chromosomes.

Notice that each face card consists of two mirror-images and that no matter which way you hold the card you can see an upright king or queen. For our purpose, each card represents a replicated chromosome ready to enter meiosis. The plane of symmetry (not quite duplicated in this example because left and right sides are rotated) is equivalent to a centromere, and each mirror-image represents a chromatid.

The class is looking at a diploid cell with 2n = 8 chromosomes. The chromosomes have replicated during S-phase and are ready to enter meiosis. During prophase I, the chromosomes have condensed and are visible under a light microscope. Shuffle the deck a few times. In early prophase I, the chromosomes are randomly arranged, not unlike the randomly shuffled deck in your hands. Later in prophase I, the homologous chromosomes pair and then begin to line up in metaphase I along the equator of the cell.

Lay the cards down one at a time in four rows, creating a 4 by 2 array with each row reserved for a single homologous pair. Fill the left side of each row before the right side. As you lay the cards down, note that you are laying them down and pairing them without regard to the color on the back (which shows through on the overhead projection), or to whether chromosomes are maternal or paternal. When you are done, the homologous pairs should be lined up along the metaphase plane with a random arrangement of maternal and paternal chromosomes.

Begin to move the homologous chromosomes to the left and right sides of the screen. During anaphase I, the homologous pairs separate and migrate to opposite ends of the cell. Note that migration of chromosomes is independent of whether or not they are red- or blue-backed. We have just witnessed independent assortment of homologous chromosomes to opposite poles. (Note, however, that there has not been a division of the centromere as in ~~meiosis~~ mitosis!) During telophase I, a cell membrane forms between the opposite poles forming two new daughter cells. If you are using an overhead projector, stack up the cards at opposite ends of the screen and draw a circle around each stack to represent the two daughter cells.

There is no break between the first and second meiotic divisions. From telophase I, the cells enter into prophase II during which the nuclear membranes disintegrate and the deck is randomly shuffled. During metaphase II, the chromosomes line up along the equators. Align the cards along the centers of each daughter cell. At this point it may be helpful to emphasize to students that any time they see the word "metaphase," they can think "chromosomes lining up." The chromosomes have lined up and are now ready to enter anaphase II. Remind the class that any time they see the word "anaphase" to think "separation". During anaphase II, the chromatids separate along the centromere. Form two stacks of cards, one for each daughter cell, and announce that it is now time to cut the deck, but not in the usual way. Brandishing a pair of scissors, cut along the centromere/plane of symmetry.

Immediately after the centromeres have split, move the newly divided chromosomes to opposite ends of their respective cells. If your using an overhead projector, draw new cell membranes around each pile of chromosomes to represent what happens during telophase and cytokinesis. Show the class that you are left with four haploid cells after beginning with a single diploid cell. Also remind them that

they have witnessed an independent assortment of maternal and paternal chromosomes. They should now go home and impress their families with what they have learned.

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REFERENCES

Levine, J.S. and K.R. Miller. 1991. *Biology: Discovering Life.* Lexington: D.C. Heath.