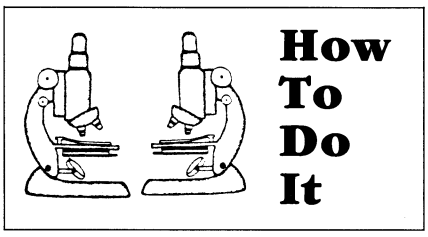


A Model for Teaching Mitosis & Meiosis

James E. Mickle

Students learn in a variety of modes. Some students process information actively, through physical activity or discussion; others reflectively, through introspection. Many students learn sequentially, in incremental steps leading toward understanding; others learn globally, by large jumps, and only achieve understanding when an entire process can be seen in a holistic light (Felder & Silverman 1988). Teaching techniques that simultaneously address the needs of different types of learners often give highly satisfactory results in the classroom (Felder & Silverman 1988). Hand models have been found to be an excellent teaching tool for illustration of various dynamic biological processes (Ward 1988; Bierman 1989). A benefit of hand models is that they cater to several learning styles. Active students are physically engaged by the model; reflective students can use the model to "think through" the concept. In a stepwise process such as cell division, the phases are illustrated for sequential learners; the fact that the entire process is shown as a dynamic whole rather than a static series of diagrams can aid the global learner.

Ward (1988) described a teaching model that uses the hands to mimic chromosome behavior during mitosis. This useful model provides a concrete tool for teaching the complexities of mitosis, but is limited because it does not incorporate concepts of meiosis or illustrate differences between mitosis and meiosis.

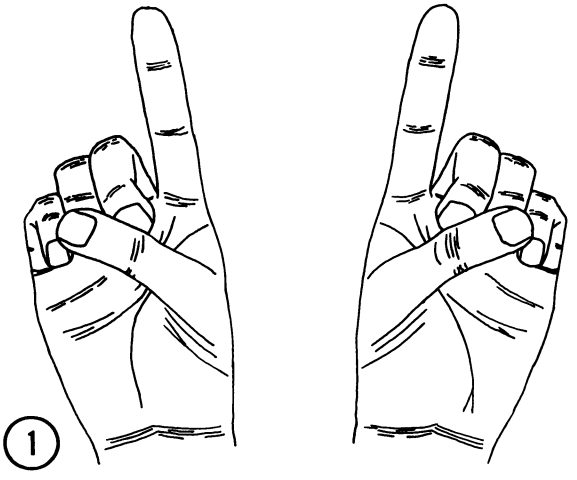
A different hand model which incorporates a comparison of chromosomal segregation during mitosis and meiosis has been used with great success in my introductory biology classes. The model is generally demonstrated during lecture and laboratory lessons aided by diagrams, three-dimensional representations and microscope slides of dividing cells. The model is intended to supplement these teaching tools. Emphasis is placed on use of the model to compare and contrast mitosis and meiosis. Students often continue using the model during review and examinations.

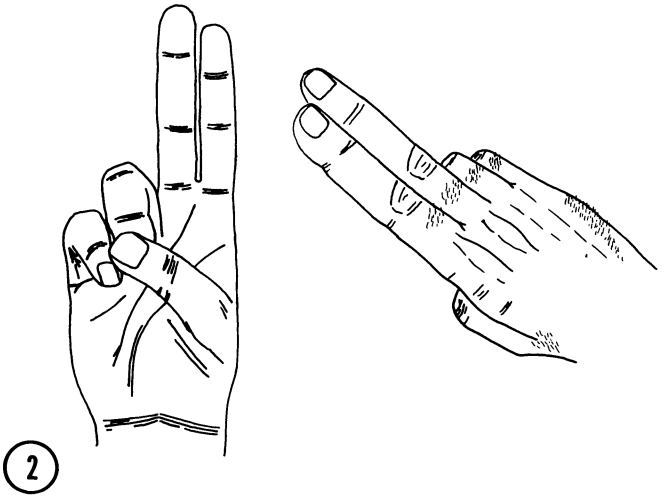
This technique lacks some features because students must imagine cellular structures, such as the nuclear membrane, cytoplasm and spindle apparatus to be present at various times during the process. In this model, the cell has two chromosomes, one for each hand.

Mitotic Division

Interphase

Students begin this exercise at early interphase (G1 or first growth phase) by extending the index finger of each





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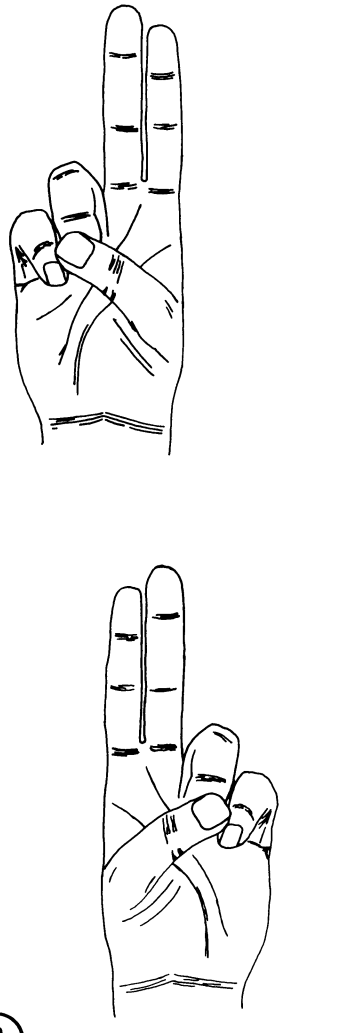

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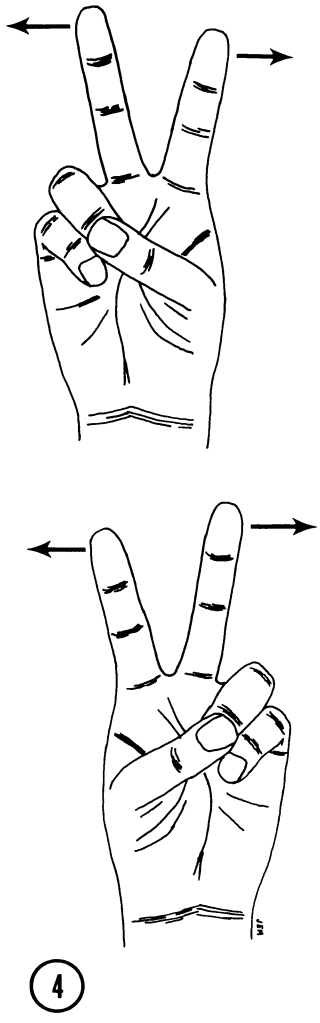

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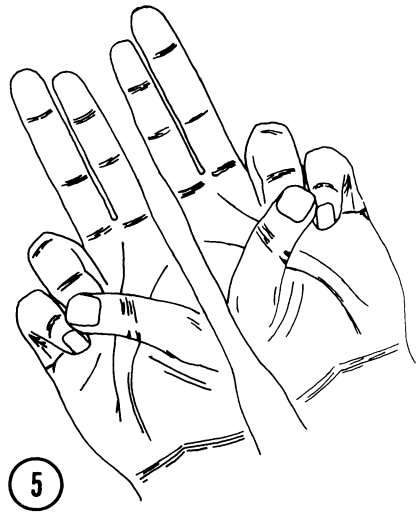

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hand (Figure 1), each index finger representing an unduplicated chromosome. Chromosomal replication (S or DNA duplication phase) is represented by the extension of the middle finger in addition to the extended index finger (Figure 2). The middle and index fingers of each hand represent the chromatids of duplicated chromosomes and should be held together to portray the connection of chromatids by the centromere. It should be emphasized that the chromatids are in the chromatin state at this point, and that interphase precedes mitosis in the cell cycle.

Mitosis

Prophase

Prophase and interphase are difficult to distinguish using this model. To illustrate the random orientation of chromosomes during late prophase, the extended fingers are held at different angles (Figure 2). Transition to metaphase is shown by moving the fingers to the metaphase position.

Metaphase

Metaphase is demonstrated by holding the two pairs of fingers (one pair on each hand) vertically, one above the other (Figure 3), lined up as in metaphase.

Anaphase

Anaphase is shown by separating the middle and index fingers of each hand into a V- or Churchill "victory" position, illustrating the separation of chromatids (Figure 4).

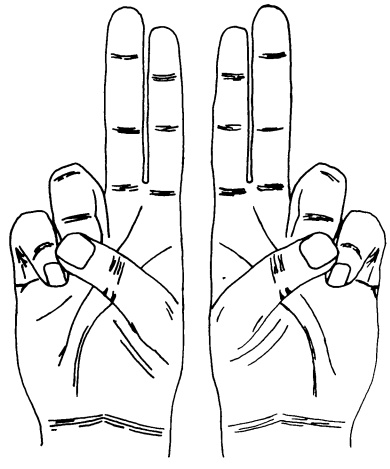
Telophase

Telophase is shown by indicating to the students that the middle finger of the upper hand and the index finger of the lower hand would be chromosomes incorporated into one daughter cell, while the index finger of the upper hand and the middle finger of the lower hand would be incorporated into the other daughter cell (Figure 4). This can be accomplished by wiggling the respective fingers incorporated into each cell.

Meiotic Division

Interphase

Interphase before meiosis is shown in a way similar to interphase of mitosis (Figures 1 & 2), with the extension of the index fingers to show chromosomes before duplication, and extension of both index and middle fingers



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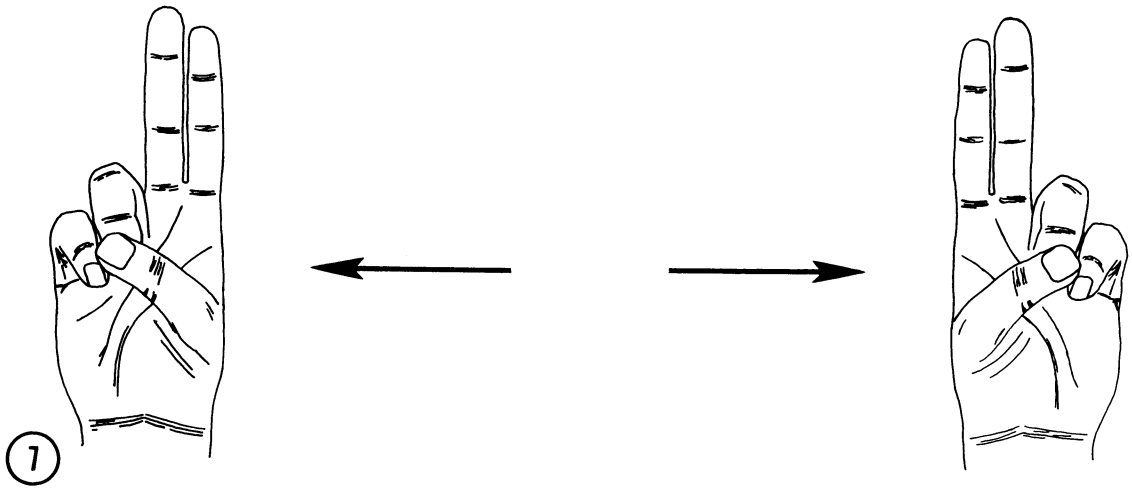

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to indicate chromosomes with two chromatids.

Meiosis

Prophase I

A key feature of the model with respect to prophase I is synapsis, shown by holding the extended fingers of both hands side by side, representing the chromosome tetrad. The tetrad can be held at an angle, suggesting the random orientation of the tetrad in the cell prior to metaphase I (Figure 5). Subphases of prophase I are not illustrated.

Metaphase I

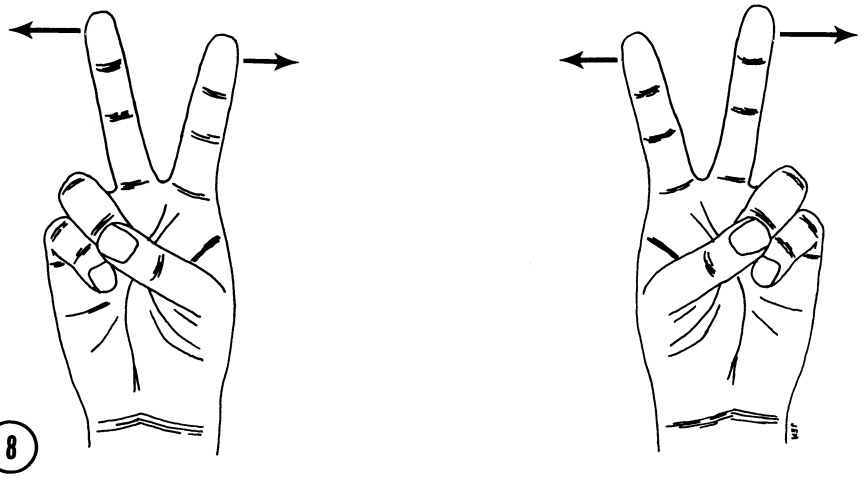
Metaphase I has the "tetrad" of fingers held upright to suggest orientation at the metaphase plate (Figure 6).

Anaphase I

For anaphase I, the hands, each with middle and index fingers upright and together, are separated horizontally (Figure 7).

Telophase I, Interkinesis and Prophase II

In Telophase I the hands are separated, with fingers of each hand upright and together. During interkinesis, no chromosomal duplication occurs. This important point is illustrated by maintaining the pairs of fingers extended. In some species, there is a period in which the chromosomes unwind to chromatin; in others, the chromosomes remain visible from telophase I to prophase II. This should be discussed at this time. Prophase II can be illustrated by holding the extended fingers at an angle.



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Metaphase II

Metaphase II finds the hands separated and fingers of each hand extended upright and together. The fingers of each hand represent the paired chromatids of single chromosomes that are still attached to each other at metaphase.

Anaphase II

For anaphase II, the fingers of each hand are separated to form a V-shape, illustrating separation of chromatids (Figure 8).

Telophase II and Cytokinesis

For telophase II, it is explained that each extended finger would be found in a separate, haploid (monoploid) cell.

Discussion

Several points of similarity between mitosis and meiosis can be brought out during discussion while teaching the model. Similarities include duplication of chromosomes during interphase and steps of mitosis and meiosis II. Contrasts are strikingly shown by the positions of the hands in mitotic metaphase and meiotic metaphase I, and the two-step nature of meiosis versus the one-step nature of mitosis.

While students must use some imagination to picture the surrounding cellular structures, the main purpose of showing chromosomal segregation is fulfilled by this model. Drawbacks to this technique include the inability to illustrate crossing over, and the fact that prophase and

telophase cannot be clearly demonstrated. An additional limitation is that independent assortment cannot be easily shown because only one pair of chromosomes is illustrated. To extend this model, have two students work together to show the process of independent assortment. As with the techniques of Ward (1988) and Bierman (1989), this model requires little preparation time and no cost, and has the additional advantage of allowing direct comparison of chromosomal behavior during mitosis and meiosis.

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