



A PILOT DVD PROJECT

MODELING MEIOSIS

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Activity: Modeling Meiosis: Clay Chromosomes

- **Time Frame:** 2 hours
- **Materials:** For students working in pairs, per pair: 4 one-inch diameter balls of modeling clay of four different colors: red, blue, yellow and green, 1 large oval and 4 smaller ovals of white paper, 1 pair of scissors, 1 2.5-ft. length thick brown yarn, 4 1-ft. lengths thick brown yarn, 1 1-ft. white string permanent markers (Sharpie)
- **Teacher Directions:**
 - Explain the difference between haploid cells and diploid cells.
 - Explain the processes of mitosis and meiosis.
 - Explain the characteristics of somatic cells and sex cells.
 - Define gamete, tetrad, chromatid, homologous chromosomes, cytokinesis, and polar bodies.
 - Explain how crossing-over in tetrads accounts for genetic variation in a species.
 - Describe the steps involved in meiosis and the significance of each step.
 - Describe how haploid sex cells are generated in parents and how fertilization occurs to produce diploid offspring.
 - Explain the processes of cytokinesis in sperm cells and egg cells and the significance of each.
 - Explain how parents' genes get passed to their offspring.
 - Tell students that normal humans carry 46 chromosomes in each cell (2 copies of 23 chromosomes).
 - Ask students why we have two copies of each of the genes in our genome?
 - Tell students that chromosomes are composed of DNA and contain the genetic blueprint for an organism. Each species has its own unique set of chromosomes, and all individuals in a particular species typically have the same number of chromosomes. E.g. Humans have 46 chromosomes. The domestic dog has 78

chromosomes, the domestic cat has 38 chromosomes, and the mouse that it chases has 40 chromosomes!

- Tell students that within each individual in a species, every somatic cell contains the same number of chromosomes as every other. Humans (and most other animals) are diploid organisms meaning that each cell contains two complete chromosome sets.
- Watch Lecture 1 Chapter 26 (stop DVD after discussion of consequences of meiosis)
- Define chromatids, homologous chromosomes (homologs), gametes, diploid, and haploid.
- What are the two consequences of meiosis?
- Discuss gene swapping (recombination) and division of chromosomes.
- Describe the stages of meiosis.
- Watch Lecture 1 Chapter 31 Animation: Meiosis

o **Student Directions and Evaluation:**

You are going to work through the cellular events involved in meiosis step by step. You will be working with the chromosomes of a *Triffle*, a mythical organism. You and your teammates are to complete the following steps, and then repeat the process until you can go through it without using these instructions.

The Triffle has a diploid chromosome number of four.

What will the haploid chromosome number be?

Setting up the Cell:

* Lay down the large oval of white paper in the center of your workspace. Imagine that this is one sex cell in a Triffle. The boundary of the paper is the cell membrane.

Setting up the Genome:

* You are going to create a diploid nucleus containing two pairs of chromosomes. First, divide each of your four balls of colored clay in half.

* Take one-half of each ball and roll it between your hands to form an elongated, snakelike piece. You will have four chromosome models. Make the green and yellow chromosomes about 4 inches long and the red and blue pair about 6 inches long.

We will refer to the yellow/green pair as PAIR 1 and the blue/red pair as PAIR 2.

Figure 1. Clay Chromosome Models and Color Key

Remember that a chromosome is tightly coiled strand of DNA. Within each chromosome there are many, many genes. The chromosomes within each pair are said to be homologous--meaning similar but not necessarily identical. Homologous chromosomes contain the same genes but not necessarily the same alleles. For instance, two homologous chromosomes might contain the

gene that codes for eye color, but the allele form might be different--like blue eye allele on one chromosome and brown eye allele on the other.

We are going to examine four Mendelian traits in the Triffle, specified by four genes. Remember that genes are segments of chromosomes that code for proteins that can result in the expression of detectable traits (phenotypes).

Table II describes some imaginary traits of our mythical creature and their location on each chromosome.

Table II -- Imaginary Traits of the Triffle

Genes on PAIR 1

	<u>Fur Color</u>	<u>Fur Type</u>
Green Chromosome	G (green fur)	c (straight fur)
Yellow Chromosome	g (yellow fur)	C (curly fur)

Genes on PAIR 2

	<u>Eye Color</u>	<u>Eyelash length</u>
Blue Chromosome	B (blue eyes)	L (long eyelashes)
Red Chromosome	b (red eyes)	I (short eyelashes)

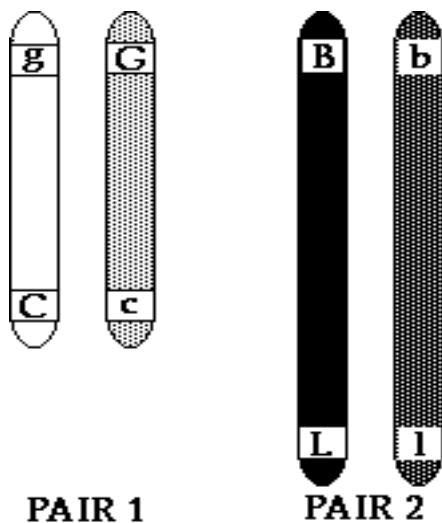


Figure 2. Map of *Triffle* Genes

Note that we are looking at only two genes (two pairs of alleles) on each chromosome, while ignoring hundreds of other genes. Also, note that the triffle we are studying is completely heterozygous for all four genes examined. This does not always have to be the case.

Label the location of each gene by carving into the clay with a sharp object or by writing on the clay with a permanent marker.

Interphase

* During interphase, each chromosome is replicated by DNA replication. Simulate replication by creating a matching chromosome (same shape and color) using the remaining bits of clay for each of the four chromosomes in your genome. Label each chromatid with genes so they are exact copies.

* Connect sister chromatids together at the centromere by pinching them together.

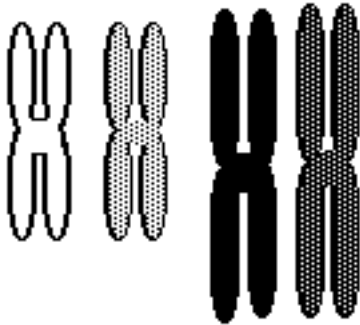


Figure 3. Replicated Chromosomes

How many chromatids are present in the nucleus after DNA replication?
How many chromosomes?

Prophase I

* Pair up each newly replicated chromosome with its homologous chromosome. This pairing will produce two tetrads containing 4 sister chromatids each. There should be 8 chromatids in all.

* Now that homologous chromosomes are near each other, crossing-over can occur. In each tetrad, trade one allele between two non-sister (non-identical) chromatids by first overlapping chromosome arms to form a crossover.



Figure 4a. Crossing-over

* Break the clay vertically to separate the chromosomes again, and join the exchanged parts to their new chromosome.



Figure 4b. Result of Crossing-over

Metaphase I

- * Imagine that the nuclear membrane has now broken down in your imaginary Triffle cell.
- * Line the two tetrads end to end across the center of the cell.
- * Attach a piece of black yarn (spindle fiber) stretching from the centromere of each chromosome to the end of the cell nearest to it.

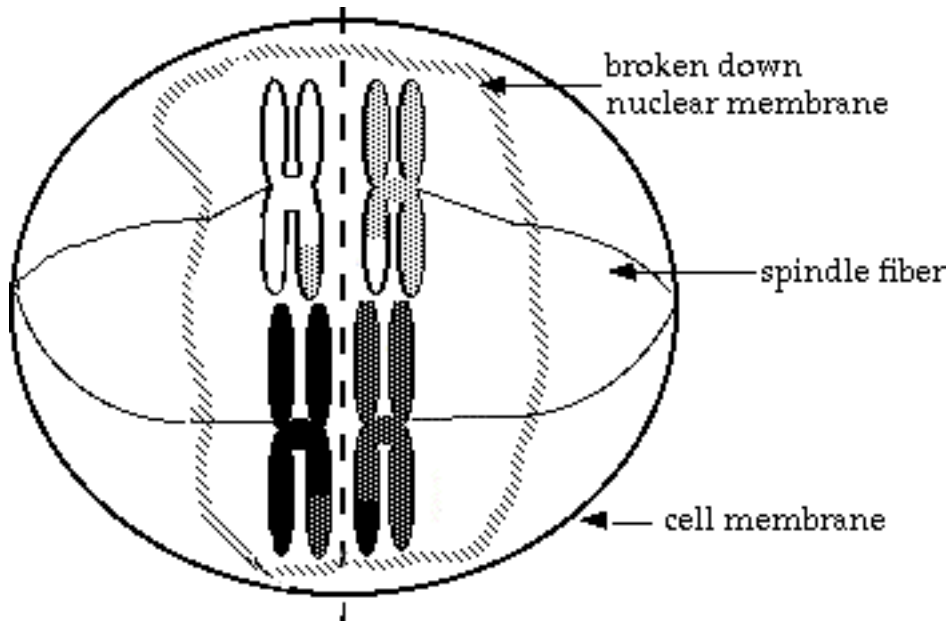


Figure 5. Metaphase I

Was there a reason why the red chromosome ended up on the same side as the green chromosome, or was it random? Why or why not?

Anaphase I

Separate each tetrad and use the spindle fibers to move the homologous chromosomes to opposite poles of the cell.

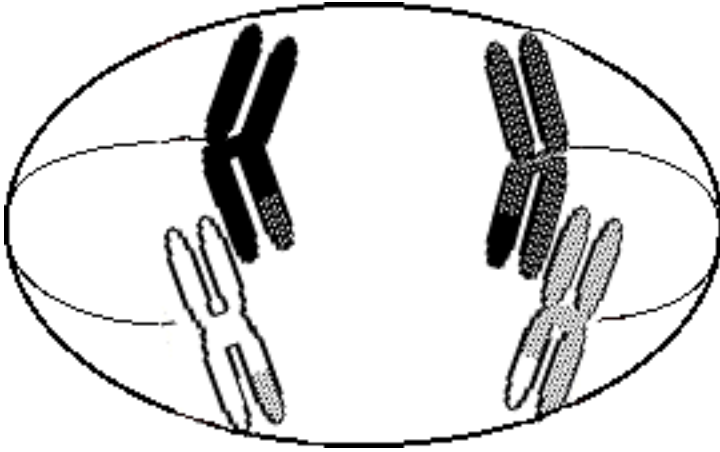


Figure 6. Anaphase I

Telophase I

Cytokinesis (cell division) occurs to form two daughter cells. These daughter cells are neither haploid nor diploid, but rather exist in some intermediate stage.

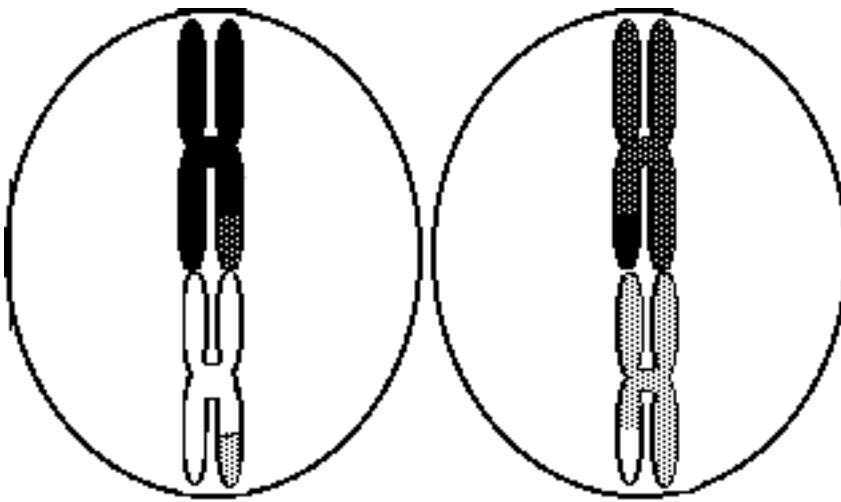


Figure 7. Telophase I

Are the two daughter cells identical (in genetic makeup)? Why or why not?

Prophase II + Metaphase II

* Line up the chromosomes in each cell end to end along the centerline. Attach spindle fibers to the centromeres.

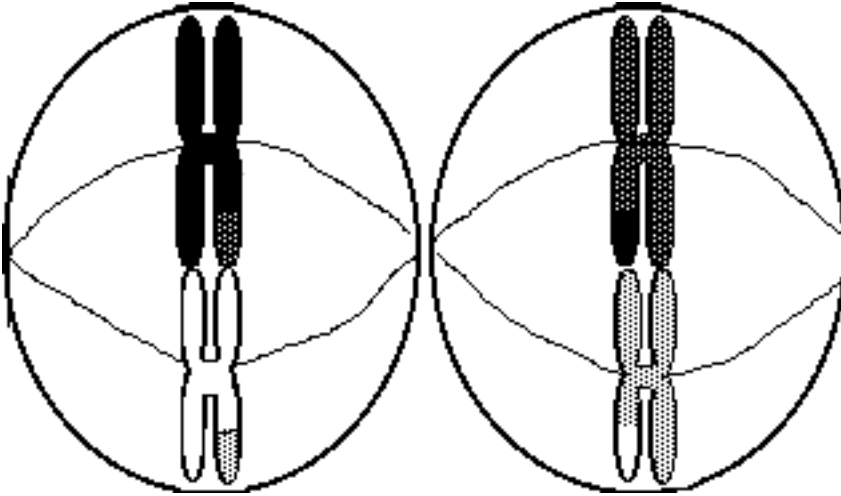


Figure 8. Prophase II + Metaphase II

Anaphase II

* Separate the two sister chromatids and use the spindle fibers to move them to opposite poles.

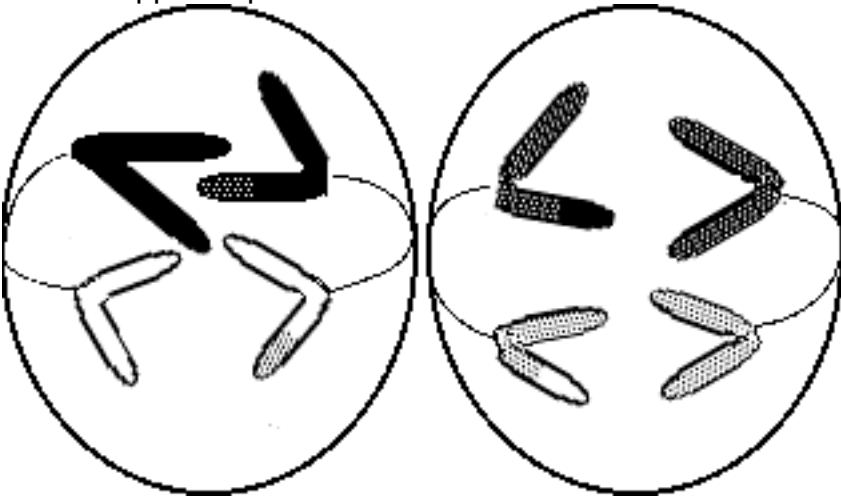


Figure 9. Anaphase II

In anaphase II, what must happen to the centromere region?

Telophase II

* Cytokinesis occurs again, producing a total of four daughter cells.

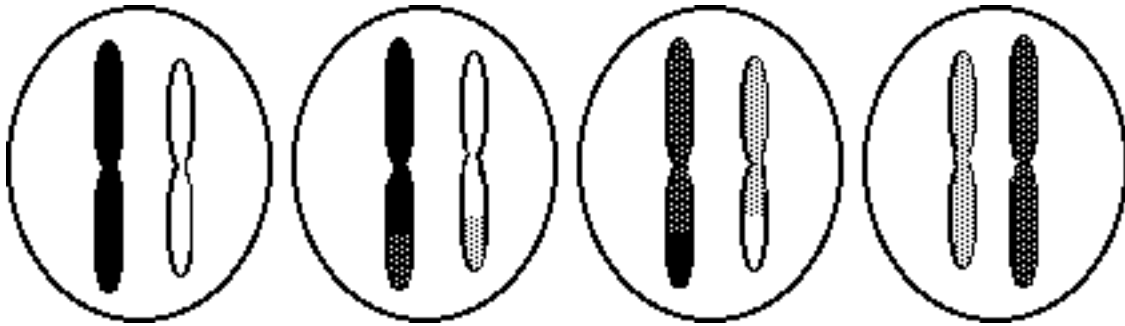


Figure 10. Telophase II

Are these cells haploid?

Note that each cell has a different genotype (combination of alleles). As a result of gene swapping, each daughter cell contains one or more chromosomes that are different from both those in the parent cell and those in other daughter cells.

* Write the genotype beneath each of the resulting daughter cells in the diagram above.

- Web Connections
 - <http://www.dartmouth.edu/~cbbc/courses/movies/meiosis.html>
 - <http://www.iacr.bbsrc.ac.uk/notebook/courses/guide/movie/meiosis/htm>
 - http://highered.mcgrawhill.com/sites/0073031216/student_view0/exercise14/meiosis_movie.html

