Activity: Pipe-cleaner Chromosomes

Lecture Concept
Chromosome structure, mitosis and meiosis

Activity Type
Group work with handout and physical models

Time Needed in Discussion
50 minutes

Purpose
• To allow the students to physically manipulate the process of mitosis and meiosis with models
• To provide the students an opportunity to learn the terminologies of genetics, i.e., homologous chromosome, diploid, haploid, etc.

Abstract
<table>
<thead>
<tr>
<th>Activity</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-class prep</td>
<td>60 min</td>
</tr>
<tr>
<td>Teacher asks questions regarding chromosomes and synthesis</td>
<td>10 min</td>
</tr>
<tr>
<td>Groups demonstrate mitosis</td>
<td>5 min</td>
</tr>
<tr>
<td>Groups demonstrate meiosis</td>
<td>25 min</td>
</tr>
</tbody>
</table>

Supplies
- Sixty pipe cleaners in at least four different colors
- Bag of 200 various beads, with small enough holes to keep beads in place on the pipe cleaner
- 40 mini-clothespins or paperclips
- 10 ziplock baggies, quart size
- Handout (similar to attached version)

Pre-class prep

![Diagram of chromosome structure](image)

Chromosome 1

Chromosome 2

© 2007 by the HHMI-UCIrvine Professor Program. For non-commercial, educational use only.
- Cut four colors of pipe cleaners into large and small sizes (6” and 3” works well).
- Place matching beads on pipe cleaners as shown above. These represent four chromosomes (2n) with their sister chromatids to be attached after S phase. The beads represent genes – notice how some loci are homozygous and some are heterozygous.
- Clip together one of each type of pipe cleaner to make a bundle of four single-stranded chromosomes. This will represent the genome of our 2n = 4 “cell.” Clip together the other four chromosomes to be brought out after S phase is complete.
- Place both clipped bundles of chromosomes in a baggie.
- Repeat for each group of three students (about 10 baggies total for most 30-student classes).

**In Class**

This activity helps students who learn kinesthetically to have models to work with (see [www.vark-learn.com](http://www.vark-learn.com) for more information). Have students work for a while using the worksheet, while you walk around and check their answers. After each segment, stop and address any confusion.

(5 min) Divide the class into groups of 3. Give each group a prepared set of pipe cleaners and beads. Have the groups remove one clipped set of four unique chromosomes. Ask the groups to find a gene, a chromosome, a homologous pair and an allele. After groups have worked on the definitions, ask what was confusing.

(10 min) Bring out the second clipped set of chromosomes. Take the groups through the steps of synthesis. Discuss sister chromatids, chromosomes, n and 2n. Talk about why cells are NOT tetraploid and do NOT have twice as many chromosomes as before.

*Note: The above section is hardest part of mitosis for students. Plan on spending most of your mitosis time here.*

(5 min) Step through mitosis by demonstrating in front of the class. Remind the students what step is taking place as the chromosomes are being paired and unparied (metaphase, anaphase, etc.)

(25 min) Afterwards, take the groups through the steps of meiosis. Once again, remind the students what step is taking place. Emphasize the differences between the two processes.

© 2007 by the HHMI-UCLIrvine Professor Program. For non-commercial, educational use only.
A comment about teaching meiosis: Students THINK they understand meiosis. They think it’s just mitosis twice. But year after year I have found that students AND SOME DISCUSSION LEADERS do not understand the difference between meiosis and mitosis. They don’t realize that metaphase 1 is profoundly different than metaphase 2. They confuse chromatids and chromosomes. And they do not understand that the first division changes ploidy. So if any of these emphases seems incorrect, ASK FOR HELP before teaching your students.

**Things to Emphasize**

- Chromosomes are single stranded before S phase. After S phase, the chromosomes become double-stranded.
- In Mitosis during Metaphase, the chromosomes line up on the metaphase plate. In Meiosis during Metaphase I, the tetrads line up on the metaphase plate. Then it’s back to chromosomes lining up in Metaphase II.
- The phases in which tetrads appear and disappear.
- How crossing over makes different combinations of genes/alleles on a chromosome.
- The first division of Meiosis creates haploid daughter cells; the change in ploidy occurs in first division of Meiosis
- Make sure the students can define and discuss these terms: haploid, diploid, homologous chromosomes, alleles, tetrad, sister chromatids, chromatid, gene, independent assortment, crossing over, and genetic variation.

**Comments:**

If your discussions are only as far as chromosome structure and synthesis, you can have your class MAKE the kits using a pile of pre-cut pipe cleaners and bags of beads.

---

Copyright 2007: This activity was created by Dianne Purvis and edited by Masa Kinoshita and Adrienne Williams

© 2007 by the HHMI-UCLArvine Professor Program. For non-commercial, educational use only.
Pipe-Cleaner Chromosome Handout

Define the following as a group, using only your lecture notes. Mark the ones you don’t understand. Discuss with your group members how you would show each using the pipe-cleaner chromosomes.

The Interphase Genome:
• gene
• chromosome
• homologous pair
• allele
• n
• 2n
• Haploid
• Diploid

(stop here and wait for your instructor)

After S Phase:
• chromatid
• pair of sister chromatids
• chromosomes – what do they look like now?
• n and 2n after replication

(stop here and wait for your instructor)

Phases of Mitosis:

<table>
<thead>
<tr>
<th>Prophase</th>
<th>Metaphase</th>
<th>Anaphase</th>
<th>Telophase</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Diagram" /></td>
<td><img src="image2.png" alt="Diagram" /></td>
<td><img src="image3.png" alt="Diagram" /></td>
<td><img src="image4.png" alt="Diagram" /></td>
</tr>
</tbody>
</table>
Phases of Meiosis:

Prophase I       Metaphase I       Anaphase I       Telophase I

Prophase II       Metaphase II       Anaphase II       Telophase II