



Teacher-to-Teacher

Video Series
for Secondary Educators

TITLE: Modeling Mitosis and Meiosis

PRIMARY SUBJECT AREAS: Science

GRADE LEVEL: 9-12

OVERVIEW: Students construct and manipulate models of mitosis and meiosis and compare and contrast them in order to demonstrate their understandings of these cellular processes and their importance in reproduction and genetics. The physical models will be constructed from index cards and yarn. Virtual models may also be constructed using computer programs for drawing. Students will also interpret diagrams or prepared slides and/or photographs of mitosis and meiosis. Students may also act out the processes as an extension or reinforcement activity.

Students will demonstrate an understanding of chromosomes, chromatids, centromeres, sexual reproduction, asexual reproduction, sex cells, genetic variation, crossing over, recombination, cell division, homologous chromosomes, and the cell cycle. High school students will emphasize comparing and contrasting mitosis and meiosis (LS-H-B1).

APPROXIMATE DURATION: Mitosis – three 50-minute class periods
Meiosis – three 50-minute class periods

LOUISIANA CONTENT STANDARDS:

<http://www/DOE/assessment/standards/SCIENCE/pdf>

Science as Inquiry

Benchmarks:

- SI-H-A1 identifying questions and concepts that guide scientific investigations

- SI-H-A4 formulating and revising scientific explanations and models using logic and evidence

SI GLEs:

1. Write a testable question or hypothesis when given a topic (SI-H-A1)
7. Choose appropriate models to explain scientific knowledge or experimental results (e.g., objects, mathematical relationships, plans, schemes, examples, role-playing, computer simulations) (SI-H-A4)

Life Science

Benchmark:

LS-H-B2 comparing and contrasting mitosis and meiosis

LS GLE:

Biology GLE 9. Compare mitosis and meiosis (LS-H-B2)

EDUCATIONAL TECHNOLOGY GUIDELINES:

<http://www/DOE/LCET/curric/cats.asp>.

Technology Communication Tools

Technology Research Tools

Basic Operations and Concepts

Use appropriate technology to locate, retrieve, organize, analyze, evaluate, and communicate information for problem solving and decision-making.

Refine knowledge and enhance skills in keyboarding, word processing, desktop publishing, spreadsheets, databases, multimedia, and telecommunications in preparing and presenting classroom projects.

INTERDISCIPLINARY CONNECTIONS:

English Language Arts Benchmarks

ELA-7-H1 using comprehension strategies in contexts

ELA-7-H2 problem-solving by analyzing, prioritizing, categorizing, and evaluating; incorporating life experiences; and using available information

OBJECTIVES:

1. The student will analyze and summarize written descriptions and diagrams and/or photographs that model mitosis and meiosis (e.g., text, Internet).
2. The student will demonstrate an understanding of mitosis and meiosis by constructing and analyzing their own models and drawing conclusions from them.
3. The student will make predictions about what would happen if the chromosomes did not separate properly during meiosis.
4. The student will compare and contrast mitosis and meiosis.

LESSON MATERIALS AND RESOURCES:

- diagrams of mitosis & meiosis found in texts, posters, or on the Internet
- prepared slides and/or photographs of mitosis found in texts, posters, or on the Internet
- 4 colors of yarn (example - 2 shades of red and 2 shades of green)
- scissors
- metric ruler
- transparent tape or glue
- 1 large index cards per student (12.7cm X 20.3 cm)
- felt-tip marker

TECHNOLOGY TOOLS AND MATERIALS:

Hardware: computer with an Internet connection, LCD projector or TV monitor, digital camera or scanner (optional)

Software: Microsoft Paint, Inspiration for constructing concept maps (optional)

Web sites:

Access Excellence. (2002). Comparison of mitosis & meiosis. [On-line] Available: <http://www.accessexcellence.org/AB/GG/comparison.html>.

Leica Microsystems. (2002). Cells alive. [On-line]. Available: <http://www.cellsalive.com/>.

Mr. Biology. (2002). Explanations: The cell mitosis and meiosis. [On-line] Available: http://www.sc2000.net/~czaremba/explanations/Mitosis_Meiosis.html

The Biology Project. (2002). [On-line]. Available: www.biology.arizona.edu/cell_bio
Think Quest. (2002).

Cellular biology. [On-line]. Available: <http://library.thinkquest.org/12413/reproduction.html>.

BACKGROUND INFORMATION:

Mitosis is often best presented at the end of a study of the cell. Prior to this lesson students should be able to distinguish between prokaryotic and eukaryotic cells, identify and explain the structure and function of cell organelles, identify and distinguish between different types of cells based on their structure and function, understand the basic functions of a living cell including metabolism or energy transformation, and understand the events in the cell cycle. Students should have prior knowledge of why cells are limited in size (cell surface to volume ratio). They should also be able to explain that the goal of asexual cellular reproduction is genetic continuity and it occurs when cells multiply during growth of an organism or when individual cells die and are replaced.

Meiosis can be studied after students acquire a basic knowledge of Mendelian genetics and are ready to learn how sex cells (gametes) are produced and serve as vectors of genetic information during sexual reproduction. Students should have prior knowledge of science concepts including mitosis, DNA, gene, chromosome, chromatid, centromere, homologous chromosomes, alleles, inherited traits, diploid and haploid chromosome number. They should also understand that sexual reproduction results in genetic variation.

Technology skills that are needed are the ability to research and evaluate information sources on the Internet and to be able to use word processing programs when organizing information and writing. Learning is enhanced if students are proficient in the use of a digital camera, scanner, and drawing software. It is also helpful if students are able to use Inspiration or other software to construct concept maps or flow diagrams.

LESSON PROCEDURES:

Mitosis

1. Before class students should actively read the section on mitosis in the text by reading one time for an overview, then reading again for details. During the second reading comprehension individual student-selected strategies such as outlining the main ideas and writing questions in the left-hand margin, constructing a concept map, or paraphrasing main concepts should be used. Student responses can be emailed to the teacher prior to class or hard copies can be collected and accessed prior to the activity. The Biology Project at the University of Arizona has an excellent animated tutorial that students can also access.
2. Students begin the activity by brainstorming ideas about mitosis. Student responses can be written on the blackboard or overhead transparencies, captured in Inspiration and projected, or written on newsprint. The student responses can be organized during class discussion by grouping them into categories and sequencing the four stages of mitosis. Graphic organizers such as concept maps or flow diagrams should be used.
3. Microscopic images of each stage of mitosis seen through a microscope and shown on the Internet or in texts are projected for the class as overhead transparencies or images projected from a computer or students can conduct an Internet survey to locate images of mitosis. Students should view each stage and list observations about the nucleus. Through class discussion a final list of visual changes that distinguish each stage is compiled.
4. Present diagrams of the stages of mitosis to the class and ask them to correctly identify each stage and summarize what is happening.
5. Give directions for making models of mitosis (Student Worksheets 1 and 2) and have the class develop the criteria to be used to evaluate the models. Sample criteria include accuracy, clarity, and esthetics (Attachment 2).
6. Divide students into teams of two to make models of the stages of mitosis using yarn and index cards. Assign one team member an animal cell and one a plant cell. They will work together to make two sets of models (one for each person) and will need five cards per student (prophase, metaphase, anaphase, telophase, and cytokinesis).
7. Students cut 2 pieces of yarn about 5 cm long from each color of yarn. Each piece of yarn will represent a chromatid. Use tape to join the two chromatids together at the centromere.
 - There are two dark green chromatids attached at a centromere.
 - There are two light green chromatids attached at a centromere.
 - The dark green ones are from one parent, for example, the father and the light green ones are from the other parent, or mother. Both greens make up a homologous pair.
 - The red yarn represents a different homologous pair. In other words the genes on the red contribute to traits or characteristics that are different from those of the green. Genes on the light and dark green are for the same traits but might be different alleles. For example height is the trait and tall or short are the alleles - T).

8. The index cards represent the animal and plant cells. Students use scissors to round off the corners of the animal cell. They then glue or tape the yarn chromatids (chromosomes) to the cards to illustrate each stage of mitosis. Markers are used to draw the nuclear membrane, centrioles, and spindle fibers as needed. Each index card is labeled on the back with the name of the phase it represents.
9. The class-constructed rubric should be posted on the school network or Internet or each student can be given a handout to use when evaluating student models. Each student can use a digital camera to photograph her model or scan it, then E-mail it to a classmate to evaluate (interpret). Students can evaluate the actual model as an option.
10. During class discussion students present their models and discuss types of cells (e.g., red blood cells and nerve cells) that do not undergo mitosis.
11. To self-assess understanding students can shuffle the cards and then arrange the phases in correct sequence while explaining them to their partners.

Meiosis

1. The students each use 10 index cards representing specialized animal cells that will become gametes and follow the procedure for Modeling Mitosis. Instruct them to make changes where needed to show tetrad formation, crossing-over, genetic segregation, and the change in chromosome number from diploid to haploid.
2. Ask students to compare and contrast mitosis and meiosis during a final class discussion.
3. Have students make predictions about what will happen if chromosomes do not separate properly during mitosis.

ASSESSMENT PROCEDURES:

Reading comprehension prior to the learning activity should be assessed by evaluating the student strategies [e.g., notes, concept map, outline]

Participation in class discussions is ongoing and a tally sheet made from the class roll can be used. Use a + to indicate a positive response and a – for a negative response. A student who does not participate in the discussion will have no mark by her name.

Collaboration skills can be assessed by having students record their contributions to the group in a daily work log and/or complete guided self and peer evaluations (Attachment 1) during and at the completion of the activity.

Student interpretations (analysis) of diagrams should be evaluated. Students use a simple checklist (Attachment 2) that can then be assessed by the teacher.

Student models should be evaluated using criteria (Attachment 3) that has been predetermined and made available to the students prior to constructing the model.

Students can be asked to summarize their predictions in writing.

ACCOMMODATIONS/MODIFICATIONS:

Use clay instead of yarn to model the chromosomes for those who have difficulty handling small items. Pipe cleaners (chromosomes/chromatids) with wooden beads representing the centromere can also be used.

REPRODUCIBLE MATERIALS:

Attachment 1 – Sample self and peer evaluation criteria

Attachment 2 – Sample diagram criteria

Attachment 3 – Sample model criteria

Attachment 4 - Student Worksheet 1: Modeling Mitosis

Attachment 5 - Student Worksheet 2: Modeling Meiosis

EXPLORATION AND EXTENSION:

This is an excellent time to research and discuss regulation of the cell cycle, uncontrolled cell growth (e.g., cancer), cellular differentiation, cellular aging, and stem cells. Students work in pairs to use microscopes to observe prepared slides of mitosis and correctly find and identify cells in each stage. They produce labeled drawings of each stage from these observations. In addition, have them count the number of cells in each stage of mitosis and determine the amount of time spent in each phase of mitosis. Compile a list of hereditary diseases that result from cell division gone wrong. Conduct research on specific chromosomal disorders. Write a song about mitosis and meiosis or act out each of the stages.

LESSON DEVELOPMENT RESOURCES:

BSCS. (2002). BSCS biology: An ecological approach. Colorado Springs, CO.

Miller, K. R., & Levine, J. (2002). Biology. Upper Saddle River, NJ: Prentice Hall.

Web sites previously listed

REFLECTIONS:

The process of mitosis and meiosis are studied at different times so that students can understand them in context. Often when students are taught both processes at the same time they simply memorize the steps in each process without developing meaningful understandings of them and their significance to living things. When constructing meaningful learning, students connect prior knowledge to their learning experiences therefore prior knowledge is of great importance. Don't rush the students because they will be confused if they don't take the time to model each step.

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Attachment 1

**COLLABORATION SKILLS
SELF & PEER EVALUATION FORM**

PROJECT TITLE: _____

GROUP MEMBERS: _____

Please rate your contribution to the group and evaluate the group on a scale of 1 – 10 with 10 being the highest.

INDIVIDUAL EVALUATION: Name _____

___1. Following teacher's instructions

___7. Sharing responsibilities

___2. Asking meaningful questions

___8. Respecting others

___3. Contributing ideas and information

___9. Explaining things to others

___4. Helping the group stay on task

___10. Doing things on time

___5. Contributing materials

___11. Doing my best

___6. Asking for help when needed

I could improve on _____

I rank my contributions to the group as _____.

GROUP EVALUATION:

___1. Following teacher's instructions

___6. Respecting others

___2. Asking meaningful questions

___7. Explaining things to others

___3. Contributing ideas and information

___8. Solving problems within
the group

___4. Staying on task and meeting deadlines

___9. Consistent effort

___5. Sharing responsibilities

___10. Producing a quality product

I rank our group's efforts at working together as _____

PEER EVALUATION:

Rank each member of your group on a scale of 1 – 10 and cite specific reasons why you evaluated each person's contribution to the group that way.

Attachment 2

Assessment Criteria for Diagrams

NAME _____ PERIOD _____ DATE _____

Diagram Title _____ Diagram Type _____

Diagram Description _____

Diagram Source _____

Content:

___ accurate information

___ clarity of information

___ enhances understanding of the concept or process

___ correct order or sequencing

Images:

___ visually pleasing

___ appropriate size

___ enhance understanding

___ directionality

___ creative

___ clear (focused)

___ effective use of color and/or contrast

___ components within images are consistent in design when moving from image to image
(ex – chromosomes are always the same design when more than one cell is shown)**Text:**

___ readable

___ key terms highlighted

___ minimum of words, phrases, or sentences

___ easy to comprehend

___ meaningful connections between words, phrases,
or sentences

___ enhances understanding

___ meaningful positioning of words, labels, headings,
or subheadings

Attachment 3

Assessment for Project Presentations

Evaluator _____ PERIOD _____ DATE _____

Topic _____ Group Members _____

Description of Model _____

Content:

_____ accurate information

_____ clarity of information

_____ enhances understanding of the concept or process

_____ correct order (sequencing)

_____ appropriate resources used

_____ sufficient amount of detail

Project:

_____ follows directions

_____ enhances understanding of the concept or process

_____ accurately represents concept or process

_____ presents information clearly

_____ labeled accurately

_____ appropriate use of materials

_____ uses reasonable scale

_____ shows all necessary components

_____ visually pleasing (e. g., neatness, color)

_____ accomplished its purpose (goal)

_____ creative or novel approach

Student Explanation/Presentation

_____ adequate amount of preparation and research

_____ maintained audience interest

_____ speaking skills (posture, eye contact)

_____ clarity of explanation

_____ able to explain in own words

_____ used appropriate examples

_____ able to apply concepts to novel situations

_____ able to answer audience questions

_____ references cited correctly

_____ appropriate use of time

NAME _____

PERIOD _____

DATE _____

Modeling Mitosis Student Worksheet

Purpose: In your own words write the purpose of this investigation.

Procedure:

1. Work with a partner to construct a model of the process of mitosis. One team member will model mitosis in an animal cell and the other member will model mitosis in a plant cell. Each member will need 5 index cards, one each for prophase, metaphase, anaphase, telophase and cytokinesis.
2. Cut 2 pieces of yarn about 5 cm long from each color of yarn. Each piece of yarn will represent a chromatid. Use tape to join the two chromatids together at the centromere.

There are two dark green chromatids attached at a centromere.

There are two light green chromatids attached at a centromere.

The dark green ones are from one parent, for example, the father and the light green ones are from the other parent, or mother. Both greens make up a homologous pair.

The red yarn represents a different homologous pair. In other words the genes on the red contribute to traits or characteristics that are different from those of the green. Genes on the light and dark green are for the same traits but might be different alleles. For example height is the trait and tall or short are the alleles (T, t).

3. The index cards represent the animal and plant cells. Using scissors, round off the corners of the animal cell. Keep the plant cell rectangular. Glue or tape the yarn chromatids (chromosomes) to the cards to illustrate each stage of mitosis. Use markers to draw the nuclear membrane, centrioles (if appropriate), and spindle fibers as needed. Label each card on the back with the name of the phase it represents.
4. Use the class-constructed rubric to evaluate your model. When your model meets the criteria ask a classmate to evaluate it. Shuffle the cards and then put them in the proper sequence while explaining the phases of mitosis to your classmate.
5. Present your model to the class.

Analysis:

1. What types of cells go through mitosis? _____

2. When do cells go through mitosis? _____

3. What is the purpose of mitosis? _____

4. Describe the events that must occur in the cell cycle before mitosis can take place.

5. Using as few sentences as possible summarize the main events in each phase.

Prophase - _____

Metaphase - _____

Anaphase - _____

Telophase - _____

6. What changes in the nucleus would you look for in order to correctly identify each of the 4 phases of mitosis?

Prophase - _____

Metaphase - _____

Anaphase - _____

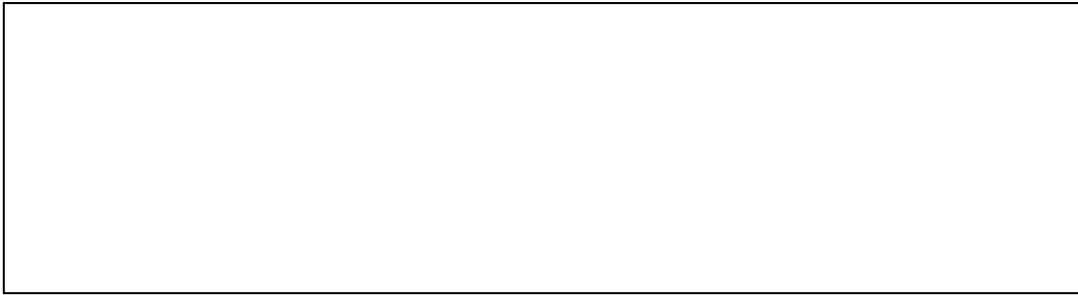
Telophase - _____

7. Cytokinesis occurs after mitosis. Compare and contrast cytokinesis in plant and animal cells.

Conclusion: Write a paragraph that summarizes mitosis.

Extension Activities:

8. Research human cell types that do not divide. In the space below draw (or paste images from the Internet) and label cells that do not undergo mitosis (www.cellsalive.com).



9. For each cell type propose reasons why they do not divide. _____

10. How might the inability of these cell types to divide affect the overall health of a person?

11. Stem cells have been proposed as possible sources of replacement cells for those that have been destroyed by injury or disease. However, there is currently a tremendous amount of disagreement over whether it is ethical to experiment with stem cells. Research stem cells and the issue of stem cell research (<http://www.nih.gov/news/stemcell/primer.htm>), then see if you can form an opinion as to whether stem cell research should be allowed or not. Do you think there are other alternatives to stem cell research? Summarize your ideas in a few paragraphs.
12. The timing of the cell cycle in eukaryotic cells is highly regulated. The growth of cancer cells is uncontrolled and can cause disastrous effects in an individual. Research the causes of uncontrolled growth in cancer cells (www.nci.nih.gov) and summarize your findings.
13. Scientists are also trying to better understand cell aging and its relationship to health. Research some of the effects that aging cells have on health (www.grc.nia.nih.gov) Share you findings with the class for discussion.

NAME _____ PERIOD _____ DATE _____

Modeling Meiosis

Student Worksheet

Purpose: In your own words write the purpose of this investigation.

Procedure:

1. Work with a partner to construct a model of the process of meiosis. Each team member will model meiosis in an animal cell. Each member will need 10 index cards, one each for prophase, metaphase, anaphase, telophase and cytokinesis in meiosis I and II.
2. Cut 2 pieces of yarn about 5 cm long from each color of yarn. Each piece of yarn will represent a chromatid. Use tape to join the two chromatids together at the centromere.
 - There are two dark green chromatids attached at a centromere.
 - There are two light green chromatids attached at a centromere.
 - The dark green ones are from one parent, for example, the father and the light green ones are from the other parent, or mother. Both greens make up a homologous pair.
 - The red yarn represents a different homologous pair. In other words the genes on the red contribute to traits or characteristics that are different from those of the green.
 - Genes on the light and dark green are for the same traits but might be different alleles. For example height is the trait and tall or short are the alleles (T, t).
3. The index cards represent animal cells. Using scissors, round off the corners of the cells. Glue or tape the yarn chromatids (chromosomes) to the cards to illustrate each stage of meiosis. Use markers to draw the nuclear membrane, centrioles, and spindle fibers as needed. Label each card on the back with the name of the phase it represents.
4. Use the class-constructed rubric to evaluate your model. When your model meets the criteria ask a classmate to evaluate it.
5. Present your model to the class.

Analysis:

1. What types of cells go through meiosis?
-

2. When do cells go through meiosis?
-
-

3. What is the purpose of meiosis? Why must diploid cells go through meiosis?

4. Describe the events that must occur in the cell cycle before meiosis can take place.

5. Using as few sentences as possible summarize the main events in each phase.

Meiosis I

Prophase I - _____

Metaphase I - _____

Anaphase I - _____

Telophase I - _____

Meiosis II

Prophase II - _____

Metaphase II - _____

Anaphase II - _____

Telophase II - _____

6. What changes in the nucleus would you look for in order to correctly identify each of the phases of meiosis?

Meiosis I

Prophase I - _____

Metaphase I - _____

Anaphase I - _____

Telophase I - _____

Meiosis II

Prophase II - _____

Metaphase II - _____

Anaphase II - _____

Telophase II - _____

7. Cytokinesis usually occurs after meiosis I and II. Compare and contrast the number of cells and the chromosome number in the cells after each meiotic division.

8. Describe how and why tetrad formation and crossing over (Prophase I) occur.

9. Describe the effect(s) on the gametes if a pair of chromatids failed to separate during meiosis II.

10. Compare and contrast mitosis and meiosis.
