Divide to Multiply

Overview

Description

In this activity, students will explore the stages of mitosis and the primary events that occur in each stage. This activity also assesses students' understanding of mitosis by requiring students to model the process.

Final Product: Groups will create and present physical or digital models of the stages of mitosis. Individual students will conduct research and prepare a 500-word essay investigating the question, "What are the relationships among mitosis, control of cell division, and cancer?"

Subject

Biology

Task Level

Grade 9

Objectives

Students will:

- Describe the major features of mitosis.
- Explain the purpose of mitosis in growth and asexual reproduction.
- Observe and identify the stages of mitosis using prepared slides.
- Describe the difference in plant and animal cell cytokinesis.
- Construct a model of the stages of mitosis that indicates the changes in cellular features that occur during each stage.
- Perform independent research using a variety of resources.
- Write a 500-word essay about the relationships among mitosis, regulation of cell division, and cancer.

Preparation

- Read the Instructor Task Information and the Student Notes.
- Prepare student copies of the Student Notes pages and the *Introduction to Mitosis, Microscopic Observations of Mitosis*, *Mitosis Model Planning*, and the *Mitosis Storyboard* handouts.

- Obtain texts, Internet access, and other resources that will be used to answer the assigned questions from the *Introduction to Mitosis* handout.
- Set up light microscopes (one per group) and slides of onion root tip cells undergoing mitosis for the lab activity. If microscopes and slides of cells undergoing mitosis are not available, obtain photomicrographs of cells undergoing mitosis from the Internet. Use a projector to display the photomicrographs to the class.
- Gather materials that can be used to model the process of mitosis such as socks, balloons, chenille, clay, and yarn. Use the materials to introduce students to the modeling assignment.
- For electronic models, make copies of the *Mitosis Storyboard* worksheet. Locate a student-made video from a source such as the Internet to show students how mitosis can be modeled electronically. You may also want to bring an example of a completed storyboard to show students how to design a video or animation. Examples of completed storyboards can be found on the Internet.

Prior Knowledge

Students are expected to be familiar with the use of a light microscope and a word processing program. Students need to be able to recognize the appearance of cell organelles and structures involved in the process of mitosis, including chromosomes. Students should be able to prepare labeled biological drawings.

Vocabulary

- Anaphase
- Centriole
- Centromere
- Centrosome
- Chromatids
- Chromosome
- Cytokinesis
- Kinetochore
- Metaphase
- Mitosis
- Nuclear membrane
- Prophase
- Spindle fibers (and/or microtubules, depending on the textbook)
- Telophase

Time Frame

This assignment will require approximately 10 class days to complete although some of the work can be delegated to outside of class if class time is limited (working on models, preparing and revising essay). The students are given two days to prepare their rough drafts before peer review during class then two more days to complete their essays. This five-day period can also be spent working on their models, both in and out of class, as is appropriate. The students' presentation of their mitosis models will take one to two additional class periods. This assignment can be modified to

meet the needs of different classroom schedules and student ability levels.

Day 1:

1. Ask students how an organism grows. Lead discussion to concepts of mitosis and cytokinesis.
2. Introduce the stages of mitosis, using schematic diagrams (cartoons). Address any questions.

Day 2:

3. Assemble students into groups. Provide a light microscope and a prepared, stained slide of an onion root tip to each group. Students should find each stage of mitosis and prepare labeled drawings of each stage in the proper order. If microscopes are not available, provide photomicrographs of each stage and have students identify the stages and put them in order.
4. If students are proficient at microscopy or assemble their photos quickly, the remainder of the class period can be spent discussing examples of models of mitosis.

Day 3:

5. Each group should create a storyboard that outlines a model of the events of mitosis. Their final model will use either physical materials (clay, yarn, pipe cleaners, etc.) or digital resources (slideshow, video, etc.).

Days 4-5:

6. Groups use their storyboards to prepare their models using either physical materials or digital resources.
7. Each student should also prepare a rough draft of their 500-word essay describing the overall purpose and individual steps of mitosis and how this relates to cancer.

Day 6:

8. Participate in a peer review of the essay rough draft.

Days 7-8:

9. Groups are given time to finalize models, if necessary.
10. Individual students complete revisions of the essay.

Days 9-10:

11. Individuals submit their 500-word essays.
12. Groups present their models of mitosis.

Instructional Plan

Getting Started

Learning Objectives

Students will:

- Describe the major features of mitosis.
- Explain the function of mitosis in growth and asexual reproduction.
- Observe and identify the stages of mitosis using prepared slides.

Procedure

1. Ask students to suggest explanations of how a human embryo grows into an adult or how an acorn becomes a tree. Accept several explanations and redirect as needed to lead students to understand that growth and development occur through cell division.
    a. An eight-week-old human embryo is only about an inch long. What accounts for the difference in size between the embryo and the human adult—the number of cells or the size of the cells?
2. Divide the class into groups and assign each group a question from the *Introduction to Mitosis* handout. Instruct each group to find the correct answer and share it with the class. If smaller group sizes are preferred, each question may be assigned to more than one group. Supply texts, Internet access, and other resources students can use to locate answers. Allow 10 minutes for students to prepare their answers.
3. Call on each group to share their response with the class as students make notes on their copy of the *Introduction to Mitosis* handout.
4. Show cartoon schematics of cells in various stages of mitosis as you describe the main events that occur in each stage.
5. Direct students to take turns on the microscope within their group. Each student should independently find each phase of mitosis and draw and label diagrams of the cell using the *Microscopic Observations of Mitosis* handouts. You may want to provide students with a list of structures you expect to see labeled, such as the cell membrane, cytoplasm, chromosomes, spindle fibers, etc.

Investigating

Learning Objectives

Students will:

- Describe the differences between plant and animal cell cytokinesis.

- Work with a group to construct a model of the stages of mitosis that indicates the changes in cellular features that occur during each stage.

Procedure

1. Introduce the modeling project to students by sharing with them a sample electronic model with an accompanying storyboard, such as a student-produced animation, and examples of physical models.
2. Place students into groups to design their models, and give each group several copies of the *Mitosis Storyboard* worksheet. Instruct half the groups to model mitosis and cytokinesis in plant cells and the other groups to model these two processes in animal cells.
3. Instruct the groups to conduct research to find an organism with a small number of chromosomes to represent in their models. Wikipedia has a helpful table here: http://en.wikipedia.org/wiki/List_of_organisms_by_chromosome_count. Emphasize the usefulness for modeling of choosing an organism with a small number of chromosomes. Allow time for the groups to research, brainstorm design ideas, select a design, and assign group member roles.
4. Emphasize due dates, project expectations, and the need for collaboration outside the classroom.
5. Require each group to present its model to the class on the specified due date. Limit presentation times to 5–10 minutes per group. After all the groups have presented their models, lead the class in a discussion about the similarities and differences between mitosis and cytokinesis in plant and animal cells.

Drawing Conclusions

Learning Objectives

Students will:

- Describe the major features of mitosis.
- Perform independent research using a variety of resources.
- Write a 500-word essay about the relationships among mitosis, control of cell division, and cancer.

Procedure

1. Set the stage for this activity by explaining that mitosis and cytokinesis are the last stages of the cell cycle and that the cell cycle is closely regulated in multicellular organisms. Start a discussion about cell cycle regulation by asking the following questions:
   a. How do you think a cell's rate of division is regulated?

b. Think back about your answer to the question about embryonic growth (size vs. number of cells). Now think about the growth of a tumor (in cancer). Is this due to an increase in number or increase in size of cells?

c. What do you think would happen if a cell became unregulated and the cell started dividing at an uncontrolled rate?

2. Explain that the purpose of the essay is to answer the question, "What are the relationships among mitosis, control of cell division, and cancer." Provide students with a variety of resources to start their research and emphasize the importance of citing all references. The essay should include a Works Cited page. Make rough and final draft due dates clear.

3. Describe the peer review process that will occur.

Scaffolding/Instructional Support

The goal of scaffolding is to provide support to encourage student success, independence, and self-management. Instructors can use these suggestions, in part or all together, to meet diverse student needs. The more skilled the student, however, the less scaffolding that he or she will need. Some examples of scaffolding that could apply to this assignment include:

- Populate each group with students of different abilities so that students will be able to learn from each other as they work together.
- Provide an example of an appropriate biological drawing to students that have not been taught how to prepare scientific diagrams.
- Determine whether some students need more structure in the modeling assignment. If so, assign a media type to certain groups. For example, you may need to tell a group to use paper plates and yarn to represent the process of mitosis.
- Show a video of a cell undergoing mitosis to help students visualize it.
- To help inform students about the relevance of this work to their broader lives, consider sharing additional resources about cancer and how the development of cancer is connected to the ideas in these activities. Consider sharing links to such sites as http://en.wikipedia.org/wiki/Cancer.
- Give extended due dates to students as necessary.
- Have advanced learners animate the behavior of microtubules and present the animation to the class when they submit their essay.

Suggested activity for advanced learners:

Set the stage for this activity by explaining that descriptions of mitosis usually focus on the movement of chromosomes and that scientists are beginning to understand how the chromosomes are actually moved around in the dividing cell by microtubules. Start a discussion about microtubules and mitosis by asking the following questions:

- What do you think microtubules, the components of the spindle, are made of?
- How do you think microtubules move chromosomes; by pushing, pulling, both?
- Do you think microtubules need energy to work?

Questions to enhance this activity for advanced learners:

1. What are microtubules made of and how are they constructed?
2. What is the role of the centrosome?
3. What are the different functions of microtubules in the mitotic spindle?
4. Where do microtubules attach to chromosomes?
5. How do microtubules move chromosomes?

Solutions

The information below is intended to help you assess students' final work products. It may not represent all possible strategies and ideas. The accompanying scoring guide provides specific examples of ways a student might demonstrate content understanding and mastery of cross-disciplinary skills.

Necessary Elements

Students who choose to prepare a digital model could use one of the following formats: a video, an animation, a PowerPoint presentation, or a podcast in which the stages of mitosis are "acted out" and recorded.

Suggestions for physical model components include pipe cleaners, yarn, modeling clay, plastic spoons and forks, balloons, and pop beads. Students may demonstrate their creativity by using any household objects that effectively represent the relevant components.

Students should include a wide variety of cancer topics in their essay. The essay should contain few if any grammatical and spelling errors, include properly formatted citations, and a Works Cited page.

Key Connections

Students should understand that tumors are the result of uncontrolled cell division.

It should be reinforced that mitosis is only a portion of what is collectively termed "cell cycle," and students should demonstrate awareness that biologically essential cell cycle events take place outside of mitosis, during interphase.

Cancer is fundamentally a cell cycle disease; therefore, understanding how the cell cycle functions and is controlled is critical for understanding what cancer does and how to treat it.

Common Misconceptions

A frequent misunderstanding involves differentiating between mitosis (division of the nucleus) and cytokinesis (the division of the entire cell). Students may also misunderstand the differences between cytokinesis in animal cells and cytokinesis in plant cells. These differences are largely related to the presence of a cell wall in plant cells and its absence in animal cells. Animal cells divide by furrowing and cleavage initiated at the outside surface, like tying a string around a balloon. In plant cells, cytokinesis begins with construction of a new cell, beginning in the center of the cell. Students' work should reflect an understanding of this process.

Introduction to Mitosis - Sample Solutions

Directions: You will be assigned one of the questions below to answer and share your answer with the class. Your responses should be in your own words written in complete sentences. (Sample solutions in italics.)

1. Why would mitosis need to occur in the body of a human adult? *In adult humans, mitosis is responsible for the production of red blood cells and lymphocytes, for the replacement of epithelial cells on our skin and in our gastrointestinal tract, and for hair growth and sperm cell production.*
2. Explain the differences between these terms: chromatin, chromosomes, and chromatid. *A chromosome is a highly organized cellular structure that contains genetic information in the form of DNA as well as associated proteins necessary for its function. In eukaryotic cells, chromosomes are usually made up of two sister chromatids, each containing identical genetic information, joined together at a central point (the centromere). Chromatin is the name given to the complex of DNA and proteins that makes up a chromosome.*
3. What is cytokinesis? *Cytokinesis ("cell motion") is the process by which the cytoplasm of a cell is divided to form two daughter cells. Cytokinesis usually occurs late in cell division, after the genetic material has been duplicated.*
4. How is cytokinesis in plant cells different from cytokinesis in animal cells? *The presence of a rigid cell wall in plant cells involves the formation of a structure called the cell plate. The cell plate serves as the site of formation of the new cell wall that will be required to completely enclose the daughter cells after division is complete.*
5. Which cells in mature plants and animals most likely undergo mitosis most frequently? *In mature plants and animals, the cells that undergo mitosis most frequently include stem cells in the bone marrow and epithelium of animals and cells of the meristematic tissue responsible for plant growth.*
6. What is asexual reproduction? What kinds of organisms can reproduce asexually by mitosis? *Asexual reproduction is the mode of reproduction in which the offspring arise from a single parent and receive genetic material only from that parent. All asexual reproduction involves variations of the process of mitosis; in bacteria, this process is given the name binary fission, while in other organisms this process is variously referred to as budding (e.g., hydra, yeast) or sporulation (e.g., certain algae and fungi).*
7. At what stage in the cell cycle does chromosome replication occur? At what stage in the cell cycle do chromatids separate from each other? *Chromosome replication occurs during interphase. Sister chromatids separate during anaphase.*

TCCRS Cross-Disciplinary Standards Addressed

Performance Expectation	Getting Started	Investigating	Drawing Conclusions
I. Key Cognitive Skills			
B.3. Gather evidence to support arguments, findings, or lines of reasoning.	✓	✓	✓
D.1. Self-monitor learning needs and seek assistance when needed.	✓	✓	✓
D.2. Use study habits necessary to manage academic pursuits and requirements.		✓	✓
D.3. Strive for accuracy and precision.	✓	✓	✓
D.4. Persevere to complete and master tasks.	✓	✓	✓
E.1. Work independently.			✓
E.2. Work collaboratively.	✓	✓	✓
F.1. Attribute ideas and information to source materials and people.			✓
F.2. Evaluate sources for quality of content, validity, credibility, and relevance.			✓
F.4. Understand and adhere to ethical codes of conduct.			✓
II. Foundational Skills			
A.5. Analyze textual information critically.		✓	✓
B.3. Compose and revise drafts.			✓
C.1. Write clearly and coherently using standard writing conventions.			✓
C.2. Explore a research topic.		✓	✓
C.4. Evaluate the validity and reliability of sources.			✓
C.5. Synthesize and organize information effectively.	✓	✓	✓
C.6. Design and present an effective product.		✓	✓
C.7. Integrate source material.		✓	✓
C.8. Present final product.			✓
E.1. Use technology to gather information.	✓	✓	✓

TCCRS Science Standards Addressed

Performance Expectation	Getting Started	Investigating	Drawing Conclusions
I. Nature of Science: Scientific Ways of Learning and Thinking			
A.1. Utilize skepticism, logic, and professional ethics in science.		✓	✓
A.2. Use creativity and insight to recognize and describe patterns in natural phenomena.		✓	
C.1. Collaborate on joint projects.	✓	✓	✓
D.1. Demonstrate literacy in computer use.		✓	✓
E.1. Use several modes of expression to describe or characterize natural patterns and phenomena. These models of expression include narrative, numerical, graphical, pictorial, symbolic, and kinesthetic.	✓	✓	✓
E.2. Use essential vocabulary of the discipline being studied	✓	✓	✓
III. Foundation Skills: Scientific Applications of Communication			
A.1. Use correct applications of writing practices in scientific communication.			✓
B.3. Recognize scientific and technical vocabulary in the field of study and use this vocabulary to enhance clarity of communication.	✓	✓	✓
C.1. Prepare and present scientific/technical information in appropriate formats for various audiences.		✓	✓
D.1. Use search engines, databases, and other digital electronic tools effectively to locate information.		✓	✓
VI. Biology			
A.4. Describe the major features of mitosis and relate this process to growth and asexual reproduction.	✓	✓	✓
A.5. Understand the process of cytokinesis in plant and animal cells and how this process is related to growth.	✓	✓	✓

TEKS Standards Addressed

Divide to Multiply - *Texas Essential Knowledge and Skills (TEKS): Science, Biology*
112.34.c.3. Scientific processes. The student uses critical thinking, scientific reasoning, and problem solving to make informed decisions within and outside the classroom. The student is expected to: 112.34.c.3.B. communicate and apply scientific information extracted from various sources such as current events, news reports, published journal articles, and marketing materials
112.34.c.5. Science concepts. The student knows how an organism grows and the importance of cell differentiation. The student is expected to: 112.34.c.5.A. describe the stages of the cell cycle, including deoxyribonucleic acid (DNA) replication and mitosis, and the importance of the cell cycle to the growth of organisms.

Divide to Multiply

Introduction

Your body contains trillions of cells. Amazingly, all of these cells are descended from a single cell—a fertilized egg. How did that single cell end up producing the trillions of cells that now compose your body? It all happened through processes called *mitosis* and *cell division.*

Mitosis is a form of nuclear division. It allows organisms to grow, develop, and reproduce. Before mitosis occurs, the chromosomes in a parent cell are duplicated. During mitosis, the duplicated chromosomes of the parent cell are equally partitioned into two separate nuclei. Cytokinesis, or division of the cytoplasm, follows mitosis. Cytokinesis results in the formation of two new cells. These new cells contain the same genetic information as the original parent cell.

In this activity, you will explore the events of mitosis as you observe cells that are in various stages of division. You will apply your understanding of mitosis as you develop a model of the stages of mitosis. You will extend your knowledge as you conduct research and prepare an essay explaining how the process of mitosis is related to cancer.

Directions

Getting Started

1. You will be given one of seven questions to answer. Work with your assigned partner or group to formulate a brief response to the assigned question. Use texts, Internet sources, and other resources to research your response.
2. On your handout entitled *Introduction to Mitosis,* record the answers to each of the questions as reported by the other groups.
3. Take notes on your own paper as your instructor describes the events of the major stages of mitosis. You will find it helpful to include sketches of the stages in your notes.
4. When directed by the instructor, move to the microscope. Carefully observe the cells under the microscope and find cells representing each phase of mitosis. Record the phase name in the corresponding space on the *Microscopic Observations of Mitosis* handout.
5. Prepare a sketch of the cell in the space provided on your lab handout. Label the observable parts of the cell.

Investigating

1. Read through the requirements found in the *Mitosis Model Planning* handout.
2. Conduct research on the Internet or in the library to select a plant or animal that will form the basis for your model. Choose an organism with a manageable number of chromosomes for the model; human cells, for example, have 46 chromosomes and would be difficult to represent in a model.
3. Work with your group members to brainstorm a list of ideas as to what you could use to construct a model of the stages of mitosis. Brainstorm about different items that could be used to represent the chromosomes in a model of mitosis. These could be physical models using craft supplies, household items, etc., or digital models such as animations, videos, etc. During brainstorming, a member of your group should record all ideas generated without judgment. You may wish to use the *Mitosis Storyboard* handout to help explore different ideas.
4. After the group agrees on a model, decide on a task and completion dates for a specific portion of the model for each group member. List the materials, software, or equipment that will be needed to make the model.
5. Arrange/schedule any time outside of class needed for group collaboration on this project.
6. Prepare the mitosis model, and be ready to explain the model to the class on the assigned due date.

Drawing Conclusions

1. In this portion of the activity, you will prepare a 500-word essay in response to the following question: “How is the regulation of mitosis related to the development of cancer cells?”
2. Conduct a literature search using your textbook, library resources, and/or Internet resources to gather the necessary background information.
3. You should investigate, at least, the following general questions:
   a. What kinds of cells can become cancerous?
   b. What changes in control of cell division could lead to cancer?
   c. Apply your knowledge of your research relating cancer and mitosis, and suggest how some anti-cancer drugs could work.
4. Prepare a rough draft of your essay and submit it for peer review on the date assigned.
5. Using the input from the peer-review process, edit your essay and prepare a

final version.

6. Prepare a Works Cited page reflecting the references that you used in researching your essay.
7. Submit your completed essay on the assigned due date. Your group will also present your mitosis model to the class on the due date.

Introduction to Mitosis

Directions: You will be assigned one of the questions below to answer and share your answer with the class. Your responses should be in your own words written in complete sentences.

1. Why would mitosis need to occur in the body of a human adult?

2. Explain the differences between these terms: *chromatin, chromosomes,* and *chromatid.*

3. What is cytokinesis?

4. How is cytokinesis in plant cells different from cytokinesis in animal cells?

5. Which cells in mature plants and animals most likely undergo mitosis most frequently?

6. What is asexual reproduction? What kinds of organisms can reproduce asexually by mitosis?

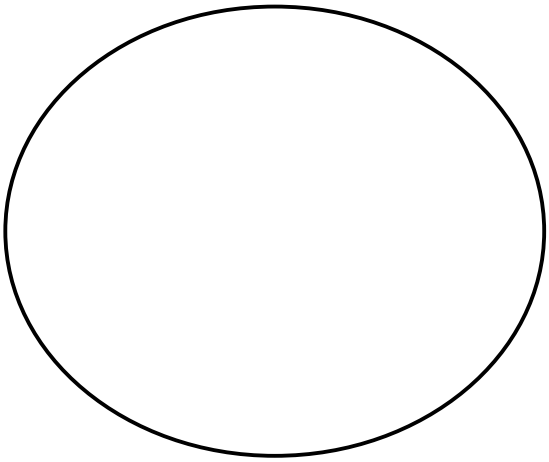
7. At what stage in the cell cycle does chromosome replication occur? At what stage in the cell cycle do chromatids separate from each other?

Microscopic Observations of Mitosis

Directions: Rotate through each lab station at your instructor's signal. Observe the cells shown in the microscope. Draw and label the cell indicated by the microscope's pointer. Record the magnification on your diagram. Identify the stage of mitosis observed in the indicated cell.

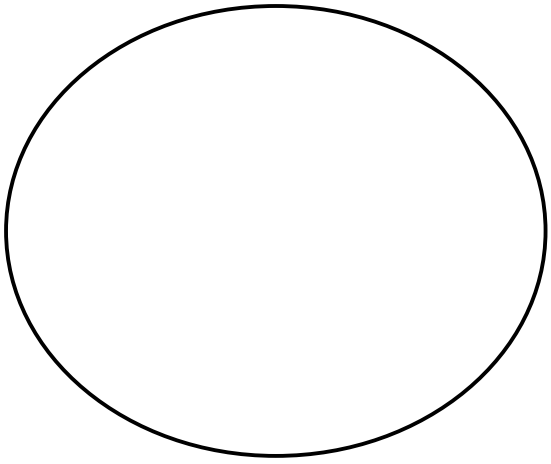
Station 1: Stage of mitosis observed _____

Sketch



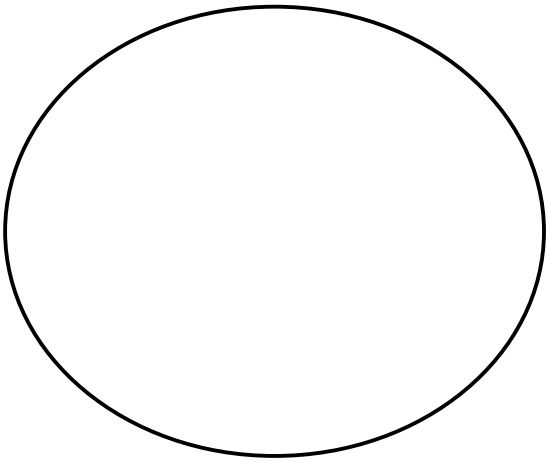
Station 2: Stage of mitosis observed _____

Sketch



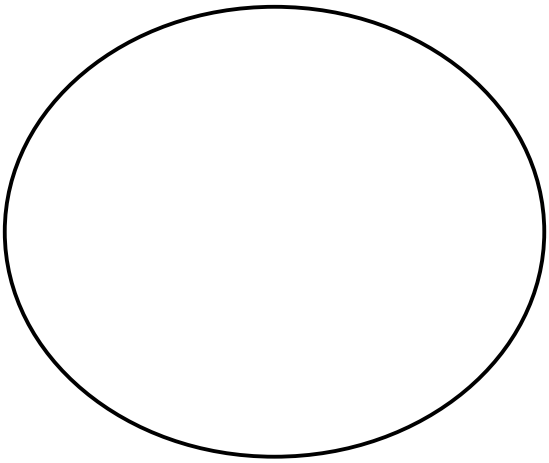
Station 3: Stage of mitosis observed _____

Sketch



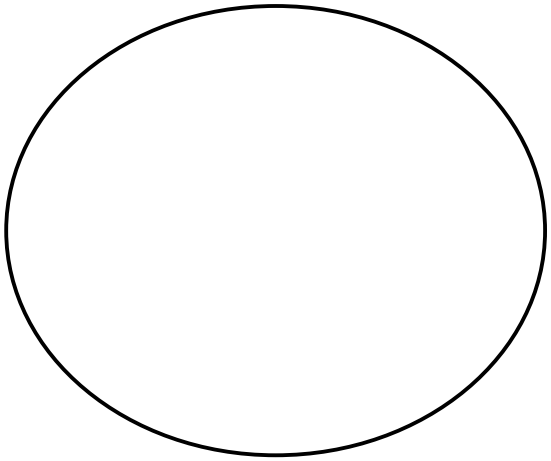
Station 4: Stage of mitosis observed _____

Sketch



Station 5: Stage of mitosis observed _____

Sketch



Mitosis Model Planning

Model Requirements: Your model of mitosis should represent prophase, metaphase, anaphase, telophase, and cytokinesis in a plant or animal cell (your instructor will designate which type of cell you will model). The model should show the number of chromosomes found in the plant or animal species you have researched. The model should clearly show the differences between chromatin, chromosomes, and chromatids. Cytokinesis, all of the stages of mitosis, and all of the depicted structures should be clearly labeled. Your model should only include original work (no diagrams, pictures, or video clips produced by anyone other than your group members). Every group member must contribute to the model.

Latin name of plant/animal: _____

Common name: _____

Diploid (2*n*) number of chromosomes: _____

Brainstorming: In the space below, list the various ideas suggested by group members regarding the design of your group's mitosis model.

Design Description: Prepare a description of the type of model your group decided to design.

Members' Roles: List each group member's name and his or her role in the production of the model.

Group Member's Name	Role in model production	Due date

Mitosis Storyboard

Key Ideas:	Visual Representation:

