



Introduction to the Decoding Cancer curriculum

The Decoding Cancer curriculum, an innovative, standards-aligned curriculum for biology courses, is designed to improve science skills and increase awareness of breast cancer among high school students. Students develop problem solving and decision making skills, apply their knowledge of biology, expand their understanding of genetics, and explore relationships between science and technology. Using breast cancer as the context, students also learn how cancer develops, identify risk factors for cancer and investigate ways to reduce cancer risk. The curriculum contributes to both the improvement of science literacy and the increase of breast cancer awareness among youth. By emphasizing healthy behaviors during adolescence, long-term health benefits may be attained throughout adulthood. Based on real-life case studies, the curriculum centers around Steve and Nikki, twins who are grappling with understanding their mother's new diagnosis of breast cancer.

Hands-on Technology

Students create virtual presentations on breast cancer diagnostic tools using wiki technology. Wikis are an online directory that can be edited by many users, and offer a unique way to display and present information. Teachers can monitor the effort made by each group member by assessing external access to the wiki pages.

Meet Steve and Nikki

Steve and Nikki are fraternal twins in high school. Steve likes to play sports and video games while Nikki enjoys shopping and playing the guitar. These fictitious twins are like any high school students, and like many others, their mother has breast cancer. Steve and Nikki are confused about the disease and what is happening to their mom. They reach out to other students for answers. Students who participate in the curriculum will answer Steve and Nikki's questions using knowledge they acquire through the Decoding Cancer curriculum.



Lesson 1: What Is Cancer?

Lesson Summary:

In this lesson, students will be introduced to breast cancer through fictional characters, Steve and Nikki, who are high school students and siblings. Students will discuss what they currently know about cancer, and learn about common misconceptions. The class will examine healthy versus cancerous cells, review cell structure, function, and quality control, and learn about gene mutations that lead to cancer. Activities in this lesson include creating a graphic organizer, small group brainstorms, writing activities related to Steve and Nikki, a jigsaw activity to enact the cell cycle, and a mitosis role play. Video links that illustrate healthy cell and cancerous cell activity are included, as well as handouts, answer keys, a quiz, and additional resources.

Lesson Duration: Two 45–60-minute class periods

How to Use This Guide

This lesson plan was created to aid instructors in planning their lesson. It provides slide-by-slide details so educators will be prepared to engage, explain, discuss, and analyze every part of the lesson. The lesson is designed to be two 45–60-minute class periods, but it is flexible, depending on the students' needs and time available. Note there are several activities that are optional and can be deleted or modified for specific classroom needs. All handouts are included in this guide, as well as additional resources for more learning activity ideas.

Objectives

Upon completion of this lesson, students will be able to:

- Identify common misconceptions about cancer
- Create a graphic organizer to represent what they know about cancer
- Summarize the characteristics of the cell cycle and its regulation
- Recognize the consequences of uncontrolled cell division
- Compare the appearance, structure, function, and replication of healthy cells to those of cancerous cells
- Describe how cancer develops

Materials:

- Handout: [What Do YOU Believe?](#)
- Handout: [Breast Cancer Trends \(optional\)](#)
- Handout: [Cancer Concept Map Worksheet](#)
- Handout: [Cell Structure and Function \(optional\)](#)
- Handout: [The Cell Cycle and Checkpoints](#)
- Handout: [Mitosis](#)
- Video: The Cell Cycle
<http://outreach.mcb.harvard.edu/animations/cellcycle.swf>
- Video: Eukaryotic Cell Cycle
http://www.cellsalive.com/cell_cycle_js.htm



- Video: Checkpoints and Cell Cycle Control
 - <http://outreach.mcb.harvard.edu/animations/checkpoints.swf>
- Video: Tumor Suppressor Genes
 - <https://www.youtube.com/watch?v=OGIOb76xPW4>
- Materials for Mitotic Division Role-Play (optional)
 - Blank name tags/card stock paper
 - Yarn
 - 6 unsharpened pencils (2 per scenario)
 - Scissors
 - Markers
 - Normal Cell Division Script (optional)
 - Tumor Suppressor Gene Mutation Script (optional)
 - Proto-oncogene Mutation Script (optional)
- [Lesson 1 Quiz](#)
- Answer Keys
- Interactive white board (optional)
- Computer with Internet access/LCD projector

Subjects:

- Health
- Language Arts and Literacy
- Science

Vocabulary:

anaphase, apoptosis, cancer, cell, cell checkpoint, cell cycle, cell membrane, centriole, chromatid, chromosome, cytokinesis, cytoplasm, DNA, G0 phase, G1 checkpoint, G1 phase, G2 checkpoint, G2 phase, gene, inheritance, interphase, metaphase, mitosis, mutation, nondisjunction, nuclear envelope, nucleus, oncogene, organelle, prophase, proto-oncogene, replication, S phase, spindle checkpoint, spindle fiber, telophase, tissue, tumor, tumor suppressor gene

Advance Preparation

Day 1

Real-World Scenario – Steve and Nikki

- Review Steve and Nikki's real-world scenarios in all of the lessons so that you can effectively use their story in the classroom.

What Do You Know about Cancer?

- Make one copy per student of **What Do YOU Believe?**). Answer sheets are optional; the presentation will provide answers.
- Make one copy per group of **Cancer Warriors**.
- Optional: Make one copy per student of **Breast Cancer Trends**. This can be used for a learning activity, for a homework assignment, or to provide more detail of slide 7.



Create a Graphic Organizer

- Make one copy per student of **Cancer Concept Map Worksheet** for the version you plan to use if you will have students create concept maps for their graphic organizers. **Cancer Concept Map Sample** is optional.

Day 2

Review cell structure and function (optional)

- Optional: Make one copy per student of **Cell Structure and Function**. Answer sheets are optional; the presentation will provide answers.

Review cell structure and quality control

- Review videos and animations; ensure LCD projector works properly
<http://outreach.mcb.harvard.edu/animations/cellcycle.swf>
http://www.cellsalive.com/cell_cycle_js.htm
<http://outreach.mcb.harvard.edu/animations/checkpoints.swf>

Analyze tumor suppressor gene mutation and proto-oncogene mutation

- Review videos and animations; ensure LCD projector works properly
<https://www.youtube.com/watch?v=OGIOb76xPW4>

Demonstrate understanding of cell division scenarios (optional)

- Review the role-play and decide whether you will have students use the completed scripts or use their knowledge of the cell cycle to complete the role-play.
- Make one copy per student of the appropriate script:
 - Normal Cell Division Script (two pages)
 - Tumor Suppressor Gene Mutation Script (two pages)
 - Proto-oncogene Mutation Script (two pages)
- Identify and reserve an appropriate space to conduct the activity.
- Cut six pieces of yarn into approximately six-foot lengths (two per scenario).
- Cut six pieces of yarn into approximately three-foot lengths (two per scenario).
- Cut 18 pieces of yarn into approximately four-foot lengths. Tie yarn to “spindle fiber” pencils (three per scenario).

Overview

- Discuss what students want to know about cancer or what they’re most curious about learning.
- Poll the class about cancer knowledge, and make a graphic organizer summarizing the results.
- Distinguish between images of healthy cells and images of cancerous cells.
- Review cell structure and function, if needed.
- View animations to compare the cell cycles of healthy and cancerous cells.
- Analyze the mitotic division of healthy and cancerous cells.
- Complete drag-and-drop activities to compare healthy and cancerous cells.
- Write a description of how cancer develops.
- Talk about It: What do you believe would be the most useful facts to learn about cancer? What are you most curious about?



Career Connection

- Physician
- Researcher

A Note for the Teacher about Cancer

Cancer is a disease that unfortunately touches many people. You may have students with a parent, guardian, or loved one affected by cancer. Adolescents affected by cancer cope in their own ways. Some students may want to share their personal experiences, while others may not. Reassure students that you want them to be comfortable in the classroom and will not require them to share any personal or private experiences.

You may learn a student is personally affected prior to or while implementing the curriculum. If you discover a student is affected by cancer, speak with them privately and make sure they are comfortable with participating in the learning activities, discussions, and explorations.

If you know a student is affected by cancer prior to starting the curriculum:

- Give the student a brief summary of the lessons, and ask how they feel about it. Tell the student it may not bother them now, but they should let you know if it does.

If you learn a student is affected by cancer while implementing the curriculum:

- Ask who they have spoken to about the cancer. If the answer is no one, ask if they would like to talk to someone, such as a guidance counselor or other trusted adult.

Connect students with support. Possible sources include the following:

- Guidance counselors
- Family friends
- Family doctors or pediatricians
- Faith-based counselors

Look for warning signs. Keep an eye out for signs of distress, such as

- Changes in academic performance
- Changes in behavior with other students
- Evidence of alcohol or drug use
- Evidence of anxiety or depression



Lesson 1 Plan – Day 1: Cancer Overview

ENGAGE

Real-World Scenario – Steve and Nikki

- [Slide 3] Introduce Steve and Nikki, who are fraternal twins in high school. They recently learned that their mother has been diagnosed with cancer. They have no idea what this really means for their mom or for them. This is a fictional scenario that will be used throughout this lesson and others to reinforce key concepts in a more realistic way.
- [Slide 4] Students read a firsthand excerpt from Steve: “What Is Cancer?” Tell the class that they will develop a response to Steve’s question.

What Do You Know about Cancer?

- [Slide 4] **Learning Activity: Small Group Brainstorm.** Divide the class into small groups, and have students brainstorm what they know about cancer and discuss it in their small groups. Ask students to share their thoughts with the whole class. If an interactive white board is available, write students’ responses in the box provided. You can save the notes the students make by saving via one of the following methods:
 - Press the Print Screen button on the keyboard, and paste the screen image into a Word document.
 - Use the screen capture feature of the Notebook software that comes with the interactive white board to add the screen to a set of class notes to be shared with the class later.
 - Use PowerPoint’s annotate pen, and save the notes to the slide.
- [Slide 5] **Learning Activity: What Do You Believe?** Distribute *What Do YOU Believe?* and give students a few minutes to fill it out. Ask them to check their answers as you read through the next 12 slides (6–17). For each question, ask students to informally share their responses using a thumbs-up for true and a thumbs-down for false. Ask volunteers to discuss why they selected their responses before moving on to the answer slides. Several slides have partial explanations with additional detail in the notes section.

Following is all of the detail from these slides and this activity.

- [Slides 6–7] *Question 1: The risk of dying from cancer in the United States is increasing. (False.)* The risk of dying from cancer in the United States decreased from 1975 to 2012.
 - **Optional Learning Activity/Homework Assignment.** Students review and plot the data from *Breast Cancer Trends* and draw conclusions about the answer to Question 1. Students can graph data individually or as a class. Graphs can also be completed as a homework assignment.
- [Slide 8] *Question 2: Cancer can be spread from person to person. (False.)* Cancer cannot be passed from one person to another. Though cancer itself isn’t contagious, sometimes viruses, which are contagious, can lead to the development of cancer. Two common cancers caused by viruses are cervical cancer and liver cancer. Human papillomavirus (HPV), a sexually transmitted disease, can cause cervical cancer. Hepatitis C, a virus transmitted through sexual intercourse or use of infected



- intravenous (IV) needles, can cause liver cancer, though only a small number of those with the virus will develop liver cancer.¹
- [Slide 9] *Question 3: What someone does as a young adult has little effect on their chance of getting cancer later in life. (False.)* In most cases, cancer is the consequence of many years of exposure to several risk factors. What you eat, whether you are physically active, whether you are sunburned, and especially whether you smoke as a young person have a substantial influence on whether you develop cancer later in life.²
 - [Slide 10] *Question 4: There is currently a cure for cancer but the medical industry won't tell the public about it because they make too much money treating cancer patients. (False.)* Plenty of doctors and their loved ones die of cancer each year. Why would anyone hide such an important discovery? Think about the speed with which other medical breakthroughs in vaccines and antibiotics have been announced and applied. Remember, cancer is many diseases rather than a single disease, and cures are already available for many forms of cancer. Fewer than half of all people with cancer in the United States actually die of the disease.¹
 - [Slide 11] *Question 5: Treating cancer with surgery can cause it to spread throughout the body. (False.)* Specialists in cancer surgery know how to safely take biopsy samples and how to remove tumors without causing the cancer to spread. In many cases, surgery is an essential part of the cancer treatment plan.²
 - [Slide 12] *Question 6: Cancer can be effectively treated. (True.)* The five major types of treatment for cancer are surgery, radiation, chemotherapy, biologic therapies, and therapies that boost the patient's immune system.
 - [Slide 13] **Learning Activity: Small Group Brainstorm.** Pause the True/False slides to discuss how effective cancer treatments can include several types of "Cancer Warriors." Divide the class into small groups, and assign one of the professions listed on the slide to each group (oncology physician, cancer researcher, nurse, pharmacist, social worker/advocate). Ask each group to brainstorm ideas of how each role works toward fighting cancer. Ask a member of each group to share what they've determined.
 - [Slide 14] *Question 7: Cancer is a group of over 100 diseases. (True.)* There are more than 100 different types of cancer. The main categories of cancer include:
 - Carcinoma: cancer that begins in the skin or in tissues that line or cover internal organs
 - Sarcoma: cancer that begins in bone, cartilage, fat, muscle, blood vessels, or other connective or supportive tissue
 - Leukemia: cancer that starts in blood-forming tissue, such as the bone marrow, and causes large numbers of abnormal blood cells to be produced and enter the blood
 - Lymphoma and myeloma: cancers that begin in the cells of the immune system
 - Central nervous system cancers: cancers that begin in the tissues of the brain and spinal cord³
 - [Slide 15] *Question 8: Cancer cells can be distinguished from normal cells because of their abnormal growth. (True.)* Normally, cells grow and divide to produce more cells as they are needed to keep the body healthy. Sometimes, this orderly process goes wrong. New cells form when the body does not need them, and old cells do not die when they should.³



- [Slide 16] *Question 9: Cancer can only occur in specific cells in the body. (False.)* The body is made up of many types of cells, and all cancer begins in cells. Cancer can develop in any cell in the body, which is why there are so many different types.
- [Slide 17] *Question 10: Cancer develops because of abnormal gene function. (True.)* Scientists have learned that cancer is caused by changes in genes that normally control the growth and death of cells. Certain lifestyle and environmental factors can change some normal genes into genes that allow the growth of cancer. Many gene changes that lead to cancer are the result of tobacco use, poor diet, exposure to ultraviolet (UV) radiation from the sun, or exposure to carcinogens (cancer-causing substances) in the workplace or in the environment. Some gene alterations are inherited (from one or both parents). However, having an inherited gene alteration does not always mean that that person will develop cancer; it only means that his or her chance of getting cancer is increased.²

EXPLORE

Create a Graphic Organizer

- [Slide 18] **Learning Activity: Think-Pair-Share Graphic Organizer.** Distribute **Cancer Concept Map Worksheet**, and ask students to think about what they know about cancer, allowing one to two minutes for them to think quietly to themselves. After a few minutes, ask students to partner with one or two other students to discuss their thoughts and create a concept map to organize their thinking. After four or five minutes, have each group share with the rest of the class what they know about cancer.
 - **TEACHER NOTE:** Students can create a KWL chart instead of a concept map. A KWL chart is another type of graphic organizer. To make one, have students create the following three columns on a piece of paper: K (what they know about cancer), W (what they want to learn about cancer), and L (what they have learned in the lessons related to cancer). Students should leave room in the L column for additional information.
- [Slide 19] **Homework Assignment: Answer Steve's Question.** Ask students to use their notes, graphic organizers, and everything they learned in class to write a response to Steve's question at the beginning of the lesson: What is cancer?



Lesson 1 Plan – Day 2: Cell Biology and Cancer

EXPLAIN

Review of Homework/Discussion

- [Slide 21] Remind students about Steve and Nikki. Nikki has a lot of questions; Steve doesn't have all the answers. Ask students what they would want to know if they were in Nikki and Steve's shoes. Ask students to take out their homework from the previous night.
 - [Slides 21–22] **Learning Activity: Discussion.** Ask a few students to share their homework assignment: Answering Steve's Question. Then turn to the next slide to share more about how Nikki is feeling. Students share their responses to the questions on the slide: What do you believe would be the most useful facts to learn about cancer? What are you most curious about?

Distinguish between images of healthy and cancerous cells

- [Slide 23] **Learning Activity: Healthy vs. Cancerous Cells Brainstorm.** Ask students to propose how normal and cancerous cells might differ. Write students' suggestions on the board. Tell students they are next going to compare images of healthy and cancerous cells, then divide the class into small groups of four to six students.
- [Slides 23–25] **Learning Activity: Small Groups.** Show the first slide of Normal and Cancer Cells—Structure. Allow the small groups enough time to study the images and list any differences they observe. Next, move on to the Answer slide, and have students discuss the differences between normal and cancerous cells, including:
 - Normal cells have a large cytoplasm; cancerous cells have a small cytoplasm.
 - Normal cells have a single nucleus; cancerous cells have multiple nuclei.
 - Normal cells have a nucleolus; cancerous cells have multiple and large nucleoli.
 - Normal cells have fine chromatin; cancerous cells have coarse chromatin.
- [Slide 26] **Learning Activity: Drag and Drop.** Using the interactive animation in the presentation, ask for two to three volunteers to drag the words "less" and "more" to the correct columns in relation to normal and cancerous cells.

Review cell structure and function (optional)

- [Slides 27–28] **TEACHER NOTE:** Delete these slides if students do not need this review.
 - Distribute **Cell Structure and Function** to the class, and give students a few minutes to fill it out. Have students discuss their responses before moving on to the next slide. Review the answers on the second slide, clarifying any misconceptions students have.

Review cell structure and quality control

- [Slide 29] **Review cell cycle and regulation.** Whenever possible, ask students to provide the review information. If necessary, share the following information with students:
 - Gap 0 (G0) phase is the resting stage when a cell leaves the cell cycle, either temporarily or permanently. Often, they will never reenter the cell cycle but instead will carry out their function in the organism until they die.
 - Gap 1 (G1) phase includes growth and prep of chromosomes for replication.
 - Synthesis (S) phase is where DNA replication occurs.
 - Gap 2 (G2) phase includes preparation for mitosis.



- Mitosis (M) phase is where nuclear division and cytoplasmic division occur. Mitosis is further divided into four phases (prophase, metaphase, anaphase, telophase).
- [Slide 30] Students watch a cell cycle video and animation.
 - Link to the following video:
<http://outreach.mcb.harvard.edu/animations/cellcycle.swf>
 - Link to the following animation:
http://www.cellsalive.com/cell_cycle.js.htm
- [Slides 31–32] Students review quality control of the cell cycle. Discuss this information with students to clear up any misconceptions and answer any questions they have.
- [Slide 33] **Learning Activity: Jigsaw Cell Cycle Activity.** Divide the class into five groups, and arrange the groups into a circle. Assign each group to be one of the following: Gap 0 (G0) phase, Gap 1 (G1) phase, synthesis (S) phase, Gap 2 (G2) phase, mitosis (M) phase. Walk from phase to phase, and ask each group to explain what its function is. Ask individual students to provide detailed information about their role. Assign specific roles (prophase, metaphase, anaphase, telophase) within mitosis phase and other areas where it makes sense. Switch members of groups around, and repeat the activity.
- [Slide 34] Students watch and discuss a cell cycle and quality control video.
 - Link to the following video:
<http://outreach.mcb.harvard.edu/animations/checkpoints.swf>
- [Slide 35] Ask students to summarize cell cycle quality control and cancer growth. If needed, explain to students that there are two types of mutations that can lead to uncontrolled cell division and cancer: tumor suppressor gene mutations and proto-oncogene mutations.
 - Optional: Distribute ***The Cell Cycle and Checkpoints*** for review or reinforcement of concepts.

ELABORATE

Analyze tumor suppressor gene mutation and proto-oncogene mutation

- [Slides 36–38] Understanding tumor suppressor gene mutation.
 - Provide an overview of tumor suppressor gene mutation. Remind students that everyone has tumor suppressor genes and proto-oncogenes. Normally, both work fine and cells do not grow out of control. However, mutations in either or both of these types of genes change their function, which may lead to cancer. Explain that usually the cells in tumor suppressor gene mutation and proto-oncogene mutation would go through apoptosis; however, cancer cells avoid apoptosis and keep growing and dividing, resulting in a tumor. This is a recessive mutation, so both alleles in the gene need to be mutated to cause cancer.
 - Students watch and discuss an animation of a tumor suppressor gene mutation.
 - Link to the following animation:
<https://www.youtube.com/watch?v=OGlOb76xPW4>
 - Real-world analogy: Use this analogy to help students build understanding of the role of tumor suppressor genes. When a car's brakes lose function, the car goes out of control; when tumor suppressor genes lose function, the cells grow out of control.
 - Students discuss the concept of losing both copies of the gene and how it is linked to the tumor suppressor gene function. Note that this is the same graphic students saw on Slide 17—the repetition of this graphic is meant to reinforce the concept.



- [Slides 39–41] Understanding proto-oncogene mutation.
 - Provide an overview of proto-oncogene mutation. If needed, remind students that everyone has tumor suppressor genes and proto-oncogenes. Normally, both work fine and cells do not grow out of control. However, mutations in either or both of these types of genes change their function, which may lead to cancer. Explain that usually the cells in tumor suppressor gene mutation and proto-oncogene mutation would go through apoptosis; however, cancer cells avoid apoptosis and keep growing and dividing, resulting in a tumor. This is a dominant gene mutation, so only one allele in the gene needs to be mutated to cause cancer.
 - Real-world analogy: Use this analogy to help students build understanding of proto-oncogenes. Proto-oncogenes are like the gas pedal of a car. If the gas pedal gets stuck in the “on” position, the car keeps moving whether the pedal is pushed or not. When a proto-oncogene mutates into an oncogene, a cell will keep dividing even when there are no messages to divide.
 - If needed, explain to students that most cancers have both the loss of brakes and the gas pedal on. Note that this is the same graphic students saw on Slide 17—the repetition of this graphic is meant to reinforcement the concept.

Demonstrate understanding of cell division scenarios (optional)

- [Slide 42] TEACHER NOTE: This is an optional activity. Delete slides 42-43 if you do not do the activity.
 - Students demonstrate their understanding of the relationship between the cell cycle and the development of cancer by acting out the cell cycles of healthy and cancerous cells. If needed, remind students that everyone has tumor suppressor genes and proto-oncogenes. Normally, both genes work fine and cells do not grow out of control. However, mutations in either or both of these types of genes change their function, which may lead to cancer. There are three different scenarios: normal cell division, tumor suppressor gene mutation, and proto-oncogene mutation.
- [Slide 43] **Learning Activity: Mitotic Division Role-Play.** Divide the class into three groups, and distribute one of each of the following scripts to the students in each group: **Normal Cell Division Script, Tumor Suppressor Gene Mutation Script, and Proto-oncogene Mutation Script.** Go through the learning activity below.
 - Assign each group a scenario to review, and ensure that each student selects or is assigned a role. Students can prepare for their role in several ways. Students can review the scenario script. More advanced students can write their own scripts. Give each group name tags, and ask them to write their roles on their name tags. The following players are needed for each scenario:
 - Voiceover/Teacher (1)
 - Narrator (1)
 - Enzyme 1 (1)
 - Enzyme 2 (1)
 - Cell Membrane (2)
 - Centrioles (2)
 - DNA Molecules/Chromatids (6) (Have students write “DNA” on one side of their name tag and “Chromatid” on the other side.)
 - Mutated Chromatids/Mutated DNA Molecules/Replicated DNA Molecules (6)
 - Nuclear Membrane/Nuclear Envelope (2)
 - Take the class to a large space, such as an all-purpose room or gym. Provide



- students with the appropriate prop or sign for their role. Place two large pieces of yarn in a circle to represent the cell membrane. A smaller circle of yarn in the center of the cell represents the nuclear envelope. Two students will be responsible for moving the yarn during the role-play.
- Allow students time to practice, and then present their cell cycle skit to the rest of the class.
 - Alternative suggestions for practicing the role-play:
 - Assign roles and have students research their parts for homework. Hold a “table reading” in which students read their parts aloud before conducting the role-play.
 - Students practice with materials, such as the yarn, on a desk or table prior to conducting the role-play.
 - Students model role-play concepts using clay or other materials.
 - Students presenting normal cell division go first, followed by the groups presenting tumor suppressor gene mutation and proto-oncogene mutation. While each group presents its skit, the teacher can show cell cycle images or run the animations. As a class, discuss each skit after it has been performed. Discuss what happened, and compare it with the other skits.
 - Tell students that usually the cells with DNA damage would normally go through apoptosis. However, cancer cells avoid apoptosis and keep growing and dividing, resulting in a tumor. Optional: Distribute Mitosis for review or reinforcement of concepts. Distribute **Mitosis** for review or reinforcement of concepts.

EVALUATE

- **Homework Assignment:** Students demonstrate their understanding of the relationship between the cell cycle and cancer by creating a model. The model can be an illustration, a description, a video explanation, or a physical representation.
 - Alternative homework assignment option 1: Students write an imaginary conversation among the cell, proto-oncogene, and tumor suppressor gene.
 - Alternative homework assignment option 2: Students describe how the role-play could be used to demonstrate meiosis.
- **Writing Activity:** Recall Nikki’s question at the beginning of Day 2. Ask students to write a response to Nikki’s questions about how the cell cycle relates to cancer. If an interactive white board is available, write students’ responses to this question in the box provided. You can then save the notes the students make by saving via one of the following methods:
 - Press the Print Screen button on the keyboard, and paste the screen image into a Word document.
 - Use the screen capture feature of the Notebook software that comes with the interactive white board to add the screen to a set of class notes to be shared with the class later.
 - Use PowerPoint’s annotate pen, and save the notes to the slide.

- **Lesson 1 Quiz**

- ¹ Mayo Clinic. “Cancer Causes: Popular Myths about the Causes of Cancer.” Online: <http://www.mayoclinic.org/diseases-conditions/cancer/in-depth/cancer-causes/art-20044714>
- ² American Cancer Society. Top 10 Cancer Myths Quiz.
- ³ National Cancer Institute. “What Is Cancer?” Online: <http://www.cancer.gov/cancertopics/what-is-cancer>



Additional Resources

- The National Program of Cancer Registries, Centers for Disease Control and Prevention
<http://www.cdc.gov/cancer/npcr/>
- Cancer.net
<http://www.cancer.net/cancer-types>
- CELLS *alive!*
<http://www.cellsalive.com/>
- Dolan DNA Learning Center. (2002). Inside Cancer
<http://www.insidecancer.org/>
- Emory University, CancerQuest
<http://www.cancerquest.org>
- CancerQuest Cancer Biology Documentary
<http://www.cancerquest.org/cancer-biology-animations.html>
- National Institute of General Medical Sciences: *Inside the Cell*
<http://publications.nigms.nih.gov/insidethecell/>
- National Institutes of Health: Cell Biology and Cancer Curriculum Supplement
<https://science.education.nih.gov/customers/HSCancer.html>
- Nobelprize.org, Control of the Cell Cycle
http://nobelprize.org/educational_games/medicine/2001/
- The University of Texas MD Anderson Cancer Center
<http://mdanderson.org>



Next Generation Science Standards

Performance Indicators

HS-LS1 From Molecules to Organisms: Structures and Processes

- HS-LS1-4. Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms.

Science and Engineering Practices

Developing and Using Models

- Use a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-LS1-4), (HS-LS1-5),(HS-LS1-7)

Constructing Explanations and Designing Solutions

- Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (HS-LS1-6)

Disciplinary Core Ideas

LS1.A: Structure and Function

- Systems of specialized cells within organisms help them perform the essential functions of life. (HS-LS1-1)
- All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins, which carry out most of the work of cells. (HS-LS1-1) (Note: This Disciplinary Core Idea is also addressed by HS-LS3-1.)

LS1.B: Growth and Development of Organisms

- In multicellular organisms individual cells grow and then divide via a process called mitosis, thereby allowing the organism to grow. The organism begins as a single cell (fertilized egg) that divides successively to produce many cells, with each parent cell passing identical genetic material (two variants of each chromosome pair) to both daughter cells. Cellular division and differentiation produce and maintain a complex organism, composed of systems of tissues and organs that work together to meet the needs of the whole organism. (HS-LS1-4)

Crosscutting Concepts

Systems and System Models

- Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales. (HS-LS1-2), (HS-LS1-4)



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What Do YOU Believe?

Name: _____

Date: _____

TRUE

FALSE

- | | | |
|-------|-------|---|
| _____ | _____ | The risk of dying from cancer in the United States is increasing. |
| _____ | _____ | Cancer can be spread from person to person. |
| _____ | _____ | What someone does as a young adult has little effect on their chance of getting cancer later in life. |
| _____ | _____ | There is currently a cure for cancer but the medical industry won't tell the public about it because they make too much money treating cancer patients. |
| _____ | _____ | Treating cancer with surgery can cause it to spread throughout the body. |
| _____ | _____ | Cancer can be effectively treated. |
| _____ | _____ | Cancer is a group of over 100 diseases. |
| _____ | _____ | Cancer cells can be distinguished from normal cells because of their abnormal growth. |
| _____ | _____ | Cancer can only occur in specific cells in the body. |
| _____ | _____ | Cancer develops because of abnormal gene function. |

What Do YOU Believe?

TRUE	FALSE	Answers
_____	<u> X </u>	The risk of dying from cancer in the United States is increasing.
_____	<u> X </u>	Cancer can be spread from person to person.
_____	<u> X </u>	What someone does as a young adult has little effect on their chance of getting cancer later in life.
_____	<u> X </u>	There is currently a cure for cancer but the medical industry won't tell the public about it because they make too much money treating cancer patients.
_____	<u> X </u>	Treating cancer with surgery can cause it to spread throughout the body.
<u> X </u>	_____	Cancer can be effectively treated.
<u> X </u>	_____	Cancer is a group of over 100 diseases.
<u> X </u>	_____	Cancer cells can be distinguished from normal cells because of their abnormal growth.
_____	<u> X </u>	Cancer can only occur in specific cells in the body.
<u> X </u>	_____	Cancer develops because of abnormal gene function.

Breast Cancer Trends

Age-Adjusted U.S. Death Rates by Year and Sex
(Rates are per 100,000 and are age-adjusted to the 2000 US population.)

Year of Death	Total	Males	Females
1975	17.8	0.4	31.5
1976	18.1	0.4	31.8
1977	18.5	0.4	32.5
1978	18.0	0.4	31.7
1979	17.7	0.3	31.2
1980	18.0	0.3	31.7
1981	18.2	0.3	31.9
1982	18.4	0.3	32.2
1983	18.3	0.3	32.1
1984	18.8	0.3	32.9
1985	18.8	0.3	33.0
1986	18.8	0.3	32.9
1987	18.7	0.3	32.7
1988	19.0	0.3	33.2
1989	19.0	0.3	33.2
1990	18.9	0.3	33.1
1991	18.7	0.3	32.7
1992	18.7	0.3	31.6
1993	18.0	0.4	31.4
1994	17.7	0.4	30.9
1995	17.4	0.4	30.6
1996	16.8	0.3	29.5
1997	16.1	0.3	28.2
1998	15.7	0.3	27.5
1999	15.2	0.3	26.6
2000	15.2	0.4	26.6
2001	17.7	0.3	26.0
2002	14.5	0.3	25.6
2003	14.2	0.3	25.2
2004	13.7	0.3	24.4
2005	13.5	0.3	24.0
2006	13.2	0.3	23.5
2008	12.7	0.3	22.6
2009	12.4	0.3	22.2
2010	12.3	0.3	21.9
2011	12.0	0.3	21.5
2012	11.8	0.3	21.3
1975-2012	16.0	0.3	28.2

Cancer Concept Map Worksheet

Construct a concept map illustrating what you know about cancer. You can use circles, ovals, squares, or other shapes for main concepts or ideas.

Name:

Date:



Cancer Warriors

Name: _____

Date: _____

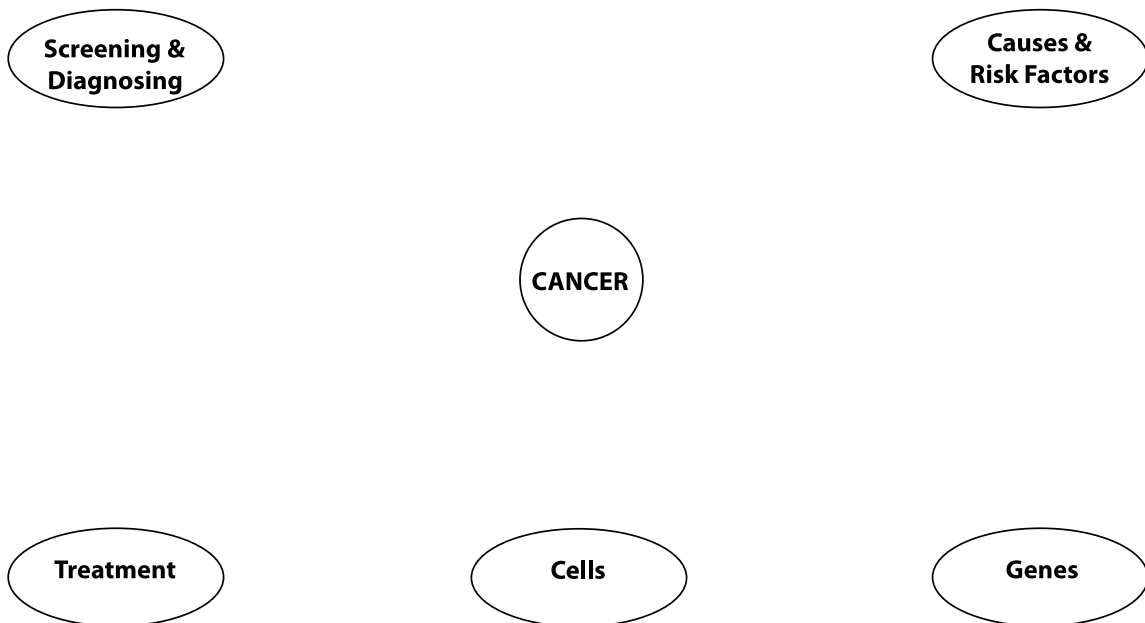
Title	Role
Oncology Physician	
Cancer Researcher	
Nurse	
Pharmacist	
Social Worker / Advocate	

Cancer Concept Map Sample

Construct a concept map illustrating what you know about cancer. You can use circles, ovals, squares, or other shapes for main concepts or ideas.

Name:

Date:



Cell Structure and Function

Name: _____

Date: _____

Complete the following table:

Structure	Function
Nucleus	
Mitochondria	
Ribosomes	
Golgi Apparatus	
Centrioles	
Chromosomes	
Endoplasmic Reticulum	

Cell Structure and Function

Answers

Complete the following table:

Structure	Function
Nucleus	<i>Control center of the cell. Contains all genetic information.</i>
Mitochondria	<i>Powerhouse of the cell. Converts sugar to usable energy by cellular respiration.</i>
Ribosomes	<i>Site of protein synthesis.</i>
Golgi Apparatus	<i>Packaging center of the cell. Packages and secretes proteins.</i>
Centrioles	<i>Organizes microtubules (spindle fibers) for mitosis.</i>
Chromosomes	<i>Made of condensed DNA and proteins. Codes for genetic traits.</i>
Endoplasmic Reticulum	<i>Transports intracellular materials.</i>

The Cell Cycle and Checkpoints

Page 1 of 1

Name: _____

Date: _____

1. Complete the following table:

Phase	What Happens?
Gap 0 (G0)	
Gap 1 (G1)	
Synthesis (S)	
Gap 2 (G2)	
Mitosis (M)	

2. What part of the cell cycle is the fastest?
3. What is interphase?
4. Describe in your own words the purpose of the cell cycle checkpoints.

The Cell Cycle and Checkpoints

Answers

Page 1 of 1

1. Complete the following table:

Phase	What Happens?
Gap 0 (G0)	<i>Resting Stage</i>
Gap 1 (G1)	<i>Growth</i>
Synthesis (S)	<i>DNA Replication</i>
Gap 2 (G2)	<i>Growth</i>
Mitosis (M)	<i>Nuclear Division and Cytokinesis</i>

2. What part of the cell cycle is the fastest?

Mitosis

3. What is interphase?

Interphase is the name given to the G1, S and G2 phases.

4. Describe in your own words the purpose of the cell cycle checkpoints.

Student answers will vary. However, students should note the checkpoints verify the steps in the cell cycle. If the steps have been correctly completed, the cell gets the signal to continue dividing. However, if damage is found, the checkpoint stops the cell cycle until repairs are completed. If repairs can not be made, the cell is targeted for apoptosis.

Mitosis

Page 1 of 1

Name: _____

Date: _____

1. Complete the following table:

Stage	What Happens?
Telophase	
Metaphase	
Prophase	
Anaphase	

2. List the phases of mitosis in the correct order.

Mitosis

Answers

Page 1 of 1

1. Complete the following table:

Stage	What Happens?
Telophase	<i>Cell divides/Cytokinesis</i>
Metaphase	<i>Chromosomes line up along the center of the cell</i>
Prophase	<i>Centrioles move to opposite poles</i> <i>Chromosomes become visible</i>
Anaphase	<i>Sister chromatids separate and move towards opposite poles</i>

2. List the phases of mitosis in the correct order.

Prophase

Metaphase

Anaphase

Telophase

Normal Cell Division Script

Page 1 of 2

The **CELL MEMBRANE** sets up the cell by placing two long pieces of yarn in a circle on the floor. The **NUCLEAR ENVELOPE** is then formed by placing two smaller pieces of yarn in the shape of a circle inside of the cell membrane.

ACT I. Interphase

Scene I: G0 Phase

NARRATOR: The Cell is in the G0 Phase, the resting state.

[VO] VOICE OVER: CENTRIOLE #1 enters the cell, standing near the cell membrane. DNA MOLECULES #1, # 2, and #3 enter the cell and stand inside the Nuclear Envelope. ENZYME 1 and 2 stand outside of the cell. The enzymes of the cell starts the events of the cell cycle.

Enzyme 2: Go!

Scene II: G1 Phase

Narrator: We are now entering the G1 Phase. During G1 Phase of Growth 1/Gap 1 phase, the cell prepares for S phase by increasing in size.

[VO]: Cell Membrane increases the size of the cell membrane by a small amount.

Narrator: G1 Checkpoint!

Enzyme 1: Stop! There is a problem.

Enzyme 2: The Cell is too small. It needs to be bigger.

Narrator: Cell Membrane then stretches the yarn out to make the cell bigger.

Enzyme 1: The Cell is the right size. The G1 Checkpoint is all clear!

Enzyme 2: Go!

Narrator: G1 phase is complete.

Scene III: S Phase.

Narrator: We are now entering the S Phase. In S phase (synthesis phase), DNA is replicated.

[VO]: CENTRIOLE #2 enters the cell and stands next to Centriole #1. REPLICATED DNA MOLECULES #1, 2 and 3 enter the cell. Each replicated DNA stands next to its original DNA Molecule and links arms forming their centromere.

Narrator: S phase is complete. We are now entering the G2 Phase

Scene IV: The Cell is in the G2 Phase.

Narrator: G2 phase is a period of rapid cell growth and protein synthesis. Many organelles and molecules needed for cell division are being produced.

Enzyme 2: Go!

Narrator: G2 phase is now complete. We are ready to move to the next phase!

Normal Cell Division Script

Page 2 of 2

ACT II. Mitosis

Scene I: Prophase.

Narrator: The Cell is now in Prophase.

[VO]: Cell Membrane *removes the* Nuclear Envelope. The DNA Molecules formed chromosomes are now known as sister chromatids which are linked together at the centromere (*Chromatids are standing making a triangle-shape*). DNA Molecules *flip nametags to be* CHROMATIDS. Centriole #1 & #2 *each hold one unsharpened pencil with three pieces of yarn attached [representing spindle fibers], and start to move toward opposite ends of the cell.*

Narrator: Prophase is complete.

[VO]: Centrioles extend out their hands to reach the Chromatids. Each of the Chromatids *grab the spindle fiber from the opposite Centriole.*

Scene II: Metaphase.

Narrator: The Cell is in Metaphase.

[VO]: Chromatids *form three rows in the center of the cell. Facing the enzymes, they stand with their shoulder in the direction of the centriole they are attached to. Centrioles extend out their hands to reach the Chromatids. Each of the Chromatids continue holding the spindle fiber from the opposite Centriole. Chromatid #2 takes the fiber, but then drops it.*

Narrator: Spindle Checkpoint!

Enzyme 1: Stop! There is a problem. The Chromosomes are not connected correctly! This needs to be repaired.

[VO]: Chromatid # 2 *picks up the dropped spindle fiber [yarn].*

Narrator: The Spindle Checkpoint is all clear!

Enzyme 2: Go!

Narrator: Metaphase is complete. We are now entering Anaphase.

Scene III: Anaphase.

[VO]: Each Centriole *steps back, pulling their attached Chromatids along, chromatids unlock arms and move towards opposite ends of the cell. The Cell Membrane is pulled back at the poles and starts to pinch in the middle so the cell resembles a peanut.*

Narrator: Anaphase is complete. We are now entering Telophase.

Scene IV: Telophase.

[VO]: Chromatids *release spindle fibers, and the Centrioles condense the spindle fibers and lower arms. The Nuclear Envelope is restored in each daughter cell.*

Narrator: Telophase is complete. We are now entering Cytokinesis.

[VO]: The Cell Membrane *separates to form the membrane of the two daughter cells.*

Enzyme 1: Stop

Narrator: The Cell has successfully divided into two identical Cells, which will now rest in the G0 phase until they receive the signal to divide again.

The End.

Tumor Suppressor Mutation Script

Page 1 of 2

The **CELL MEMBRANE** sets up the cell by placing two long pieces of yarn in a circle on the floor. The **NUCLEAR ENVELOPE** is then formed by placing two smaller pieces of yarn in the shape of a circle inside of the cell membrane.

ACT I. Interphase

Scene I: G0 Phase

NARRATOR: The Cell is in the G0 Phase, the resting state.

[VO] VOICE OVER: CENTRIOLE #1 enters the cell, standing near the cell membrane. MUTATED DNA MOLECULE #1, DNA MOLECULE #2, and DNA MOLECULE #3 enter the cell and stand inside the Nuclear Envelope. ENZYME 1 and 2 stand outside of the cell. The enzymes of the cell start the events of the cell cycle.

Enzyme 2: Go!

Scene II: G1 Phase

Narrator: We are now entering the G1 Phase. During G1 Phase of Growth 1/Gap 1 phase, the cell prepares for S phase by increasing in size.

[VO]: Cell Membrane increases the size of the cell membrane by a small amount.

Narrator: G1 Checkpoint!

Enzyme 1: Stop! There is a problem.

Enzyme 2: The Cell is too small. It needs to be bigger.

Narrator: Cell Membrane then stretches the yarn out to make the cell bigger.

Enzyme 1: The Cell is the right size. The G1 Checkpoint is all clear!

Enzyme 2: Go!

Narrator: G1 phase is complete.

Scene III: S Phase.

Narrator: We are now entering the S Phase. In S phase (synthesis phase), DNA is replicated.

[VO]: CENTRIOLE #2 enters the cell and stands next to Centriole #1. REPLICATED DNA MOLECULES #2 and #3 enter the cell. Each replicated DNA stands next to its original DNA Molecule and links arms forming their centromere. The four REPLICATED MUTATED DNA MOLECULES 1 enters the Cell and stands next to original mutated DNA 1 molecule, and link arms forming a long chain of mutated DNA molecules

Narrator: S phase is complete. We are now entering the G2 Phase

Scene IV: The Cell is in the G2 Phase.

Narrator: G2 phase is a period of rapid cell growth and protein synthesis. Many organelles and molecules needed for cell division are being produced.

Enzyme 2: Go!

Narrator: G2 phase is now complete. We are ready to move to the next phase!

Tumor Suppressor Gene Mutation Script

Page 2 of 2

ACT II. Mitosis

Scene I: Prophase.

Narrator: The Cell is now in Prophase.

[VO]: Cell Membrane *removes the* Nuclear Envelope. The DNA Molecules formed chromosomes are now known as sister chromatids which are linked together at the centromere (*Chromatids are standing making a triangle-shape*). DNA Molecules *flip nametags to be* CHROMATIDS. Centriole #1 & #2 *each hold one unsharpened pencil with three pieces of yarn attached* [representing spindle fibers], *and start to move toward opposite ends of the cell.*

Narrator: Prophase is complete.

[VO]: Centrioles extend out their hands to reach the Chromatids. Each of the Chromatids *grab the spindle fiber from the opposite Centriole.*

Scene II: Metaphase.

Narrator: The Cell is in Metaphase.

[VO]: Chromatids *form three rows in the center of the cell. Facing the enzymes, they stand with their shoulder in the direction of the centriole they are attached to. Centrioles extend out their hands to reach the Chromatids. Each of the Chromatids continue holding the spindle fiber from the opposite Centriole. Chromatid #2 takes the fiber, but then drops it.*

Narrator: Spindle Checkpoint!

Enzyme 1: Stop! There is a problem. The Chromosomes are not connected correctly! This needs to be repaired.

[VO]: Chromatid # 2 *picks up the dropped spindle fiber [yarn].*

Narrator: The Spindle Checkpoint is all clear!

Enzyme 2: Go! Keep moving through the Cycle!

Narrator: I guess everything is okay. The Spindle Checkpoint is all clear!

Enzyme 2: Go!

Narrator: Metaphase is complete. We are now entering Anaphase.

Scene III: Anaphase.

[VO]: Each Centriole *steps back, pulling their attached Chromatids along, chromatids unlock arms and move towards opposite ends of the cell. The Cell Membrane is pulled back at the poles and starts to pinch in the middle so the cell resembles a peanut.*

Narrator: Anaphase is complete. We are now entering Telophase.

Scene IV: Telophase.

[VO]: Chromatids *release spindle fibers, and the Centrioles condense the spindle fibers and lower arms. The Nuclear Envelope is restored in each daughter cell.*

Narrator: Telophase is complete. We are now entering Cytokinesis.

[VO]: The Cell Membrane *separates to form the membrane of the two daughter cells.*

Enzyme 1: Everything looks good.

Narrator: The Cell has successfully divided into two non-identical Cells, due to a Tumor Suppressor Gene which does not function properly. The Cell will now rest in the G0 phase until they receive the signal to divide again.

The End.

Proto-oncogene Mutation Script

Page 1 of 2

The **CELL MEMBRANE** sets up the cell by placing two long pieces of yarn in a circle on the floor. The **NUCLEAR ENVELOPE** is then formed by placing two smaller pieces of yarn in the shape of a circle inside of the cell membrane.

ACT I. Interphase

Scene I: G0 Phase

NARRATOR: The Cell is in the G0 Phase, the resting state.

[VO] VOICE OVER: CENTRIOLE #1 enters the cell, standing near the cell membrane. MUTATED DNA MOLECULE #1, DNA MOLECULE # 2, and DNA MOLECULE #3 enter the cell and stand inside the Nuclear Envelope. ENZYME 1 and 2 stand outside of the cell. The enzymes of the cell starts the events of the cell cycle.

Enzyme 2: Go!

Scene II: G1 Phase

Narrator: We are now entering the G1 Phase. During G1 Phase of Growth 1/Gap 1 phase, the cell prepares for S phase by increasing in size.

[VO]: Cell Membrane increases the size of the cell membrane by a small amount.

Narrator: G1 Checkpoint!

Enzyme 1: Stop! There is a problem.

Enzyme 2: The Cell is too small. It needs to be bigger.

Narrator: Cell Membrane then stretches the yarn out to make the cell bigger.

Enzyme 1: The Cell is the right size. The G1 Checkpoint is all clear!

Enzyme 2: Go!

Narrator: G1 phase is complete.

Scene III: S Phase.

Narrator: We are now entering the S Phase. In S phase (synthesis phase), DNA is replicated.

[VO]: CENTRIOLE #2 enters the cell and stands next to Centriole #1. REPLICATED DNA MOLECULES #2 and #3 enter the cell. Each replicated DNA stands next to its original DNA Molecule and links arms forming their centromere. The four REPLICATED MUTATED DNA MOLECULES 1 enters the Cell and stands next to original mutated DNA 1 molecule, and link arms forming a long chain of mutated DNA molecules

Narrator: S phase is complete. We are now entering the G2 Phase

Scene IV: The Cell is in the G2 Phase.

Narrator: G2 phase is a period of rapid cell growth and protein synthesis. Many organelles and molecules needed for cell division are being produced.

Enzyme 2: Go!

Narrator: G2 phase is now complete. We are ready to move to the next phase!

Proto-oncogene Mutation Script

Page 2 of 2

ACT II. Mitosis

Scene I: Prophase.

Narrator: The Cell is now in Prophase.

[VO]: Cell Membrane *removes the Nuclear Envelope*. The DNA Molecules formed chromosomes are now known as sister chromatids which are linked together at the centromere (*Chromatids are standing making a triangle-shape*). DNA Molecules *flip nametags to be CHROMATIDS*. Centriole #1 & #2 *each hold one unsharpened pencil with three pieces of yarn attached [representing spindle fibers], and start to move toward opposite ends of the cell.*

Narrator: Prophase is complete.

[VO]: Centrioles extend out their hands to reach the Chromatids. Each of the Chromatids *grab the spindle fiber from the opposite Centriole.*

Scene II: Metaphase.

Narrator: The Cell is in Metaphase.

[VO]: Chromatids *form three rows in the center of the cell. Facing the enzymes, they stand with their shoulder in the direction of the centriole they are attached to. Centrioles extend out their hands to reach the Chromatids. Each of the Chromatids continue holding the spindle fiber from the opposite Centriole. Chromatid #2 takes the fiber, but then drops it.*

Narrator: Spindle Checkpoint!

Enzyme 1: Stop! There is a problem. The Chromosomes are not connected correctly! This needs to be repaired.

[VO]: Chromatid # 2 *picks up the dropped spindle fiber [yarn].*

Narrator: The Spindle Checkpoint is all clear!

Enzyme 2: Go! Keep moving through the Cycle!

Narrator: I guess everything is okay. The Spindle Checkpoint is all clear!

Enzyme 2: Go!

Narrator: Metaphase is complete. We are now entering Anaphase.

Scene III: Anaphase.

[VO]: Each Centriole *steps back, pulling their attached Chromatids along, chromatids unlock arms and move towards opposite ends of the cell. The Cell Membrane is pulled back at the poles and starts to pinch in the middle so the cell resembles a peanut.*

Narrator: Anaphase is complete. We are now entering Telophase.

Scene IV: Telophase.

[VO]: Chromatids *release spindle fibers, and the Centrioles condense the spindle fibers and lower arms. The Nuclear Envelope is restored in each daughter cell.*

Narrator: Telophase is complete. We are now entering Cytokinesis.

[VO]: The Cell Membrane *separates to form the membrane of the two daughter cells.*

Enzyme 1: Everything looks good.

Narrator: The Cell has successfully divided into two non-identical Cells, due to a mutated Oncogene which does not function properly. The Cell will now rest in the G0 phase until they receive the signal to divide again.

The End.

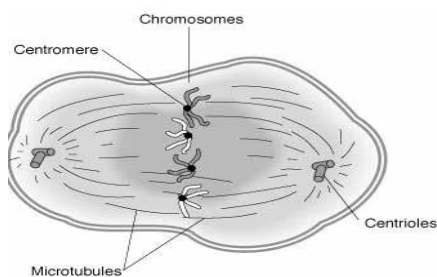
Lesson 1 Quiz

1. In what types of cells does mitosis occur? Give an example.

2. Match the phase of the cell cycle on the left with the activity it corresponds to on the right.

- | | |
|---|---------------|
| ___ Chromatids of each chromosome separate and move to opposite poles | a. Prophase |
| ___ Chromosomes condense and become visible | b. Telophase |
| ___ Cell is not dividing | c. Anaphase |
| ___ Nuclear envelope forms around daughter nuclei | d. Interphase |
| ___ Chromosomes align at the middle of the cell | e. Metaphase |

3. Which stage of mitosis is depicted in the figure?



- a. Interphase
- b. Prophase
- c. Anaphase
- d. Metaphase
- e. Telophase

Source: www.genome.gov

4. Compare and contrast tumor suppressor gene and proto-oncogene mutations. You may use an analogy or draw a diagram. Be sure to explain the function of both the tumor suppressor gene and proto-oncogene and describe the difference between a proto-oncogene and an oncogene. Describe what happens when a mutation occurs.

5. Describe the differences in structure between a cancerous cell and a normal cell. You may include a drawing. Be sure to discuss the cytoplasm, nucleus, and number of cells.

6. Explain cell cycle checkpoints and how they relate to cancer.

Lesson 1 Quiz Answers

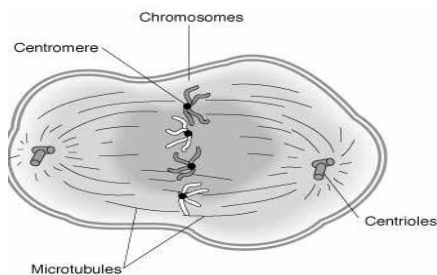
1. In what types of cells does mitosis occur? Give an example.

Mitosis occurs in all somatic cells. It is a division of cells that is occurring constantly, such as in skin, hair, etc. For example, the body is constantly shedding skin cells and replacing these cells with new ones by mitosis.

2. Match the phase of the cell cycle on the left with the activity it corresponds to on the right.

- c. Anaphase Chromatids of each chromosome separate and move to opposite poles
- a. Prophase Chromosomes condense and become visible
- d. Interphase Cell is not dividing
- b. Telophase Nuclear envelope forms around daughter nuclei
- e. Metaphase Chromosomes align at the middle of the cell

3. Which stage of mitosis is depicted in the figure?



d. Metaphase

Source: www.genome.gov

4. Compare and contrast tumor suppressor gene and proto-oncogene mutations. You may use an analogy or draw a diagram. Be sure to explain the function of both the tumor suppressor gene and proto-oncogene and describe the difference between a proto-oncogene and an oncogene. Describe what happens when a mutation occurs.

Both tumor suppressor genes and proto-oncogenes regulate cell growth. Tumor suppressor genes are like the brakes of a car. When the brakes lose function, the car moves out of control. Similarly, when tumor suppressor genes mutate and lose function, the cell grows out of control. Proto-oncogenes are like the gas pedal. When everything is working right, the car only moves when the gas pedal is pushed. However, if the gas pedal gets stuck in the "on" position, the car will keep moving whether it is being pushed or not. Similarly, when a proto-oncogene mutates into an oncogene, the cell will keep dividing even when there are no messages to divide. Mutations in tumor suppressor genes and proto-oncogenes have the same overall effect on the cell cycle.

5. Describe the differences in structure between a cancerous cell and a normal cell. You may include a drawing. Be sure to discuss the cytoplasm, nucleus, and number of cells.

A normal cell has a large cytoplasm, a single nucleus. Since cancerous cells are dividing more, they have smaller amounts of cytoplasm and multiple nuclei. There are also more cancerous cells than non cancerous cells.

6. Explain cell cycle checkpoints and how they relate to cancer.

The cell cycle is an organized set of events. There are control points set up in the cycle to ensure that all steps are completed exactly as they should; these are called cell cycle checkpoints. When DNA is damaged, the cell cycle checkpoints stop the process and a cell can either repair or destroy itself. There are at least 3 cell cycle checkpoints: G1 checkpoint, G2 checkpoint, and the Metaphase checkpoint (also known as Spindle checkpoint). The first checkpoint is located at the end of the cell cycle's G1 phase, just before a cell enters S phase, making the key decision of whether the cell should divide, delay division, or enter a resting stage. Many cells stop at this stage and enter a resting state called G0. The second checkpoint is located at the end of G2 phase, and it is responsible for starting M phase (mitosis). The third checkpoint occurs at the point in metaphase where all the chromosomes should have aligned at the mitotic plate. This checkpoint is responsible for starting anaphase.