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USING CANCER TO MAKE CELLULAR REPRODUCTION RIGOROUS AND RELEVANT

By

Cynthia F Duncan

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ABSTRACT

USING CANCER TO MAKE CELLULAR REPRODUCTION RIGOROUS AND RELEVANT

By

Cynthia F. Duncan

The 1983 report *Nation at Risk* highlighted the fact that test scores of American students were far below that of competing nations and educational standards were being lowered. This trend has continued and studies have also shown that students are not entering college ready for success. This trend can be reversed. Students can better understand and retain biology content expectations if they are taught in a way that is both rigorous and relevant. In the past, students have learned the details of cellular reproduction with little knowledge of why it is important to their everyday lives. This material is learned only for the test. Knowing the details of cellular reproduction is crucial for understanding cancer. Cancer is a topic that will likely affect all of my students at some point in their lives. Students used hands on activities, including simulations, labs, and models to learn about cellular reproduction with cancer as a theme throughout. Students were challenged to learn how to use the rigorous biology content expectations to think about cancer, including stem cell research. Students that will some day be college students, voting citizens, and parents, will become better learners. Students were assessed before and after the completion of the unit to determine if learning occurs. Students did learn the material and became more critical thinkers. Statistical analysis was completed to insure confidence in the results.

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Introduction

Statement of Problem and Rationale for the Study

In 1983, the *Nation at Risk* report was released by the National Commission on Excellence in Education. This report highlighted the fact that students in the United States are performing well below many students in Europe and Asia and the standards in American schools are lower than those in other countries. In 2001, with the No Child Left Behind mandate, the need for educational reform was again been spotlighted. **Rigor** and **relevance** are familiar buzz words that have arisen from the push to reform education.

In evaluating my ninth grade biology curriculum, I find that it is rigorous in the sense that the content is difficult and is found in both national standards and state content expectations. Students are exposed to material that is challenging. However, I have come to realize, after reading the research, that rigor is more than content. It includes teaching students to think and synthesize the material at a higher level as well as having relevance to real world experience, clear expectations, variety in classroom activities, expectations that all students will learn, and assessment that uses higher level questions.

In the past, about three days were spent on the process of cell reproduction with students staring dazed and confused. In addition, it is one of those topics about which students will often say, "Why do we have to know this? How will this help me in the future?" Students were expected to know the names and details of all the phases of mitosis. The diligent students memorized the steps of mitosis and regurgitated them back to me on the test. Those that had difficulty memorizing or were unmotivated to memorize often found this test to be difficult. I do not believe many of the students in

any of these groups really had a clear understanding and appreciation of the process of cell division at the end of instruction. They have seen the details on the surface but lack depth and understanding of the importance of the process to life itself.

This unit in cellular reproduction was designed to challenge students to take the information about the cell cycle and apply that to a real world issue. Cancer was the guiding theme of relevance in this unit. Students were challenged to understand cell reproduction and how it relates to cancer. Bill Daggett (Daggett and Nussbaum, 2008) has said that rigorous curriculum without relevance leads to the scenario I have described, "Teach it, test it, and lose it." I will support students that struggle with the content by modeling and providing a variety of lesson formats. I will expect all students to be successful and I will use more formative assessment embedded into activities to gauge success each day. I want students to become life long learners who will become scientifically literate citizens who vote in elections. I also want to mold future parents who will make wise decisions for their families.

Review of Relevant Pedagogical Literature

Arne Duncan (2009), Secretary of Education, in a recent speech to the Governors spoke of four areas of reform that each state should be working on. One of those concerns higher standards for success in college and the workplace. Duncan encourages states to have standards that prepare students for the day after they graduate. He encourages the governors to make the standards rigorous and tightly focused on the most important things. He wants teachers to be able to teach depth rather that breadth. According to Duncan, no matter where he goes in the United States, the kids are saying, "Challenge me, push me, make me work - and I will do it." (Duncan, 2009) Studies have shown that American students are not succeeding in college and the workplace. The Conference Board released a study in 2006 based on surveys from 400 employers. Employers believe that high school students lack the basic skills in reading and writing needed for entry level work. High school students also lack professionalism and a work ethic and do not demonstrate critical thinking skills. Chrys Dougherty, et al (2006) and colleagues at the National Center for Educational Accountability have determined that the number of classes you take does not always make you prepared for college or the workplace. Rather, it is the quality of the coursework that you receive that will determine success in the future. According to ACT research (2007), only 26 percent of students taking the science core (three years) in high school are prepared to get a C or above in an introductory biology class at the university level. This number only increases to 38 percent when a student takes an extra science course. ACT research also discovered that High School teachers and university faculty do not seem to agree on what is necessary for university success. High school teachers seem to believe that many topics need to be

covered as important, and many state standards drive this notion. However, university faculty would rather high school teachers be more rigorous in the treatment of fundamental content knowledge and skills. These skills include being able to critically think, problem solve, and communicate. Why are students not ready for college courses? Could it be that students are lacking in the skills that are not taught in the core curriculum. The core curriculum usually includes a set of standards or facts in biology, chemistry, and physics that students should master while in high school. Students have mastered the content by memorizing the information, but have not learned how to use critical thinking skills. A more rigorous core curriculum is needed in classes in America if we want to catch up to our global partners and competitors. More rigor in the classroom is necessary for students to be academically ready for the expectations of colleges and universities as well as employers.

Rigor is a word that continues to be used in educational reform. What is rigor? What does it include? It is clear that there are different definitions of rigor. For some it means the quality of thinking (Bogess 2007), for others it is higher expectations (Wasley, et al 1997), still others believe students need to be in a real world setting to get true rigor (Washor and Mojkoski 2006), and others would say there must be an activity or experience to be considered rigorous (Beane 2001). The definition that Barbara Blackburn used in her book **Rigor is Not a Four-Letter Word** (2008) seems to encompass many of these thoughts. Rigor is quality, high level education that can be demonstrated by every student. Blackburn believes that high level learning includes high expectations, challenging curriculum, high level questioning, and instruction that is differentiated and varied for multiple intelligences. Bill Daggett (Daggett and Nussbaum,

2008) has also come up with a Rigor/Relevance Framework grid that is helpful in describing the rigor that is desired. In quadrant A, students memorize the knowledge and rigor is low. Students who reach quadrant C can assimilate the knowledge and use it to routinely solve problems. Quadrants B and D refer to relevance and will be discussed in a later section. In this project, a student in Quadrant A would memorize all of the phases of mitosis and be able to identify the pictures on the test. Students who can move to Quadrant C will be able to use the information about the phases of mitosis to figure out what happens to the cell when one of the phases does not work. ACT results show that many students are stuck in Quadrant A and need to be pushed to Quadrant C by raising the rigor in the classroom. This project will include all of these features. Students will be held to high expectations with curriculum that is challenging. Labs will be used to give students opportunities to answer high level questions and solve problems with the knowledge they have gained. There will be opportunities for auditory, visual, and tactile learners to be successful. Lessons will include various teaching techniques keeping in mind all the different learning styles.

Relevance is another buzz word in educational reform. Relevance is often connected to motivation in the classroom. Barbara Blackburn (2005) in her book, **Classroom Motivation from A to** Z, states that, "Engagement equals success." She includes making it fun, having routines, student involvement, making it related to life experiences, and working together in her recipe for success. Erik Robelen reported in **Education Week** (2010) that there is a move to improve science lab experiences in the United States. Robelen refers to a report recently completed by The National Research Council that states that lab experiences have the potential to help students learn science

material and increase reasoning skills. The National Research Council also reports that many students do not currently get an adequate lab experience in their science classrooms. Without adequate lab experience, students fail to learn to reflect and discuss the application of what they have learned to the real world. The use of labs in science gives opportunities to bring relevance to content being learned. As students manipulate data, they begin to think critically and apply the information to different examples and issues.

Students make a choice everyday to learn. An engaging classroom with engaging activities is an important part in motivating a student to be active in their learning. This project will incorporate lab activities that will allow students to design their own experiments and will also give them opportunities to apply the activities to real world experiences. James Stone and colleagues (2008) looked at rigor and relevance in math classes. They looked at teaching a different mathematics, one that can be engaging through real work situations. This project reported here, intends to use mathematics in many of the activities, providing a real-world application of the mathematics students have learned. In Daggett's (Daggett and Nussbaum, 2008) Rigor/Relevance Framework grid relevance is addressed in Quadrant B and D. Students that are in quadrant B can take the knowledge that they have learned and apply it to solve real world problems. In quadrant D students can think in complex ways and solve new unpredictable problems that might require learning new information. In this study, a student in quadrant B will be able to apply what they have learned to the real world example of cancer. They will understand what happens at the cellular level when someone has cancer. Students will

move to quadrant D when they can pose a new hypothesis for therapies for cancer based on what they know about cellular reproduction.

Rigor and Relevance are requirements at every level of education. Jules Dienstag (2009) recently reported in the New England Journal of Medicine that universities are looking at rigor and relevance in premedical education programs across the country. Universities need to take a look at what is relevant to the medical field and teach those topics in depth rather than teach many topics that have no significance to medicine and take time away from the student. The topic of depth rather than breadth is a reoccurring theme. Teachers have to be willing to make choices on what is most important for students to learn and not just what we like to teach or have taught for so many years. Rigor and relevance should take precedence over getting the most amount of material covered as possible in one year. I expect that making the choice to spend extra time teaching cellular reproduction with rigor and relevance, with the theme of cancer, will cause students to become active learners that will remember the material and thought processes long after they graduate from high school.

Overview of Science Content

This unit will cover cellular reproduction. As organisms grow, their cells will grow until they reach a size limit and then they will divide. There are two main reasons that a cell will divide. First there will be larger demands on the DNA as the cell gets larger. In addition, the larger cell is less efficient at transporting nutrients into the cell and wastes out of the cell. The process of the cell dividing when it has reached its size limit is called mitosis, which is part of the cell cycle.

An understanding of chromosomes is important for understanding the cell cycle. Genetic information is bundled into chromosomes and is tightly wound in a helix with proteins and fits in the nucleus of each cell. The chromosome will duplicate during the cell cycle and will look like an "X" when fully condensed prior to metaphase. These duplicated chromosomes are also referred to as sister chromatids. When the chromosome condenses, you can make out the centromere, regions where chromatids join and where the spindle fibers will attach to separate the chromatids. The cell cycle is divided into interphase, mitosis, and cytokinesis. Interphase is the longest part of the cell cycle. The cell will grow during Gap 1 (G1) and carry out normal cell functions. Synthesis (S) includes the replication of DNA. One cell will become two and all DNA has to be passed on to both cells. Finally Gap 2 (G_2) is the time when the cell prepares for cell division. During interphase, G_1 takes the longest to complete. Mitosis is further divided into prophase, metaphase, anaphase, and telophase. During prophase, the nuclear membrane disintegrates, the nucleolus disappears, chromosomes condense, and the spindle apparatus begins to form between the poles. Metaphase, the shortest phase, includes chromosomes attaching to the spindle fibers and aligning with the centromeres along the equator.

During anaphase, the microtubules shorten, split the sister chromatids apart and move the chromosomes to opposite poles of the cell. Telophase is when the chromosomes reach the poles, the nuclear envelope re-forms, the nucleolus reappears, and the chromosomes disperse. Finally, when mitosis is complete, cytokinesis occurs. Cytokinesis is when the cytoplasm divides and the cell becomes two new cells. The percent of time spent in each part of the cell cycle is similar across organisms, but the number of minutes spent in each phase is specific to organism and tissue type. However, if the rate at which cells go through the cell cycle speeds up, this indicates that they have become cancerous and tumors will form.

The timing and rate of cell division is critical for cells to grow correctly. Proteins called cyclins and enzymes called cyclin dependent kinases (CDKs) work together to orchestrate the events in the cell cycle. In the simplest model, the first checkpoint in the cell cycle is the growth regulator protein Ras cyclin. As the cell grows, the amount of Ras cyclin increases; when it reaches a certain level, it signals the cell to move to the next step. Before continuing, the cell must be checked at the second checkpoint. Another protein, p53, will check the DNA for damage. If the DNA is damaged, it will either repair it or the p53 may trigger apoptosis or programmed cell death. If the cell clears both of these checkpoints, it enters into the S phase of the cell cycle. The next checkpoint will occur after DNA has been replicated. Another protein called ATM/Nibrin will check that the DNA has been copied correctly. The protein either will make the repair if there was a mistake or will trigger apoptosis. The next checkpoint will occur during metaphase. The protein MAD1 will check to see that spindle fibers have attached correctly to the centromere. If they are attached correctly, the cell will continue

to anaphase. If spindles are not attached correctly, apoptosis is triggered. Problems at any of these checkpoints that do not lead to apoptosis can cause the cells to grow abnormally and could lead to tumors and possibly cancer.

The majority of the cells in an organism are specialized to be certain cell type. However, there is a unique type of cells called stem cells. These are the cells that are unspecialized and can develop into specialized cells when under the right conditions. When a cell is totipotent, it can develop into any type of cell in the body. Only the fertilized egg and the cells produced by the first few cell divisions of embryonic development are truly totipotent. After four days of development, a human embryo forms a blastocyst with two layers. The outer layer of cells has become specialized; however, the inner mass has not. These inner mass cells are pluripotent and can develop into most of the body's cell types. These pluripotent cells are the embryonic stem cells that scientists use in research. The third unique cell type is adult stem cells. These are cells that are more limited in their potential. These cells are mulitpotent and can differentiate into several cell types. There are many potential benefits to stem cell research including repairing damaged tissue in the body. However, there are ethical issues that surround stem cell research that have to be considered. There is also some evidence that cells with mutated DNA can become cancer stem cells. These cells propagate into many cancer cells causing tumors to grow quickly. Cancer stem cells go through the cell cycle slowly and appear to be resistant to chemotherapy treatments.

Demographics of the Classroom

I teach at Father Gabriel Regional Catholic High School, located in Ann Arbor, Michigan. Our school is a regional high school that brings in students from many communities in Michigan. These communities include, but are not limited to Ann Arbor, Ypsilanti, Belleville, Brighton, Howell, Chelsea, Dexter, Saline, Plymouth, Canton, Northville, Novi, and Livonia. The tuition at the school is approximately $9000 per year and many of our students receive financial assistance. Our student body includes 496 students, including 86% Caucasian, 3% Asian, 3% African-American, 4% Hispanic, 0.4% Native American, and 0.6% other. All graduate and in the current graduating class of 2010, there are 119 students. In this senior class, 97% are enrolling in a 4-year college or university in the fall (18% at the University of Michigan), 2% are joining the military, and only 0.8% will not be continuing their education in the fall.

There are six science teachers in our school and I am the only one who teaches the "general" level of biology. These are college bound students who not likely to enter in a science major. Our school does include special education students and they make up 0.06% of the school. These students are included in the general education classroom, with accommodations, and they receive extra assistance daily from a resource teacher. I teach 4 sections of biology with an average of 24 students per class. We have a 7 period day with classes lasting 50 minutes. The majority of my students are freshmen and are coming in from middle schools, mostly parochial, with various science experiences. My student load in general biology this year was 99 and forty-nine (49) students took part in this study, including four (4) minority students, and six (6) students with accommodations.

The majority of our students are involved in extra curricular activities, including drama, music, ministry, and athletics after school. Parents are supportive and the school model is a small community of people that care for each other. The school is faith-based and teaches the Catholic faith. 91% of our students are from Catholic families. In science, there are topics throughout the year that can be controversial due to the teaching of the Catholic Church. One such topic, stem cell research, is included in this unit.

Implementation

Timeline

Prior to this unit, students have studied the scientific method, biochemistry and the cell. Students should have an understanding of all of the cell structures and functions. Special attention is given to the cell membrane and transport and communication through the membrane. In studying the nucleus, students are familiar with chromosomes. This is the pre-requisite information now needed to study how the cell grows and divides, and what happens when this process does not go as designed. After this unit, students will study chromosomes more closely as the basis for heredity. Cancer will be a relevant theme that will come again as we look at genetics at the molecular level and study mutations and their involvement in protein synthesis.

One day before to implementation, parent consent forms (Appendix A) were distributed to students in the presence of another science teacher. Students took home the forms for signatures and they were returned to the main office. They remained in a locked drawer in the main office until the completion of the unit. At the end of the unit, once grades had been distributed, consent forms were accessed which determined that forty-nine (49) students had returned the consent form agreeing to be a part of the study. For statistical analysis in this study, n=49, unless otherwise indicated. I began the unit with a pre-unit survey (Appendix B) and pre-unit test (Appendix C). These instruments provided a way to reveal misconceptions and prior knowledge about cell reproduction. In addition, students were asked to think about science and its application to "real world" experiences. Upon completion of the pre-test, the unit began and proceeded for several weeks. Table 1 describes the activities, in order, for the cellular reproduction unit. These

lessons were developed during the Division of Science and Math Research course in the summer of 2009, and included many new labs, simulation, power points, and models. Lessons were designed in a way to apply the new knowledge to "real world" experiences, specifically cancer.

Table 1: Sequence of Events for the Cellular Reproduction Unit

Activities (* new to unit)	Objective
Implementation of Pre-Unit Survey and Pre-Unit Test * (1 Day)	Pre-Assessment
Faces of Cancer Simulation (2 Days)	Be familiar with statistics related to cancer Introduce mutagens/carcinogens
UV Detectives-Skin Cancer Simulation* (2 Days)	Investigate the risks of UV radiation Discover the usefulness of blocking radiation
Effect of Radiation on Plants* (2 Days + 7 Partial Days)	Investigate the risks of radiation
Effect of Tobacco on Bacteria* (2 Days)	Investigate the risks of tobacco use
Cell Size Lab* (2 Days)	Understanding the relationship between cell size and cell survival
Cell Cycle and Mitosis Foldable (1 day)	Be familiar with the phases of the cell cycle
How Long Does the Cell Cycle Take? (2 Days)	Determine the time it takes for each step of the cell cycle
Cell Cycle Regulation Simulation* (1 Day)	Discover the role of CDK in the regulation of the cell cycle
What Is In The Name? Play-doh Models* (1 Day)	Become familiar with the different types of stem cells
Oh No! Cancer Stem Cells PowerPoint* (1 Day)	Make a connection between stem cells and cancer
Project and Presentations* (3 Class Days + 7 Days Outside of Class)	Apply knowledge to a specific cancer and present understanding to another student
Implementation of Post-Unit Survey and Post-Unit Test* (1 Day)	Post-Assessment

Overview

Pre-unit Survey and Pre-Test

Students were given a Pre-Unit Survey (Appendix B) where they were asked to rank their opinions on twelve (12) questions related to relevance of science to their everyday lives. Students rated their opinion on a letter scale with A meaning strongly disagree, B meaning somewhat disagree, C meaning neutral, D meaning somewhat agree, and E meaning strongly agree. Letters were used so that a scantron could easily calculate the results. The Pre-Unit Test (Appendix C) was also administered. The test served as a means for getting baseline data of what students already know about cellular reproduction. A fifty (50) multiple choice questions test plus nine (9) free response questions was given to the students. These tests were stored in a locked drawer until the completion of the unit for further statistical analysis. The number of students that participated in the study was forty-nine (49).

Activities

Students participated in 11 activities in this unit. Each of the activities is briefly described in this section. In addition, there is discussion of the outcomes of the activities. Scores for the assessments of the activities are also included. Surveys (Appendix B) were also given at the end of the unit for students to share their opinions on the usefulness of these activities. Results for these surveys will be mentioned in each activity description.

Faces of Cancer (Appendix D1) was the first activity in which students (n=49) participated and it served as an introduction to cancer. Students examined recent statistics that have been generated about their chances of getting cancer during their

lifetime. Students took part in a simulation where they took on the role of an individual that may or may not have had cancer. In this part of the activity students learned about the risk factors of cancer. Students were introduced to the words "mutagens" and "carcinogens". 92% of the students found this activity to be useful in understanding cancer. Students were engaged in the activity during class and easily answered all of the assessment questions at the conclusion of the activity. The average score on the Faces of Cancer Assessments was 49.7 out of 50. The students were asked to describe the most surprising thing they learned in this activity. Students were surprised that more males are at risk for cancer than females. This may be due to the fact that our entire school highlights breast cancer (found mostly in females) during the month of October. Students were astonished by the different types of cancers they did not know about. Many students made comments about the rude reality that everyday activities can lead to cancer. In addition they also began to make connections that many cancers are preventable.

UV Detectives (Appendix D2) was a lab activity that demonstrated the power of ultraviolet (UV) radiation on special beads and what could be used to block the UV radiation. This lab served several purposes. It reinforced the previous activity that external sources have the ability to cause changes in our bodies, specifically our skin. In addition, this activity reinforced a move in our science department to have students design labs and keep a lab notebook. Students did some pre-lab research using a website to learn about the different types of UV radiation and skin cancer. The students worked together to design an experiment to show what blocks ultraviolet radiation the best and keeps the beads from changing colors. Students worked through how to minimize

variables and generated protocols for determining the rate of change in the bead color compared to a control. Class results varied through the day and discussion occurred to determine why there were differences. 98% of the students found this activity helpful and the average grade on the lab write up was 31.9 out of 50. The shortfalls in this activity came from students who did not complete the pre-lab research and/or discussion part of the lab. The students who completed the lab write up answered the questions correctly.

How Does Radiation Affect Plant Growth? (Appendix D3) was used to reinforce the idea that radiation affects living tissue. Students conducted a lab where they grew mung bean seeds that had been exposed to different levels of radiation. Students began the activity by doing pre-lab research on nuclear radiation. Students read about the different levels of radiation that they are exposed to yearly. They also learned about Chernobyl and watched some videos that demonstrated some of the devastation that people still battle today. Classes worked together to gather information and keep results in their lab notebooks. At the end, they also got to see the plants grown by other classes, which served as replicates. This activity took several weeks and students learned the details of cell reproduction and the cell cycle via lectures and other activities before reaching the conclusions of the lab. Students were assessed on the conclusions they made about the radiation exposure and the cell cycle. Students easily extrapolated that the increased radiation slowed the cell reproduction cycle. Most of the students also made the connection that in cancer therapy the radiation treatment given would also destroy "normal" cells in the area targeted. 89% of the students found this activity useful. However, of these, 27% of them rated is only a little useful. Several students

discovered that keeping the lab notebook over a long period of time was tedious and difficult. Some students shared that keeping track of the material as lessons were progressing was difficult. The students with special needs had to be assisted and assigned to groups that had a strong data collector. The average grade on this activity was 42.3 out of 50. Again, most of the low scores came from students who did not complete the pre-lab and/or discussion parts of the activity.

How Do Chemicals Affect Cell Growth and Reproduction? (Appendix D4) was an activity that showed students how chemicals we are exposed to, sometimes by choice, can alter the reproduction cycle of the cell, using bacteria and tobacco. This activity was completed while students were learning the details of cell reproduction via lectures and other activities and could make connections between cell reproduction and cancer by the time they were writing their conclusions. Students completed a pre-lab activity that required research on the bacteria that we would use. Students learned that *Serratia marcescens* normally grows red at room temperature, but will turn white when it mutates. I informed the students that UV radiation causes the bacteria to mutate and we would use that as our positive control. These bacteria will also change colors when the temperature is changed and when it is crowded. We were able to control for temperature, but not for crowding and this affected the results for some of the classes. All students learned aseptic techniques, but only one volunteer from each group used them to plate the bacteria and did so at the front desk with direct supervision. The class worked together to set up experimental groups and collect data that were shared. Students made conclusions based on the class data that were collected. We had to estimate the percentage of the plate that was pink verses white. Students were able to see a trend in the data and make

conclusions about the effect of the chemicals in tobacco on the rate of bacteria mutation. Students did see more white (mutated) bacteria growing in the plates with the highest concentration of tobacco compared to the bacteria growing in little to no tobacco. I had to be very careful how I used the words mutations and cancer in this activity. Students wanted to jump to the conclusion that the bacteria had cancer. It was important for students to understand that the bacteria had mutated. In the conclusions students did some additional research to determine what chemicals in the tobacco might have caused the mutations. They also had to discuss in their discussion why they thought some of the bacteria mutated and others did not on the same plate. Many students found this question difficult and this led to a class discussion about mutations and cancer susceptibility. In reflection on this activity, it is the one activity that I would probably not repeat. Students became confused about mutations and cancer. Additionally, getting the bacteria to grow at the right rate for a biology lab was difficult. Aseptic techniques, although monitored, were not used properly. 87% of the students found this activity useful, but 31% of these students found it only a little useful, likely due to the difficulty in collecting data. The results were not clear and there was confusion about the correlation between mutations and cancer. The average grade on this lab activity was 43.6 out of 50. There were also still some students who did not complete the pre-lab and discussion sections of the lab, causing the class average to dip.

What is the Ideal Cell Size? (Appendix D5) activity introduced the students to the concept of cell division. Students investigated through this lab why a cell would need to divide. Students soaked agar cubes containing phenolphthalein, of three different sizes, in vinegar. At the conclusion of the soaking time students could cut open the

cubes, which represented cells, and see how far the vinegar had diffused. Students did pre-lab research to determine how phenolphthalein works as an acid/base indicator. In addition, they researched how cells get needed materials and get rid of waste. Students had already learned about diffusion and the cell membrane so that connection was not difficult. Students did not adequately prepare for this lab and make many mistakes as they progressed. Some soaked cubes in the rinse water instead of the vinegar. Students weak in math had difficulty cutting the cubes correctly and making the math calculations. In reading the labs, those that prepared before coming to class and correctly carried out the experiment got the connection of cell size to survival. If this activity is repeated in the future, more care will be taken to help the students prepare better so that it will work for all of them. A good amount of time was spent on the completing the data tables. Students traditionally have difficulty with math in science classes, but it brings relevance to the math and rigor to the science. Expectations were kept high and students were assessed with a math quiz based on this activity that several students had to retake until they passed. Students begin to make the connection that cells need a large surface area to volume ratio and a large cell does not provide that and therefore has to divide. Students found this activity to be tedious, as noted in their lab notebooks and commented in the survey that this lab needed to be done slower. Only 82 % found this activity helpful and 29% of those thought it was only slightly useful. This was due to the mistakes that they made that could not be corrected. The average score on this activity was 41.9 out of 50. There were two (2) students that did not complete this lab write-up, and again there were some who did not do the pre-lab research and/or discussion. Students who completed the discussion had difficulty with the graph at the end, especially predicting change for cubes

of sizes not used in the lab. Students are being pushed to do higher level thinking and problem solving.

Cell Cycle and Mitosis (Appendix D6) gave students the opportunity to make a booklet that included information about the stages of the cell cycle, including the phases of mitosis. Simultaneously, students used pop-beads to follow the phases of mitosis on their desks. The booklet provided the opportunity for students to take notes on the phases of mitosis. Both pictures and words were used to describe all of the steps of cellular reproduction. In addition, students manipulated models and listened to the descriptions given by the teacher. The assessment of the students' understanding took place during a lab like activity. Students went to microscope stations to find pictures taken from microscope slides. They had to count the number of cells undergoing mitosis and to recognize the cells in the phases of mitosis as opposed to interphase. Students then completed a conclusions activity that served to both summarize this activity and prepare them for the next activity. The average score on this assignment was 21.2 out of 27. Five (5) students did not turn in this assignment. Again students struggled with the math in this activity, but were able to recognize the stages of mitosis accurately. 98% of the students found the foldable activity, the booklet mentioned above, to be helpful and 94% found the pop-bead models to be helpful.

How Long Does the Cell Cycle Take? (Appendix D7) **is** an activity where students determine how long it takes for a complete cell cycle. They also determined how long it takes for each phase of the cell cycle. First, students used pictures of onion cells to calculate how many cells were in each of the following phases: interphase, prophase, metaphase, anaphase, and telophase. The pictures provided an opportunity for

students to practice identifying the phases. Next, the students used prepared slides of onion root tips to count how many cells were in each phase of the cell cycle. Students were frustrated with the number of cells they were expected to count. A class discussion was held that helped them come up with ideas of how to count so many cells. Students then successfully counted and calculated the amount of time spent in each of the phases of the cell cycle. Some students had difficulty with the math. Expectations were kept high and extra assistance was provided for students that were having difficulty. Students prepared graphs to visually represent the phases of the cell cycle. Finally, a connection was made to cancer. Students were given charts of data for cancer cells in the cell cycle. Students quickly made the connection that the cell cycle is faster in the cancer cells so the cancer cells grow and crowd out the "normal" cells. Students began to understand what tumors are and why they are associated with cancer. The scores for this activity averaged 37.7 out of 50. Seven (7) students did not turn in this activity and the students had difficulty on the questions where they had to justify the amount of time spent in each phase of reproduction. Students just did not answer that question or were very vague. 84% found this activity to be useful, and of this percent only 11% found it to be very useful.

Cell Cycle Regulation Simulation (Appendix D8) was one of the most engaging activities of the unit and the students were still talking about it at the end of the year. This was a simulation activity where the students took on the role of a dividing cell going through the cell cycle. Each student was a cell with different DNA in their nucleus. The room was set up in stations that were the check points of the cell cycle. Students moved through the stations one at a time following the directions. Some had mistakes that could

be fixed and some had mistakes that led to apoptosis. When they reached the end of their cycle they were given stickers. Some got stickers that said, "Winner-You successfully divided" or "Apoptosis-sorry your cell committed suicide". At the end there was a class discussion of Cyclin Dependant Kinases (CDK) and checkpoints. This led to a connection between the checkpoints not working and cells not going through apoptosis. Students saw this as a reason why cells might begin to go through the cell cycle when they should not and that this might relate to cancer. As an assessment of their understanding, students were given an assignment to play a cell cycle simulation game on-line at http://nobelprize.org/educational/medicine/2001/cellcycle.html. Most students enjoyed the game; however many were frustrated as you could not continue through the game unless you got the regulation steps correct. This reinforced the complexity of the cell and its cell cycle. Students averaged 15 out of 20 on the on-line game. The lower scores were students that either did not do the assignment or were frustrated and did not finish the assignment. Those that completed the assignment did so with accuracy. 95% of the students found the simulation to be very helpful, while 72% found the on-line game to be helpful.

What Is In The Name? (Appendix D9) was an activity that required students to use Play-doh© to model stem cells. Students completed data tables that included pictures of the models and descriptions of the different types of cells. Students discovered definitions of totipotent, pluripotent, and multipotent. In addition they learned the difference between adult and embryonic stem cells. A class discussion about the use of stem cells, both embryonic and adult ensued. Students discussed the 2008 election and the views and decisions of Presidents Bush and Obama. In future years, more time

should be devoted to this topic to allow students to make more connections to public policy and their role. This would add to the relevancy of this topic. 95% of the students found this activity useful and many commented that they liked being able to manipulate the models. Play-doh© is always a hit with high school students. The average score on the data tables and review questions was 10.1 out of 11.

Oh No! Cancer Stem Cells PowerPoint (Appendix D10) was an activity where students viewed a Power Point® presentation that was developed by the Life Sciences Learning Center at the University of Rochester. Students completed the worksheet as we moved through the presentation. We worked through this activity so all students participated and got the full 10 out of 10 on the worksheet. 95% of the students found this activity useful. Due to time constraints the cartoon strips, intended for assessment, were not completed. In future years, as this unit is refined, the comic strips will be included.

Project and Presentations (Appendix D11) gave students the opportunity to show their classmates that they have become experts of cellular reproduction and cancer. They had the opportunity to put it all together and make a Power Point® presentation of an assigned cancer to describe what they had learned. Students drew from a hat their topic and then completed one day of research in the media center. They could complete more research at home. They then had one day in the media center plus time at home to produce the presentation. To save time, students presented in small groups in the media center and the grade was determined based on the Power Point® presentation alone. Students enjoyed doing projects like this and 98% found it to be useful. All but two (2) students participated in this project and the average score was 33.2 out of 36. Students

found it difficult to find current research and future therapies. Students found the material to be difficult to understand as it is presented on the internet. Medical and scientific journals provided the information, but it was frustrating for students to read for the information in simple terms. In the future, time could be spend learning how to read a journal article earlier in the year to make this assignment more manageable.

Post-Unit Survey and Post-Unit Test

Students were given a Post-Unit Survey (Appendix B) where they were asked to rank their opinions on twelve (12) questions related to relevance of science to their everyday lives. The survey included the same twelve (12) questions that were asked on the Pre-Unit Survey. Answers were compared to determine if opinions changed over the course of the study. The Post-Unit Test (Appendix C) was also administered. The test served as a means for determining if students learned the material during the unit. A fifty (50) multiple choice questions test plus nine (9) free response questions was given to the students. Again, this was the same test as was given before the unit began.

Data/Results

This section will include descriptions of the data that were collected throughout the unit. For all of the data collected n=49.

Pre and Post Unit-Survey

A Pre-Unit Survey (Appendix B) and Post-Unit Survey (Appendix B) was used to gage student opinions on how they learn science and how science is related to everyday life. Students rated their opinion on a letter scale with A meaning strongly disagree, B meaning somewhat disagree, C meaning neutral, D meaning somewhat agree, and E meaning strongly agree. Answers were than converted to a number scale for statistical purposes. Choice A was scored as a 1, choice B was scored as a 2, choice C was scored as a 3, choice D was scored as a 4, and choice D was scored as a 5. Figure 1 shows the results of the Pre and Post-Unit Survey. Questions can be divided into two categories; questions that are about relevance in science to real world activities (1,3,4,8,10, and 11) and questions that deal with styles of teaching and learning (2,5,6,7,9,and 12). The results show little change in student opinions during the study. In both the pre and post unit survey, most student responses are near neutral (score of 3). Using a t-test, there was no statistically reliable difference between the mean responses for the pre and post-unit surveys ($p > 0.05$). Students agreed most with question number 2 and disagreed most with question 6.

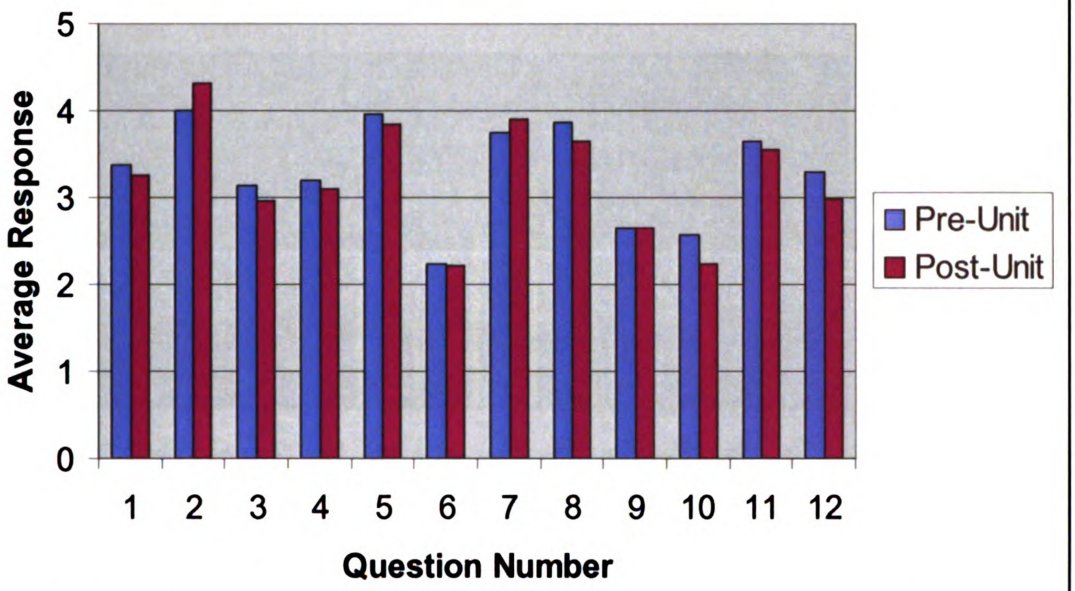


Figure 1: Pre and Post-Survey Results. Results compare average of pre and post-unit opinions scored 1-5, with 1 meaning strongly disagree and 5 meaning strongly agree. (n=49)

In addition, students completed a survey at the end of the unit to evaluate the usefulness of the activities (Figure 2). Students ranked them as not useful at all, a little useful, fairly useful, and very useful. According to the results, students found the Cell Cycle and Mitosis (Appendix D6) foldable activity to be very useful and found the online game for cell cycle regulation to be the least useful (29% of students). The cell size lab also had a number of students that found it not useful. Overall, students found all of the activities to be useful to some degree.

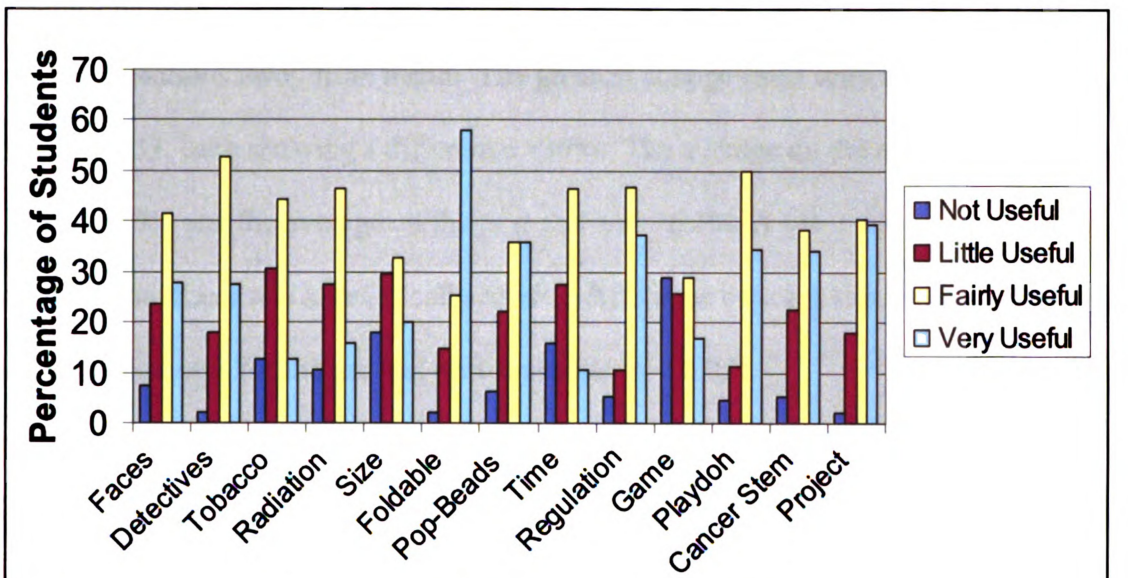


Figure 2: Student Evaluation of Activities. Results show the percentage of students responding in each opinion category for each activity. (n=49)

Pre and Post Unit-Test

Students were given a Pre and Post-Unit Test (Appendix C) with fifty (50) multiple choice questions test plus nine (9) free response questions. Multiple choice questions 1-5 address cell growth and the limits of cell size and chromosomes were covered in questions 8-12, the cell cycle was in questions 14-21 and mitosis specifically was covered in questions 6-7, 11, 13, and 22-32. Cell cycle regulation was included in questions 33-37 and cancer was covered in questions 38-45. Finally, questions 46-49 were about stem cells. In the free response questions, the first set of questions were about limits to cell size and were similar to the cell size activity we did in class. The other free response questions were about the growth of normal cells compared to cancer cells. Figure 3 is a scatter plot of the percent correct for each of the multiple choice questions on the pre and post-tests. This figure helps identify questions that are outliers in terms of performance. Questions 2, 12, 20, 21, 22, 26, 32, and 41 lie outside the standard

deviation for post-test correct with questions 2 and 26 being clear outliers more than 3 standard deviations away from mean. The greatest change came with questions 16, 17, 28, 29, and 33, each showing a difference >30%. The average on the multiple choice pre-test was 33.0% and the average on the post-test was 76.1%. A t-test was completed to determine that there was a statistically reliable difference between the standard error of the mean responses for the pre and post-unit tests ($p < 0.05$).

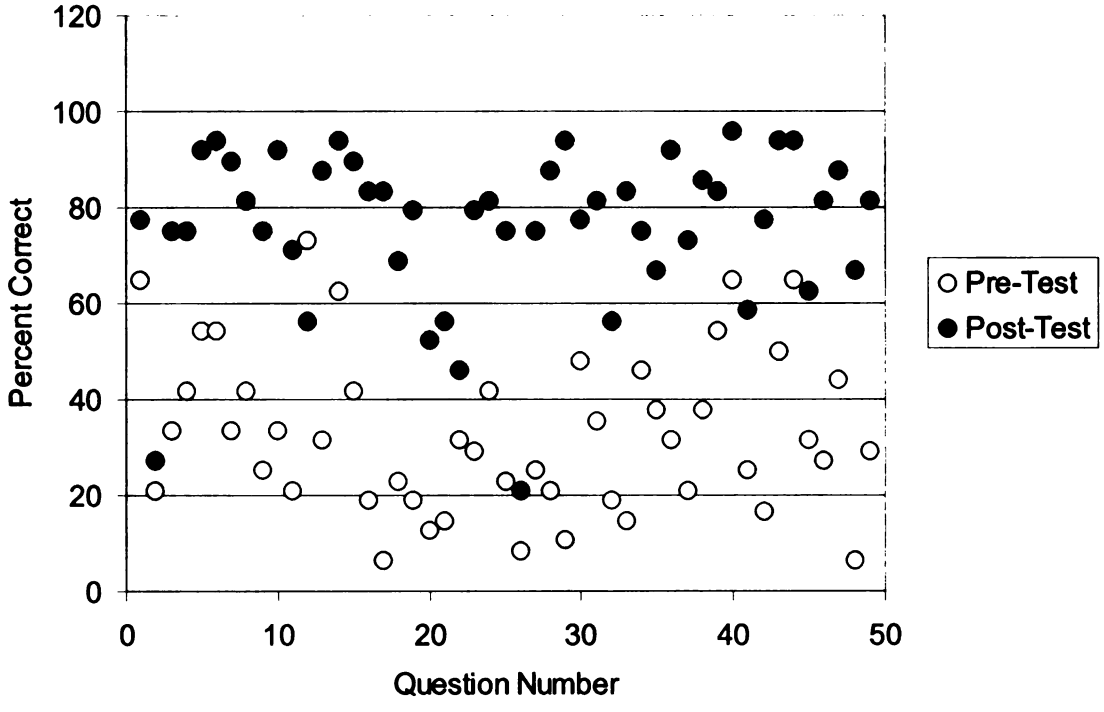


Figure 3: Percentage Correct for Each Multiple Choice Question on the Pre and Post-Test. Open circles represent percent correct on the pre-test and closed circles represent the percent correct on the post-test.

An analysis also was completed for each student to determine how they answered individual multiple choice questions on both the pre-and post-test. There were four possible scenarios: a student could have answered incorrectly on the pre-test and also incorrectly on the post-test (II), the student could have answered incorrectly on the pre-test but correctly on the post-test (IC), the student could have answered correctly on the pre-test and correctly on the post-test (CC), or the student could have answered correctly

on the pre-test and incorrectly on the post-test (CI). Table 2 shows the possible scenarios and the symbols used in the analysis.

Table 2: Symbols for Analysis of Students on Pre and Post-Test

Pre-Test Answer	Post-Test Answer	Symbol
Incorrect	Incorrect	II
Incorrect	Correct	IC
Correct	Correct	CC
Correct	Incorrect	CI

Figure 4 shows the percentage of responses for each of these categories. Close to 50% of the responses from students went from incorrect to correct (column 2). The percentage of students moving from correct to incorrect was very small (5%). A single factor ANOVA test was conducted on these results, indicating that the outcomes are not equally likely to have occurred ($p < 0.05$).

Results of the responses on the multiple choice tests were also sorted to determine if there was substantial learning (IC response) across all students. Data were sorted in Figure 5 with students on the left that performed well on the pre-test or learned a great deal from the course (large IC and CC) through students on the right that performed poorly overall (large II). It is clear that there is a large IC response in practically all students regardless of which end of the graph they reside.

Average scores for the free response portion of the pre and post-test were converted to a 100 point scale for comparison and statistical purposes. Figure 6 shows the results with error bars. The class average on the free response part of the pre-test was 23% and the post-test average was 77%. A t-test was used so show there was a statistically reliable difference between the mean score for the pre and post-unit free response ($p < 0.05$). Question 2 had the largest increase in total average score from pre-

to post-test. The lowest average score on the post-test was question 8, but that is up from 0% on the pre-test.

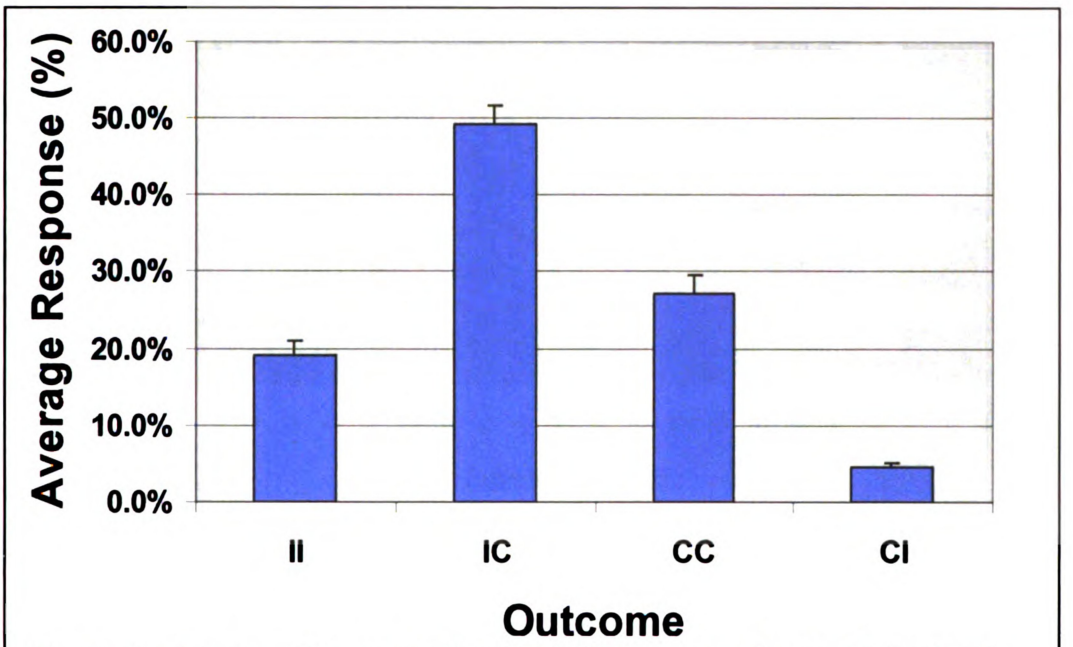


Figure 4: Averages Responses for Each Outcome on the Multiple Choice Test. Bars represent the four possible scenarios on the multiple choice test: incorrect to incorrect (II), incorrect to correct (IC), correct to correct (CC), and correct to incorrect (CI). Error bars at the top represent the standard deviation. (n=49)

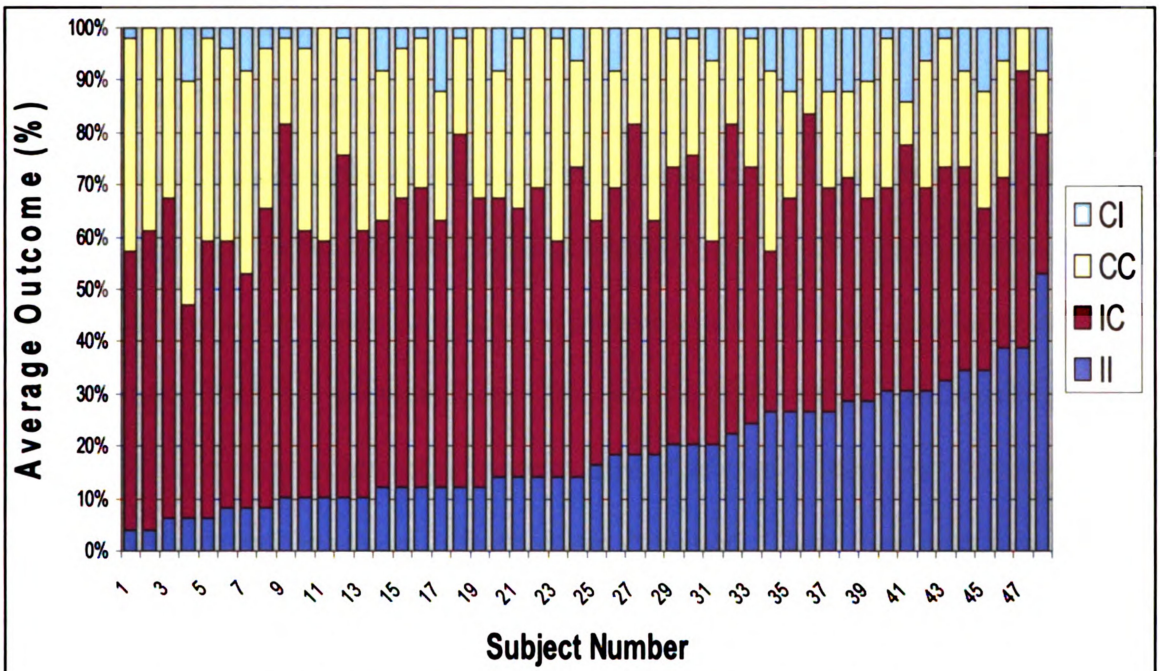


Figure 5: Analysis in Individual Students on Multiple Choice Questions on the Pre and Post-Test (n=49)

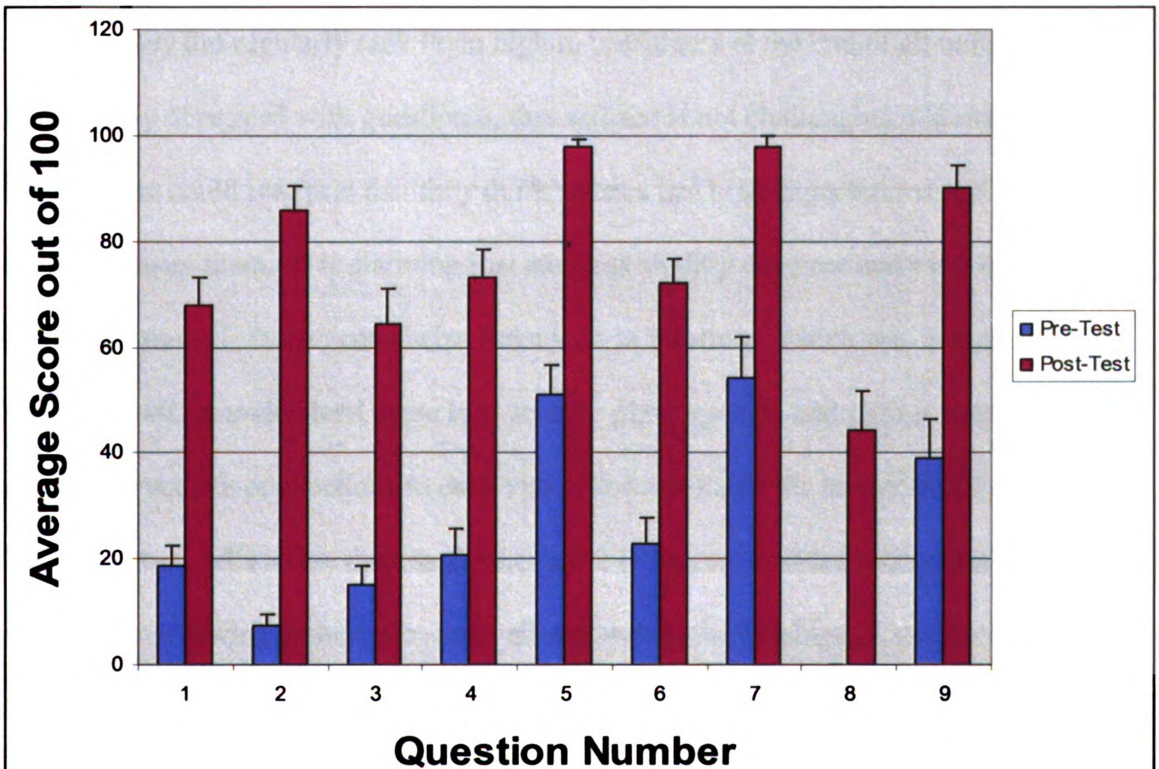


Figure 6: Average Scores for Free Response Questions. The first columns represent the average for the pre-test and the second columns represent the post-test. Error bars at the top show the standard deviation. (n=49)

Discussion/Conclusions

Pre and Post Unit-Survey

The pre and post-unit survey provided an opportunity to gauge student opinions about relevance of science and their learning styles (Figure 1). The desired outcome would have been to see student's opinion of relevance to every day life to move towards strongly agree. This was not seen during this unit. For the most part, students began and ended this unit feeling neutral about the relevance of science to their lives. Questions 2, 6, and 10 were outside the range of the standard deviation. These three questions deviated from the mean of neutral the most. Students tended to slightly agree with question 2, that experiments are helpful for understanding science. Students in my classes were exposed to lab experiences throughout the year, although they find them difficult, they did regularly rank them high in usefulness at the end of all units. Students also slightly disagreed with question 6, that science is not challenging and makes them bored. One could interpret that they think science has high expectations and they are pushed to meet them. It is alarming that students slightly disagree and even disagree more after the unit that science helps them vote in elections, which was question 10. Helping students understand more how science plays apart in addressing issues before the electorate requires connections in each unit. Students made the connection during our lesson on stem cells as we discussed Proposal 2 (Proposal 2 added a constitutional amendment allowing embryonic stem cell research to the Michigan Constitution), but seemed to have forgotten that when it was time to take the post-survey. The impact was minimal. Continual emphasis will need to be placed on the relevance of topics in science through out the school year in all units.

Activities

A survey was used at the end of the unit to determine what students thought about the usefulness of the activities (Figure 2). It was clear that a majority of the students found the activities useful at various levels. The Cell Cycle Foldable was the most popular activity. This activity involved taking notes on mitosis. However, the "Foldable" provided an interesting way to take notes. It was a well organized booklet that students made to compare mitosis in plants and animals. It included pictures and description of all the stages of the cell cycle.

There was one lab activity on which students scored low. The Cell Size activity was difficult for many of the students. Students did not read carefully and made mistakes that could not be corrected. This led to frustrations when coming to conclusions and many did not understand the activity. This activity also required what should be simple math. Math is traditionally a difficult topic for students. The math included brings relevance to the math they learn in math class, but students found it difficult to remember the equations and how to manipulate them. A combination of math expectations and mistakes led students to be frustrated and have a negative attitude about this activity. In the future, more time should be spent on applied math throughout the year. Math teachers in the past have skipped application problems with students, but with encouragement from the science department they are moving back to more application problems. The other activity that students did not find useful was a simulation computer game that was assigned as homework. Students had to remember the order and details of the cell regulation checkpoints in order to complete and "win" the game online. Students that could not remember or did not refer to their notes could not complete the activity and

became frustrated. It was interesting that some students made comments that this was their favorite activity, but as a whole the activity was not popular. A better review of the class simulation and better directions to use their notes and books might help lessen the frustration. Despite these two (2) activities having a higher percentage of "not useful" responses, overall, a majority of the students found all of the activities useful.

Pre and Post Unit-Test-Multiple Choice

The pre and post-test questions were analyzed as shown in Figure 3. Questions 16, 17, 28, 29, and 33 had the greatest change from the pre to post-test. Questions 16 and 17 were general knowledge questions requiring that students know what the synthesis and Gap 1 part of the cell cycle include. Students would not have been exposed to this vocabulary before this unit or in middle school. Question 28 and 29 had to do with the pictures of mitosis and the order of mitosis. Again, students would not have studied these topics in a previous class in detail. Finally, question 41 was related to cell growth and the triggers that keep cells from growing. Students answered "b" on the pre-test as it included the word growth. After the unit, students knew from our Cell Cycle Simulation that cells will not grow if there are two (2) healthy cells next to it. There were several questions on the post-test that were outside the post-test mean plus or minus the standard deviation and need to be examined. Question number 2 required students to know that the speed at which a cell can produce waste is dependent on its volume. 76% of the students who missed this question answered that speed of waste production was dependent on the ratio of surface area to volume. This was the topic of one of the lab activities and we spent a good amount of time calculating and discussing the ratio. It is likely the students did not read the question carefully to notice that it was asking about an

internal function of the cell and not overall survival of the cell. They answered with the phrase that they remember using in their lab write up. Question 12 dealt with a description of chromosomes in humans. 95% of the students who got this question wrong answered "a". The correct answer was "all of the above". Students possibly read choice "a", knew it was correct and did not continue to read the other choices. Question 20 was about the stages of the cell cycle and the time spent in each phase. Students had completed an activity that directly related to this question. In the activity, they learned that interphase took the longest. However, the question did not break down growth, synthesis, and preparation so students missed that growth is the part of interphase that takes the longest. There was a discussion of growth taking the longest in the Cell Cycle Foldable, but students did not seem to retain the information. Question 21 expected students to remember the order of events in the cell cycle. 86% of students answered "none of the above". Based on questions that students asked during the test, it is possible that students were confused about the letter abbreviation. Students also often think if "none of the above" is a choice, there is a good chance that is the correct answer. If they read the choices and it was not clear immediately, they would likely think it is "none of the above". Question number 22 addresses a common misconception of the cell cycle. Students often believe that interphase is part of mitosis rather than prophase. Question 26 dealt with the details of telophase. Often students get confused about the difference between chromosomes condensing verses relaxing. However, in the case of this group of students, they seem to have gotten telophase and anaphase mixed up. It is interesting that the Cell Cycle Foldable was popular with the students, yet they missed 3 questions on the assessment that were related to the Foldable. Question 32 would fall on quadrant B from

Daggett (2008). Students have to apply their knowledge of spindle fibers to a real world situation. 75% make the connection that it has something to do with the chromosome, but they can not determine what happens to the chromosome. Question 41 was about cell cycle regulation. There was no apparent choice that students picked more than the correct one. This question again related learned knowledge to a real everyday problem. It is also possible they did not recognize the answer cyclin dependent kinases was referred to as CDKs during class. 96% of students got question number 40 correct on the post-test. This question was a real world application question. These students understood what happens at a cellular level to cells when cancer is present.

An analysis was conducted of each student on each question for both the pre and post-test. Responses were divided between incorrect to incorrect (II), incorrect to correct (IC), correct to correct (CC), and correct to incorrect). Figure 4 clearly shows that 76% of the responses ended up correct. There were very few responses that went from correct to incorrect. This is the desired result that shows that there were few cases of students getting confused during the unit and actually losing some information they originally had. Question 12 was the only question that had more students' answers incorrect on the post-test than the pre-test. The question was about chromosomes and the correct answer was "d", all of the above. The nature of the question led student to read the first response and know that it was a correct statement and not read on for the other possibilities. Students should be reminded of good test taking skills such as reading all the possible answers before making a decision. Figure 5 shows the results of the analysis for each student for each question. The reason for this analysis was to see if there was learning across all aptitudes of the students. There was substantial learning for all students even if they still

had a number of answers incorrect on the post-test. For some students, especially those with IEPs and 504s, should look at success through a different lens. IEPs and 504s are individual education plans generated for students with specific learning disabilities. Success is not always, "did they get all of the answers correct", but was there improvement. This Figure makes it clear that knowledge was gained by all students during this unit. There was an increase of 43.1% on the post-test compared to the pre-test for the multiple choice part of the assessment.

Pre and Post Unit-Test-Free Response

The constructed response questions were analyzed (Figure 6). Question number 2 asked students to use math to calculate the surface area to volume ratios for three cells. This was very similar to the lab activity that frustrated students and did not think was useful. Apparently it was more useful than they remember. We spent several days in class going over the math for the lab and students improved on the post-test compared to the pre-test. Question 8 was related to cell cycle regulation, specifically the role of p53 to growth and division of the cell. This question still had a low number of students answering correctly, but it also was completely new material for students and 0% had answered correctly on the pre-test. Questions 5, 7, and 9 are all "relevance" questions. These are the questions that would fall in the quadrant B and C on the rigor and relevance framework. (Daggett and Nussbaum 2008) In these questions students had to apply knowledge of the cell and cancer to pictures of both healthy and cancerous cells. Nearly 100% of students can identify a cancer cell and explain why it is a cancer cell. In addition nearly 100% know what will happen if cancer cells are left untreated. Question 9 asks students to apply the learned information to a problem. 90% of students can come

up with ideas for keeping cancer cells from doing more harm. There was an increase of 54% on the post-test compared to the pre-test for the free response part of the assessment.

Rigor and Relevance

I have taken Arne Duncan's message from students around the country to heart. (Duncan, 2009) I have challenged the students and pushed them to work, and they stepped up to the challenge and learned the material and new critical thinking skills. The Conference Board (2006) and the ACT (2007) both have reported that students are not ready to enter college and universities or the workplace. I have tried to implement skills in this unit that will better prepare these students for either of these possibilities. This unit was taught with rigor. According to Barbara Blackburn (2008), rigor includes content that keeps expectations high and can be demonstrated by all students. William Daggett (Daggett and Nussbaum, 2008) includes being able to solve problems in his description of rigor. In this unit expectations were kept high through out the activities. Students were expected to learn the material in a way that they could use the information to answer thought provoking questions at the completion of the activity. Lab activities gave students the opportunity to keep data over periods of time and make connections as they learned new material in class. Questions on the Pre and Post-Tests Appendix C) required that students know more that just the memorized facts about the cell cycle. All students know more information about the cell reproduction after the unit than they knew before the unit.

The use of lab activities was an important component of this unit. Erik Robelen (2010) highlights in his article that lab experiences in the United States are in need of improvement. Students need to be challenged to think critically and apply what they

learn to the real world. It was a goal for this unit to provide such an experience. Students practiced using the lab notebooks and thinking more deeply about a topic and applying what they were learning to cancer. The use of cancer as a theme allowed students to use resources outside of their textbooks, use higher level thinking, use cooperation in lab groups. Students were engaged in various activities that they felt were useful and relevant during this unit.

This unit took longer to complete than in past years. Five (5) weeks rather than one (1) week were spent on the topic of cellular reproduction. However, the idea of depth rather than breadth plays out here. Jules Dienstag (2008) describes that medical schools are taking a look at what is most beneficial for students to learn. The College Board (2006) and the ACT (2007) would argue that learning more about a topic and how to think critically and apply it to a real world problem is much more important for success than memorizing content listed in state standards. Students left this class knowing about cancer and cell reproduction because we took the time to use cell reproduction to understand cancer more deeply. Since many of these students will be affected by cancer in their real world future (many have already) it seems obvious that this was the most valuable way of teaching this material.

APPENDIX A: Parent Consent Form

Parental Consent and Student Assent Form
Collection of Data for Master's Thesis
Teaching Cellular Reproduction with Rigor and Relevance

Dear Parents/Guardian and Students,

I am currently working on my Masters degree at Michigan State University's Division of Science and Mathematics Education (DSME). I am completing a research study for my master's thesis, and I have decided to do my thesis work on making cellular reproduction more rigorous and relevant by using cancer as a focus. Students will participate in research, labs, model building, and simulations.

In order to evaluate the effectiveness of this study, data will need to be collected from the students in my biology classes. This data will be collected in the form of pre- and post- tests, lab questions, homework assignment, formative assessments after lessons, presentations, and surveys. These are all assessment instruments that students will be familiar with as they are all instruments that are used throughout the year. With your permission I would like to include data from your child in my thesis. The privacy of your child is of utmost concern and will be protected to the maximum extent allowable by law. All data generated shall remain confidential and at no time will your child's name be associated with any work or photographs collected during the research.

Participation in the study is voluntary. Your child will receive no penalty in regard to his/her grade based on your decision to allow me to use the data. All students will be expected to participate in all of the classroom activities and complete assignments. Participation in surveys will be voluntary. In the surveys students will always have the right to answer, all, some, or none of the questions. The pre-unit survey will be kept in a sealed envelope and locked in a drawer in my office until grades have been calculated. If you or the student does not wish to give permission for participation in the study, their data will be removed from all data sets. Consent forms are to be returned to **Jill Rymanowicz**, in the main office. They will remain with her in a locked area until the completion of the unit. I will not know who is participating/not participating until grades have been calculated. Once grades have been distributed, I will receive the forms and begin the job of data collection and your requests for participation will be honored. There are no known risks associated with participation in this study. There will be no benefit to student in terms of extra points for participating in the study. Parents and/or students may decide at any point to withdraw from the study. If a parent/student decides to withdraw during the data collection they will need to contact Jill Rymanowicz of their decision and she will make sure this information is added to the files. Please do not contact me about this during the study, as it is important to keep participation anonymous until grades are calculated. After grades are submitted you may still withdraw from the study by contacting my directly.

If you are willing to have your student participate in this study, please complete the attached form and return it by **September 8, 2009**. If you have any questions about his study, please feel free to contact me by email at cduncan@fgrhsaa.org or by phone at 734-662-0496. Questions about this thesis project can also be directed to Dr. Merle Heidemann at DSME, 118 North Kedzie Laboratory, Michigan State University, East Lansing, MI 48824, by phone: 517-432-2152, ext. 107, or by email: heidma2@msu.edu.

This consent form was approved by the Social Science/Behavioral/Education Institutional Review Board (SIRB) at Michigan State University. Approved 08/27/09 – valid through 08/26/10. This version supersedes all previous versions. IRB# 09-688.

Teaching Cellular Reproduction with Rigor and Relevance

If you have any questions or concerns regarding your rights as a study participant, would like to obtain information or offer input, or would like to register a complaint about this study, you may contact – anonymously, if you wish – the Michigan State University's Human Research Protection Program at 517-355-2180, fax 517-432-4503, email irb@msu.edu, or regular mail 202 Olds Hall, Michigan State University, East Lansing, MI 48824.

Thanks,
Cynthia Duncan
Biology Teacher
Father Gabriel Richard High School

Please fill out the following consent information and return to **Mrs. Rymanowicz**, in the main office, by **September 8, 2009**.

I voluntarily agree to have _____ participate in this study.
(print student name)

Please check all that apply.

Data:
_____ I give Mrs. Duncan permission to use data generated form my child's work in this biology class for this thesis project. All data from my child will remain confidential.
_____ I do not wish to have my child's work used in this thesis project. I acknowledge that my child's work will be graded in the same manner regardless of participation.

Pictures:
_____ I give Mrs. Duncan permission to use pictures of my child during her work on this thesis. My child will not be identified in these pictures.
_____ I do not wish to have my child's picture used at any time during this thesis project.

_____ _____
(Parent/Guardian Signature) **(Date)**

I voluntarily agree to participate in this thesis project.

_____ _____
(Student Signature) **(Date)**

This consent form was approved by the Social Science/Behavioral/Education Institutional Review Board (SIRB) at Michigan State University. Approved 08/27/09 – valid through 08/26/10. This version supersedes all previous versions. IRB# 09-688.

APPENDIX B: Surveys

Pre and Post-Unit Survey

This survey is anonymous and voluntary. You may answer all, some, or none of the questions. When you have completed the survey please return it to the envelope taped on the office door.

Use the following choices for all of the questions.

A. Strongly Disagree
B. Somewhat Disagree
C. Neutral
D. Somewhat Agree
E. Strongly Agree

1. Much of what I learn in science classes is useful in my everyday life.
2. Experiments help me understand science.
3. Learning science will make me a better parent.
4. Science helps me make sensible decision.
5. Simulations help me understand science.
6. The things I learn in science are not challenging and leave me bored.
7. Taking notes helps me understand science.
8. Science helps me make decisions that could affect my body.
9. Doing homework helps me understand science.
10. Learning science will help me vote in elections.
11. Making decisions is difficult without reliable resources.
12. Presenting material to others helps me understand science.

Student Evaluation of Learning Gains for the Cell Reproduction Unit

Check off how well each of the following helped you learn during the Cell Reproduction Unit	Not At All Useful	A Little Useful	Fairly Useful	Very Useful
Faces of Cancer Simulation				
Skin Cancer Beads Simulation				
Affect of Tobacco on Bacteria				
Affect of Radiation on Plants				
Cell Size Lab				
Cell Cycle and Mitosis Foldable				
Cell Cycle with the Magnetic Beads				
How Long Does the Cell Cycle Take?				
Cell Cycle Regulation Simulation				
Cell Cycle Game Online				
Stem Cells with Play-doh				
Cancer Stem Cell Power Point				
Project and Presentation				
Please share any ideas you have that could help me improve this unit:				

APPENDIX C: Assessments

Cell Division: Pre and Post-Test, Part 1
Adapted from ExamView Test Bank

Multiple Choice-Answers in Bold
Identify the choice that best completes the statement or answers the question. (1 point each)

1. As a cell grows, it
   a. places more demands on its DNA.
   b. uses up food and oxygen more quickly.
   c. has more trouble moving enough materials across its cell membrane.
   d. all of the above
   e. I have no idea

2. The speed with which wastes are produced by a cell depends on the cell's
   a. ratio of surface area to volume.
   b. environment.
   c. volume.
   d. surface area.
   e. I have no idea

3. All of the following are problems that growth causes for cells EXCEPT
   a. DNA overload.
   b. excess oxygen.
   c. obtaining enough food.
   d. expelling wastes.
   e. I have no idea

4. If a normal cell divides, you can assume that
   a. its surface area has become larger than its volume.
   b. its volume has become larger than its surface area.
   c. it has grown to its full size.
   d. it has been a month since it divided last
   e. I have no idea

5. Which of the following happens when a cell divides?
   a. The cell's volume increases.
   b. It becomes more difficult for the cell to get enough oxygen and nutrients.
   c. The cell has DNA overload.
   d. Each daughter cell receives its own copy of the parent cell's DNA.
   e. I have no idea

6. The process by which a cell divides into two daughter cells is called
   a. apoptosis.
   b. metaphase.
   c. interphase.
   d. mitosis.
   e. I have no idea

7. Which of these processes is most important for the replacement of worn-out body cells?
   a. meiosis
   b. mitosis
   c. diffusion
   d. absorption
   e. I have no idea

8. In order to fit within a cell, DNA becomes more compact by
   a. breaking apart into separate genes.
   b. extending to form very long, thin molecules.
   c. wrapping tightly around associated proteins.
   d. being enzymatically changed into a protein.
   e. I have no idea

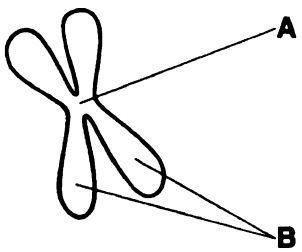


Figure 10-2

9. The structure labeled A in Figure 10-2 is called the
   a. centromere.
   b. centriole.
   c. sister chromatid.
   d. spindle.
   e. I have no idea

10. The structures labeled B in Figure 10-2 are called
    a. centromeres.
    b. centrioles.
    c. sister chromatids.
    d. spindles.
    e. I have no idea

11. During which phase(s) of mitosis are structures like the one shown in Figure 10-2 visible?
    a. anaphase and prophase
    b. prophase and metaphase
    c. metaphase only
    d. anaphase and interphase
    e. I have no idea

12. The chromosomes in your body
    a. exist in 23 pairs.
    b. each contain thousands of genes.
    c. are about 40 percent DNA and 60 percent protein.
    d. All of the above
    e. I have no idea

13. During normal mitotic cell division, a parent cell having four chromosomes will produce two daughter cells, each containing
    a. two chromosomes.
    b. four chromosomes.
    c. eight chromosomes.
    d. sixteen chromosomes.
    e. I have no idea

14. The cell cycle is the
    a. series of events that cells go through as they grow and divide.
    b. period of time between the birth and the death of a cell.
    c. time from prophase until cytokinesis.
    d. time it takes for one cell to undergo mitosis.
    e. I have no idea

15. The two main stages of cell division are called
    a. mitosis and interphase.
    b. synthesis and cytokinesis.
    c. the M phase and the S phase.
    d. mitosis and cytokinesis.
    e. I have no idea

16. Why is the synthesis stage called this?
    a. because protein synthesis is taking place
    b. because DNA synthesis is taking place
    c. because it combines several smaller stages into one
    d. because the chromosomes come together
    e. I have no idea

17. The typical growth period of a cell occurs during which stage of the cell cycle?
    a. Gap 1
    b. Gap 2
    c. synthesis
    d. mitosis
    e. I have no idea

18. When during the cell cycle is a cell's DNA replicated?
    a. G_1 phase
    b. G_2 phase
    c. S phase
    d. M phase
    e. I have no idea

19. Which of the following is a correct statement about the events of the cell cycle?
    a. Little happens during the G_1 and G_2 phases.
    b. DNA replicates during cytokinesis.
    c. The M phase is usually the longest phase.
    d. Interphase consists of the G_1, S, and, G_2 phases.
    e. I have no idea

20. The stage of the cell cycle that occupies most of the cell's life is
    a. G_1.
    b. M.
    c. G_2.
    d. S.
    e. I have no idea

21. Which of the following shows the correct sequence of the cell cycle?
    a. C → M → G_1 → S → G_2
    b. S → G_1 → G_2 → M → C
    c. G_1 → S → G_2 → M → C
    d. None of the above
    e. I have no idea

22. The first phase of mitosis is called
    a. prophase.
    b. anaphase.
    c. metaphase.
    d. interphase.
    e. I have no idea

23. During which phase of mitosis do the chromosomes line up along the middle of the dividing cell?
    a. prophase
    b. telophase
    c. metaphase
    d. anaphase
    e. I have no idea

24. What is the role of the spindle during mitosis?
    a. It helps separate the chromosomes.
    b. It breaks down the nuclear membrane.
    c. It duplicates the DNA.
    d. It divides the cell in half.
    e. I have no idea

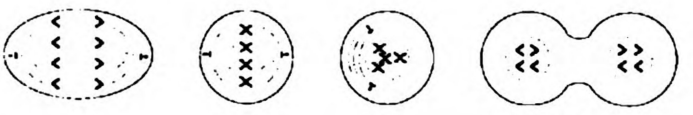
25. Which of the phases of mitosis has the shortest duration?
    a. anaphase
    b. cytokinesis
    c. metaphase
    d. prophase
    e. I have no idea

26. Which of the following occurs in telophase?
    a. chromosomes condense
    b. chromosomes line up
    c. chromosomes move to opposite poles
    d. chromosomes relax
    e. I have no idea

1 2 3 4 5

27. Refer to the illustration above. The cell in diagram "1" is in
    a. metaphase.
    b. telophase.
    c. anaphase.
    d. prophase.
    e. I have no idea

28. Refer to the illustration above. The cell shown in diagram "5" is in
    a. metaphase.
    b. telophase.
    c. anaphase.
    d. prophase.
    e. I have no idea



29. Refer to the illustration above. Which of the following correctly indicates the order in which these events occur?
    a. "A," "B," "C," "D"
    b. "C," "B," "A," "D"
    c. "B," "A," "C," "D"
    d. "A," "C," "B," "D"
    e. I have no idea

30. Refer to the illustration above. During which stage do the centromeres divide?
    a. "A"
    b. "B"
    c. "C"
    d. "D"
    e. I have no idea

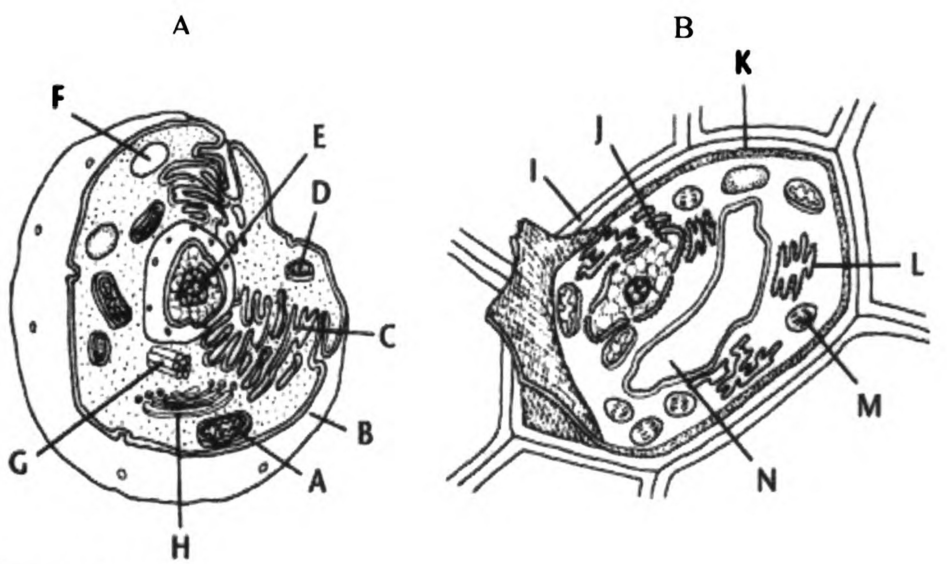


Figure 10–6

31. Some cells form a cell plate during cytokinesis. Which of the following is true of the cells in Figure 10–6 above?
    a. Both cells form cell plates during cytokinesis.
    b. Neither cell forms a cell plate during cytokinesis.
    c. Only cell A forms a cell plate during cytokinesis.
    d. Only cell B forms a cell plate during cytokinesis.
    e. I have no idea

32. Colchicine is a chemical that when applied to a cell during mitosis can be used to "freeze" cells in metaphase by preventing the chromosomes from moving away from the metaphase plate. What part of the cell does colchicine most likely affect?
    a. chromosome structure
    b. spindle fibers
    c. nuclear membrane
    d. cell membrane
    e. I have no idea

33. When cells are grown in a laboratory, which of the following is a factor that can stop normal cells from dividing?
    a. contact with other cells
    b. growth factors
    c. a cut in the skin
    d. injection of cyclin
    e. I have no idea

34. Cells grown in a petri dish tend to divide until they form a thin layer covering the bottom of the dish. If cells are removed from the middle of the dish, the cells bordering the open space will begin dividing until they have filled the empty space. What does this experiment show?
    a. When cells come into contact with other cells, they stop growing.
    b. The controls on cell growth and division can be turned on and off.
    c. Cell division can be regulated by factors outside the cell.
    d. all of the above
    e. I have no idea

35. Which of the following explains why normal cells grown in a petri dish tend to stop growing once they have covered the bottom of the dish?
    a. The cells lack cyclin.
    b. The petri dish inhibits cell growth.
    c. Contact with other cells stops cell growth.
    d. Most cells grown in petri dishes have a defective p53.
    e. I have no idea

36. Cyclins are a family of closely related proteins that
    a. regulate the cell cycle.
    b. produce p53.
    c. cause cancer.
    d. work to heal wounds.
    e. I have no idea

37. A cell with a defective p53 gene is likely to
    a. stop responding to growth regulators.
    b. stop dividing to produce daughter cells.
    c. generate hormones that combat tumors.
    d. produce cells without a defective p53 gene.
    e. I have no idea

38. Cancer affects
    a. humans only.
    b. unicellular organisms only.
    c. multicellular organisms only.
    d. multicellular and unicellular organisms.
    e. I have no idea

39. What is a tumor?
    a. an accumulation of cyclins
    b. a mass of cancer cells
    c. the rapidly dividing cells found at the site of a wound
    d. a defective p53 gene
    e. I have no idea

40. Cancer is a disorder in which some cells have lost the ability to control their
    a. size.
    b. spindle fibers.
    c. growth rate.
    d. surface area.
    e. I have no idea

41. If you were studying the causes of cancer, which topic might interest you?
    a. cyclin-dependent kinases
    b. centromere structure
    c. spindle-fiber structure
    d. cell membranes
    e. I have no idea

42. Cancer cells can reproduce rapidly because they
    a. are smaller than normal cells.
    b. bypass interphase.
    c. undergo mitosis faster
    d. spend less time in interphase
    e. I have no idea

43. What is cancer caused by?
    a. cell-membrane damage
    b. metabolic poisoning
    c. mutation
    d. immune-system damage
    e. I have no idea

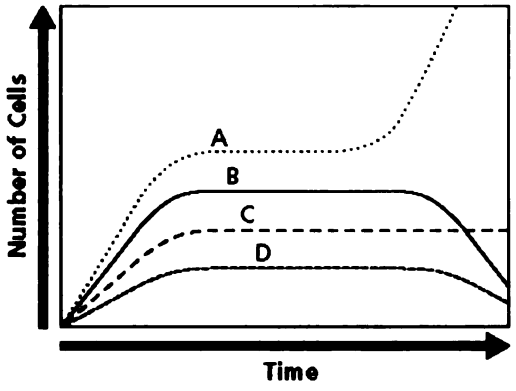


Figure 9-2

44. Which of the cells depicted in the line graph in Figure 9-2 are most likely cancerous?
    a. A
    b. B
    c. C
    d. D
    e. I have no idea

45. If cancer is present, what is the likely explanation for what happened to the cells depicted in the curves labeled B and D in Figure 9-2?
    a. They thrived with the cancerous cells.
    b. They were harmed by radiation therapy.
    c. They died off due to natural causes.
    d. They died off because the cancerous cells deprived them of nutrients.
    e. I have no idea

46. During early development, all cells in the embryo of a multicellular organism are identical. Later on in development, the cells will become specialized through a process called
    a. apoptosis.
    b. cytokinesis.
    c. differentiation.
    d. interphase.
    e. I have no idea

47. Why are stem cells important?
    a. They have specialized DNA.
    b. They are incapable of becoming cancer cells.
    c. They have the potential to undergo cell division.
    d. They have the potential to develop into other cell types.
    e. I have no idea

48. Which of the following is a possible future benefit of stem cell research?
    a. developing a vaccine for cancer
    b. reversing damage from a heart attack
    c. generating embryos from nonliving tissue
    d. increasing a person's intelligence quotient
    e. I have no idea

49. A stem cell has potential medical uses because it
    a. undergoes mitosis.
    b. is not specialized in structure and function.
    c. is similar to a cancer cell, providing a study system.
    d. undergoes apoptosis.
    e. I have no idea

Cell Reproduction: Pre and Post-Test, Part 2
Adapted from ExamView Test Bank

Constructed Response-Answers in Bold
Write the correct answer in the space given.

A student placed three cubes of agar that contained the indicator phenolphthalein in a beaker of vinegar. The cubes were the following sizes: 3 cm^3, 2 cm^3, and 1 cm^3. In the presence of an acid, such as vinegar, phenolphthalein turns from pink to clear. After 10 minutes, the student cut each cube open and measured the distance that the vinegar had diffused into each cube. She then started to complete the data table.

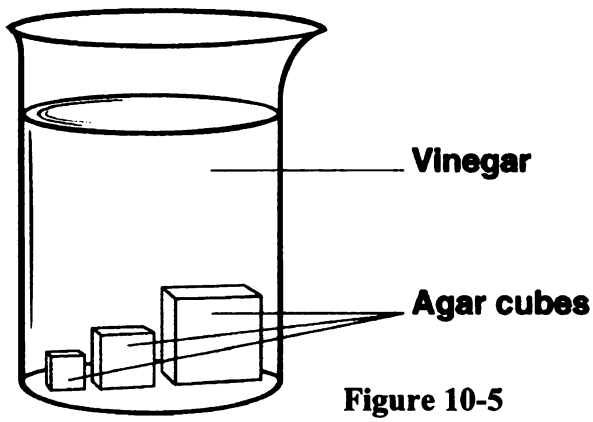


Figure 10-5

Comparison of Agar Cubes

Cube Size	Surface Area (cm^2)	Volume (cm^3)	Ratio of Surface Area to Volume	Depth of Diffusion (mm)	Time (minutes)	Rate of Diffusion (mm/minute)
3 cm^3	54	27			10	
2 cm^3					10	
1 cm^3	6	1			10	

1. What is the student probably trying to test? What do the cubes in Figure 10-5 probably represent? **The effect of size on diffusion of materials into the cube is being tested (1 point) and the cubes represent cells (1 point).**
2. Look at the data table. What are the surface area, volume, and ratio of surface area to volume for the cube that is 2 cm^3?**Surface area is 24 cm^2 (1 point), volume is 8 cm^3 (1 point), and surface area to volume ratio is 3:1 (1 point).**

3. Compare the cubes with respect to their sizes and their ratios of surface area to volume. **The largest cube has the largest area and volume, but the smallest surface area to volume ration. (1 point) The smallest cube has the smallest area and volume, but the largest surface area to volume ratio. (1 point)**
4. Look at the experimental setup. How will the student know how far the vinegar has diffused into each cube? **To determine how far the vinegar diffused into the cell the cube is cut in half and the pink part of the cube is measured. (1 point)**

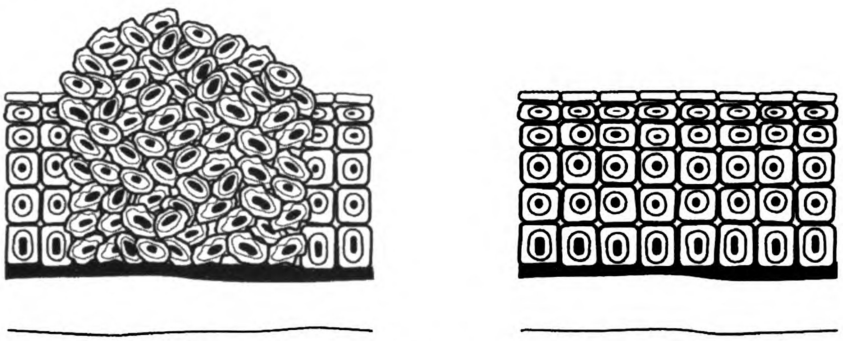


Figure 10-6

5. Look at figure 10-6. Which diagram shows cancer cells? How do you know? **Picture A shows tissue containing cancer cells. (1 point) The cells are growing out of control and abnormally in shape. (1 point)**
6. Explain how cancer cells are different from normal cells. Then, relate these characteristics to the pictures in Figure 10-6. **Cancer cells do not respond to signals for growth control and therefore grow out of control in abnormal shapes. (1 point) Picture A has grown out of control in different shaped and picture B has grown with control exactly like the previous cells.**
7. Look at the cancer cells shown in Figure 10-6. What can happen if these cells are left untreated? **If cancer cells are left untreated, tumors form that will kill off normal cells as they use up needed nutrients. They may also break off and move (metastasize) to other parts of the body. (1 point)**
8. Explain the role that p53 might have had in the growth and division of the cells shown in each picture in Figure 10-6. **p53 gene checks the genetic information the cell is going to replicate. If the p53 gene does not do its job than cells with the wrong DNA will continue through the cell cycle. If the incorrect genetic information is in the signals for growth control there will be uncontrolled cell growth as in picture A. Picture B has p53 genes that are working correctly and checking that correct DNA is being replicated. (1 point)**
9. How might the cancer cells shown in Figure 10-6 be prevented from doing harm to the organism they are a part of? To prevent harm to theorganism, **chemotherapy or radiation can be used to destroy the cancer cells in picture A. In addition, surgery could be performed to remove the cancer cells. (1 point)**

APPENDIX D: Activities

D1-Faces of Cancer (50 Points)
Updated and Adapted from: *Cell Biology and Cancer* (1999)
NIH, BSCS, and Videodiscovery

Introduction: What are the chances that you will get cancer? What are the chances that you will not survive your cancer? These are questions that have become very important in this day and age. If you do not experience cancer directly, someone you love may. It is important that you understand the causes of cancer. You may be able to protect yourself or someone you love.

Purpose/Objectives: You will participate in several simulations to look at statistics of cancer and causes of cancer.

Materials:
- Handout
- Envelope of Individual

Procedure: Simulations
Simulation 1
- Listen carefully to the teacher instructions for the first simulation and fill in the following facts as you participate.
    - What is the probability that you will have a child in your lifetime?
    - What is the probability that you will be involved in a car accident that involves alcohol?
    - What is the probability of males in the US getting cancer?
    - What is the probability of females in the US getting cancer?
    - What is the probability of people in the US dying of their cancer?

Simulation 2
- Use the envelope and take on the identity of the person described. Complete the "Team Summary" with your lab group (one copy). Please pick a team reporter that will share information during the class discussion.
- Complete the "Class Summary" as the class discusses the results. Every lab member will need a copy of this summary.
- Complete the "Drawing Conclusions for the Faces of Cancer" individually.

Team Summary (10 Points)

Team Members: (actual names)

Use the information provided in the envelope to complete this worksheet as a team.

Section 1: Family History
Tally the number of people in your team that have a family history of cancer. You will find this information on the outside of the envelope.

- Number if individuals **with** a family history of cancer. _____
- Number of individuals **without** a family history of cancer. _____

Section 2: Cancer History
Take out the pieces of paper in the envelope and line them up in chronological order. Complete the table by writing in the number of people in your team who were diagnosed with cancer during each period of life. Then list the type of cancer each person developed. If no one was diagnosed with cancer, leave the section blank.

Type of Information	Period of Life			
	0-19 years	20-39 years	40-59 years	60+ years
Number of Individuals Diagnosed				
Type of Cancer				

Section 3: Possible Risk Factors
Go back through your cards and identify possible risk factors associated with the development of cancer in the people in your team. List those risk factors here.

Class Summary (10 Points)
Period _____

Section 1: Family History

- Yes_____
- No _____

Section 2: Cancer History

Type of Information	Period of Life			
	0-19 years	20-39 years	40-59 years	60+ years
Number of Individuals Diagnosed				
Type of Cancer (number of each)	• Bladder • Brain • Breast • Cervical • Colon	• Leukemia • Lung • Oral • Ovarian • Pancreatic	• Prostate • Retinoblastoma • Skin • Uterine • Other	

Section 3: Possible Risk Factors

Assessment: Drawing Conclusions (30 Points)

Name: (actual name)

- Write a conclusion you can make about the following based on the results of the simulation. (16 Points)
    - What does family history have to do with cancer?
    - What is the relationship between cancer and age?
    - What are some of the possible external risk factors of cancer?
    - What is the relationship between types of cancer and family history, age, and external risk factors?

- In the second simulation, all students in the class assumed roles of someone who developed cancer sometime in his or her lifetime. Is this an accurate picture of the risk of cancer among the American population? Explain your answer using the first simulation information. (4 Points)

- What explanation can you offer for the observation you made about the incidence of cancer compared with age. (4 Points)

- Mutagens are external factors that cause cancer. Make a list of things that you think might be mutagens. (4 Points)

- What is the most interesting or surprising thing you learned from this activity? What is the most important? Why? (2 Points)

D2-UV Detectives (35 Points)
Updated and Adapted from: Thinkport Lesson Plans
www.thinkport.org

Introduction: There are more that 1 million people diagnosed each year with skin cancer in the United State. 1 in 5 Americans will be diagnosed with skin cancer in their lifetime. Skin cancer is the most common cancer in the United States. The most common cause of skin cancer is ultraviolet (UV) light. UV light exposure comes from the sun or tanning beds.

Purpose/Objectives: You will use the scientific method to explore the effects of UV radiation on objects that react to UV light. Students will also determine what products are used to block UV rays. Work will be completed in the lab notebook.

Materials:
- UV Sensitive Beads
- Ziplock Bag
- UV Blocker (Sun Block, Clothes, Sunglasses)

Procedure: Lab
Part A: Introduction (10 points)
- Go to http://enviromysteries.thinkport.org/insidestories/ and read through Amy's story.
- Answer the following questions in your lab notebook. Use complete sentences.
  - What are the two main types of skin cancer?
  - What is the difference between A, B and C UV Radiation?
  - How does UV radiation cause skin damage?
  - How are tanning and skin cancer related?
- Do independent research to determine what SPF means.
- In class, take a bag of beads and take a walk with Mrs. Duncan. Discover what happens to the beads as you go outside.
- Tomorrow you will be given this same bag of beads and your mission is to block the sun's exposure to the beads, therefore keeping the beads from turning colors.
- After determining your method, identify the following for this experiment:
  - Control Group:
  - Experimental Group:
  - Independent Variable (what I change):
  - Dependent Variable (what I observe):
  - Constant Variable(s):

Part B: Methods (5 points)
- As a group decide what you will use and write a methods section in your lab book. You may bring in your won blockers or pick from some that will be provided. Your choices for provided blockers are:
  - Banana Boat SPF 50-old
  - Banana Boat SPF 50-new

- Walmart SPF 50
- Banana Boat SPF 8
- UV Protective Glasses
- Clothes

- Mrs. Duncan will set up a control bag that will have no blockage that will serve as a comparison.

Part C: Results (5 points)

Color Scale:
4—Brightest (Wow, you'd really be burning!
3—Medium brightness
2—Pale color
1—Very pale; only slight change of color
0—No change (You're really protected!)

Data Table 1: Class Sun Block Data

Sample	Method	Color Result
1		
2		
3		
4		
5		
6		
7	No Blockage	

Part D: Discussion (15 points)
Answer the following questions in your lab book. Please use complete sentences. Use the data posted on the board from all classes.

- Did you notice any difference in brands of sunscreen with the same SPF levels? (2 Points)
- Sunscreen manufacturers suggest that you throw away old sun screen because it doesn't block the harmful UV light. Do your results support this? (2 Points)
- Some people use tanning oils when sunbathing. They think that the oils increase their ability to get a tan. What color would you predict the beads to be if you tried to use oils as a blocker? (2 Points)
- Experts recommend avoiding exposure to the sun between the hours of 11:00 a.m. and 4:00 p.m. Why is this? How might the beads change earlier or later in the day? (3 Points)
- What are some protective measures you can take to avoid exposure to UV rays? (3 Points)
- If exposed to artificial UV light such as the lamps used in tanning salons, what color level do you think the beads would be? Support your answer. (3 Points)

D3-How Does Radiation Affect Plant Growth? (50 Points)

Introduction: Radiation results from a radioisotope undergoing nuclear decay. Radioisotopes affect the environment in two ways: by emitting radiation that affects other materials or by entering the normal pathway of mineral cycling and food chains. There are three types of radiation: alpha particle, beta particles and gamma particles. You will research each type of radiation to understand the differences and to make a hypothesis for your experiment. Radiation exposure is measured in multiple ways. We will use the rad in this experiment. Listed below are some interesting facts about radiation.

- A person living in the US is exposed to approximately 0.170 rads of radiation each year from the environment.
- A person living near Chernobyl (location of a nuclear plant meltdown) has an increase of 43 rads of radiation from having been present during the meltdown.
- 1000 rads of radiation are used to kill bone marrow before doing a bone marrow transplant.
- A dental x-ray exposes someone to 0.0094 rads of radiation.
- Radiation treatments for liver cancer will not exceed 3,000 rads of radiation.
- 25,000-700,000 rads of radiation are used to sterilize packaged meat products that are not refridgerated.
- 10,000-100,000 rads of radiation are used to sterilize fresh meat products that are refridgerated.

Purpose/Objectives:
You will work through the scientific method to conduct your own experiment. This will be completed in your lab notebook. You will conduct some research and develop a hypothesis, experiment, and create data tables. You will develop conclusions based on the results you and the rest of the class obtain.

Materials:

- Seeds-Exposed to radiation
  (Ordered from Ward's)
  - 0 rads
  - 50,000 rads
  - 100,000 rads
  - 150,000 rads
- Petri Dish
- Sponge
- Dome
- Magnifying Glass
- Pipette

Procedure: Lab

Part 1: Introduction (10 Points)

- Research radiation and cell growth to develop a testable hypothesis for your experiment. You should be developing a hypothesis that answers the question: How does radiation affect plant growth? Make sure all of the following questions are answered before making a hypothesis.
    - Describe the differences between alpha, beta and gamma radiation. Include in your answer a description of each and an explanation of concerns we would have about each in the environment.
    - You will be using seeds that have been exposed to gamma radiation. What does radiation do to cell growth?
- Identify the following for your experiment:
    - Hypothesis:
    - Control Group:
    - Experimental Group:
    - Independent Variable:
    - Dependent Variable:
    - Constants Variable(s):

Part 2: Methods (10 Points)

- Remember to include lab safety protocols. You will wear aprons and goggles and follow safety rules.
- Describe in detail the experiment that you will perform to test your hypothesis. You may use words and write out the steps or you may use detailed pictures.
    - Obtain a petri dish and place your name, date, and radiation dose on the bottom of the dish.
    - Place one of the soaked foam germination pads in the petri dish.
    - Place 8 seeds that your group has been assigned on the foam pad. Add a few drops of water, using a pipette, on the seeds to hasten germination.
    - Place the Germination Chambers on the tray which will be placed under the grow lights and kept at 60-80 F.
    - Add half a teaspoon of water to the chamber every other day to replace water that is lost.
    - Look at the seedlings and record changes every day.
    - When the plants need more room for growth, replace the cover with a Development Dome (plastic cone). Continue to add water every other day.

Part 3: Results (10 Points)

- Construct a data table (1) that you will use to track your data. Include a row for plant stem height (units), plant root length (units), color of stem, germination rate (number of seeds that grow), and number and pattern of secondary roots.
- Plot graphs (2) of the average stem height and germination percentages for each seed irradiation.

Part 4: Conclusions (20 Points)

- Write a paragraph summarizing the conclusions you have made. Include whether the data supported your hypothesis.
- Include the following information in your conclusion
    - Summarize what you did in the experiment.
    - Explain the purpose of the experiment.
    - What are the results and what do they mean?
    - What do you suppose happens to the cell cycle when the cell is exposed to radiation?
    - What is the purpose of radiation therapy for cancer patients? What happens to the "normal" cells near the cancer cells targeted in the therapy.

Websites used to gain information for introduction:
www.epa.gov/rpweboo/sources/food_irrad.html
www.cancer.gov/cancertopics/factsheet/therapy/radiation
www.ada.org/public/topics/xrays_faq.asp#4

D4-How Do Chemicals Affect Cell Growth and Reproduction? (50 points)

Adapted from a lab developed by **Rebecca Milholland**, Graduate Student & NSF CATTS Fellow, University of Arizona, Department of Pharmacology & Toxicology & **Stefani D. Hines, M.A., M.S.**, Director Community Outreach and Education Program, Southwest Environmental Health Sciences Center, University of Arizona.

Introduction: In this experiment you will add tobacco to the food supply of bacteria and discover if it will cause a change. Tobacco is known to cause cancer in humans by mutating (changing) the DNA.

Purpose/Objective: Students will make a hypothesis to describe the effect of tobacco on cell growth and observe bacteria grown in the presence of various concentrations of tobacco. Students will also learn how to plate bacteria. Work will be completed in the lab notebook.

Materials:

- *Serratia marcescens* student stock plate
- Petri Dishes (labeled)
- Inoculating loops
- tube of LB liquid media (10mL) labeled "Bacteria" in a beaker
- Glove

Procedure: Lab

Part A: Introduction (5 points)

- Read the lab and do independent research on *Serratia marcescens* and answer the following questions.
    - What happens to these bacteria when they are mutated?
    - Create a testable hypothesis that addresses the problem: Will tobacco cause a mutation in the *S. Marcescens*? If there is a mutation how will you know?
- After reading the procedure, identify the following for this experiment:
    - Hypothesis:
    - Control Group:
    - Experimental Group:
    - Independent Variable:
    - Dependent Variable:
    - Constants Variable(s):

Part B: Procedures (10 points)

- Put on lab aprons and goggles.
- Assign the following roles: Writer, Looper, Cleaner, and Runner. Loopers will wear gloves!
- The writer will label the bottom of the plate with your names and date. You will also find out what concentration of tobacco you have. (1:1 means there is a high concentration of tobacco and 1:10000 means there is little tobacco. Control –

means there is no tobacco and it will not be exposed to UV light and Control + means there is no tobacco and it will be grown in UV light)

- Looper will go to the teacher station the teacher will flame the bacteria tube each time.
    - Obtain a sterile inoculation loop from the package and dips it into the "Bacteria" tube.
    - Use the loop to plate the bacteria onto one of the Petri plates. Use a zig-zag pattern from one side of the plate to the other. Only make one pass across the plate!
    - Repeat on the second petri plate with a new inoculation loop.
    - Discard all loops and gloves in the disinfectant tub at the teacher station.
- The runner will take the plates to the correct storage station at the side of the room. Check the label on the plate for the correct location.
- +Control goes in the goggle cabinet and all others go in the cabinet at the back door.
- Plates will be left overnight and results will be obtained tomorrow.
- The cleaner will wipe down table and everyone washes hands!
- Day 2-Obtain all of the plates for the group you are assigned. Count the number of white colonies in each plate and get an average number of colonies present. Use the grid sheets for all counts.
- The cleaner will wipe down table and everyone washes hands!
- Plates are discarded in the disinfectant tub at the teacher station.

Part C: Results (5 points)

Table 1: Treatment Conditions and Number of White (Mutated) Colonies

	Controls		**Dilutions of Cigarette Solution**			
	No Treatment (NT – negative control)	UV light (positive control)	1:1	1:100	1:1000	1:10000
White (# of Colonies)						

Part D: Discussion (25 points)

Write up a conclusion for your experiment. Write as if you are submitting your results to the Journal of Tarinfestation. This should be in paragraph form when submitting to a journal. Make sure you include the following:

- An introduction that describes the experiment that you performed. (2 points)
- Re-state your hypothesis and describe if the data supported the hypothesis. (4 points)
- Was there any trend in the data? What happened to the number of colonies with mutations as the tobacco concentration increased? (6 points)
- What is in cigarettes that might cause the bacteria to mutate? How could you improve this experiment to test this? (4 points)
- Why are mutations important in cancer? (2 points)

- How might these results be applied to "real life" situations like smoking or exposure to second hand smoke? (2 points)
- How do you explain why on some plates some cells were mutated and some were not? How is this related to cancer susceptibility? (5 points)

D5-What Is the Ideal Cell Size? (50 Points)
Adapted from: Birgit Musheno, www.nclark.net/What_is_the_ideal_cell_size.doc , a lesson found at www.geh.nj.k12us.com/_tools?u=45379, and the Ward's Natural Science Diffusion and Cell Size Lab Activity

Introduction: As you have observed, cells are small. Consider your little toe: it is made of about 2-3 billion cells! A new cell will begin to grow, but when it reaches a certain size it will form 2 new cells rather than grow bigger. Why? How big is the cell going to get? Why do we have so many cells? Why are single celled organisms so small?

Purpose/Objective: You will use the scientific method to determine the ideal cell size. You will observe the diffusion rate of diffusion medium into 3 model cells containing phenolphthalein. Work will be completed in the lab notebook.

Materials:

- Pink agar cube containing phenolphthalein
- Cup
- 250 mL beaker
- Spoon
- Paper towels
- Knife
- 1 glove
- Metric ruler
- Diffusion medium from teacher

Procedure: Lab
Part A: Introduction (5 points)

- Answer the following questions and do independent research in order to develop a testable hypothesis. Use the text, notes, other books, internet, and previous experience. The problem to be answered is: Which cell will be the ideal cell size?
    - What are some factors that limit the ability of cells to survive?
    - How do cells obtain materials they need and get rid of waste?
    - What are the three factors that limit cell size?
    - What will happen to the phenolphthalein in the agar when an acid like vinegar is added?
    - In this lab you will investigate the ability of three model cells (agar) of different sizes to obtain nutrients (vinegar) from the environment. If the cell sizes are 1cm, 2cm, and 3cm, which cell do you think will be most successful? Explain your reasoning. (This is your hypothesis.)
- After reading the procedure, identify the following for this experiment:
    - Hypothesis:
    - Control Group:
    - Experimental Group:
    - Independent Variable:
    - Dependent Variable:
    - Constants Variable(s):

Part B: Procedure (10 points)

- Obtain safety goggles and lab aprons and put them on.
- Decide in your group who will be Knife Wielder 1, 2 and 3, and who will be the Metric Master.
- From the agar block, Knife Wielders measure and cut three cubes (one each) with the following dimensions:
  - Knife Wielder 1: 1 cm^3
  - Knife Wielder 2: 2 cm^3
  - Knife Wielder 3: 3 cm^3
- Metric Master will verify accuracy and cubic dimensions, and fill the 250 mL beaker about ¾ full with tap water, to be used later for rinsing the stained cubes.
- When the cubes are perfect, the Metric Master will place the three cubes in the cup and then the teacher will cover the cubes with diffusion medium. Allow the cubes to soak in the solution for 5 minutes (Knife Wielder 2 keeps track of time).
- After 15 minutes, Knife Wielder 3 obtains three folded squares of paper towel. Knife Wielder 1 puts on the glove and carefully removes the three cubes from the diffusion medium, swirls them in the large beaker of water to rinse off excess medium, and then place them on the paper towel squares. Distribute the cubes to the Knife Wielder that created it.
- Metric Master will return the cup of diffusion medium to the teacher station.
- Knife Wielders will cut their cubes in half.
- Metric Master will measure in cm and report (in Data Table 2) how far the diffusion medium traveled in each cube. Measure quickly to obtain accurate results.
- Wash and dry all utensils, including beakers, and return them to their original positions. Dispose of cubes, paper towels, and gloves in the trash. Wipe your work surface area.
- Work together to complete Tables 2 and 3 in the data section.

Part C: Results (5 points)

Data Table 1: Cube Data

Cube Size (cm)	Surface Area (cm^2) =L*W*# of sides	Volume (cm^3) =L*W*H	Surface Area:Volume (reduced)
1 cm			
2 cm			
3 cm			

Data Table 2: Diffusion of Vinegar

Cube Size (cm)	Depth of Diffusion (cm)	Time (min)	Rate of Diffusion (cm/min)
1 cm			
2 cm			
3 cm			

Data Table 3: Percent of Cell Receiving Nutrients

Total Volume of Original Cube (cm^3)	Length of Area Unchanged (Depth of Diffusion – Original Length)	Volume of Unchanged Cube (cm^3) (unchanged length^3)	Percent of Cube that Received Diffusion Medium*

*Percent = [(total cube volume) – (volume of unchanged cube) / (total cube volume)] x 100

Part D: Discussion (25 points)

Answer the following questions in your lab book.

- What does the agar cube represent in the lab? (1 points)
- Why did some of the agar turn white? (1 points)
- If each cube is a living cell, and the vinegar was a substance needed within the cell, what problem might the largest cell have? (1 points)
- Examine your data in table 2. What pattern do you notice in the relationship between cube size and the rate of diffusion? (2 points)
- Examine your data in table 1. Describe what happened to the surface area and volume as the cell grows larger. (2 points)
- Still considering table 1, what happens to the ratio between surface area and volume as the cell grows larger? (2 points)
- According to you data, which cell was most successful at receiving the needed nutrient (diffusion medium) in the allowed time? (2 points)
- What can you say about the surface area to volume ratio that will best meet the needs of living cells? (2 points)
- Why is the surface area significant in this situation? (2 points)
- Use what you have learned to answer the original questions? Why do cells only get so big? How big is the cell going to get? Why do we have so many cells? Why are single celled organisms so small? (3 points)
- Does the data support your hypothesis? Explain why or why not. (2 points)
- Graph the Percent Volume of Cube Changed by Cell Size (1 cm, 2 cm, and 3 cm), then use your graph to predict the percent change for a cell that is 0.5 cm and one that is 4 cm. Follow all the rules for making a graph. (5 points)

D6-Cell Cycle and Mitosis (50 Points)

Introduction: The cell cycle is the complete description of how a cell grows and divides to create a new cell. This is also known as asexual reproduction or cloning. All of the new cells will look identical to the original parent cell. When does a cell grow? It could be that cells are part of a growing organisms or it could be growing to replace a dead cell. Regardless it will should always follow the same pattern and go through all of the same steps.

Purpose: Students will use a foldable and pop-beads to understand the steps of the cell cycle and mitosis. Students will learn to identify what each of the phases in the cycle looks like so that they can identify them in pictures and under the microscope. Activity B will be completed in the lab notebook.

Materials:

- 4 Pieces of Paper
- Bag of Pop-Beads

Procedure: Discussion, Simulation, and Activity

Part A: Discussion and Simulation (20 Points)

- Stack 4 pieces of notebook paper approximately 1.5 cm apart vertically.
- Roll the bottom edges and fold to form 8 tabs.
- Staple along the folded edge to secure all sheets. Rotate the foldable with the stapled end at the top and Label the top page, "Cell Cycle".
- On the second page draw the circle graph that shows the entire cell cycle.
- On the third page divide the page into 3 even sections by drawing 2 lines on the paper. In the sections describe what happens in each step of interphase.
- Remove the pop-beads from the bag and place them in what you think might represent interphase. After being checked by the teacher, draw the diagram on the foldable.
- On the fourth page, divide the page in half and label one side Prophase Animal and the other side Prophase Plant.
- Write down a description for this phase at the top.
- Using the description, move the beads into a configuration that you think shows prophase. After being checked by the teacher, draw the diagram on the foldable.
- Continue this process through all the phases of the cell cycle, including cytokinesis, for both plant and animal.

Part B: Activity

Does Mitosis Occur All the Time? Complete this activity in your lab notebook.

- Go to the microscope stations and find pictures of different tissue types.
- Count the number of cells that are in mitosis verses not in mitosis. Use the transparency to help you count. Place a dot on each cell as you count. Fill in Table 1.

Part C: Data (5 Points)

Table 1: Number of Cells in Mitosis of Various Tissues

Tissue	Total Number of Cell	Number of Cells in Mitosis	Percentage of Cells in Mitosis
Liver			
Stomach Lining			
Skin			

Part D: Conclusions (25 Points)

Answer the following questions in your lab notebook.

- The drug Griseofulvin is used to treat fungal infections of the skin, like ringworm. Griseofulvin attaches to microtubules (spindle fibers) and disrupts their formation. Hypothesize how this affects cell division of the fungus. (4 Points)
- If a human cell completes the cell cycle in 20 hours, how many cells will be produced in a week? (3 Points)
- How many plant cells will you have at the end of the week if it takes 9 hours for a plant cell to complete the cell cycle? (3 Points)
- Bacteria cells take 20 minutes to go through the cell cycle, how many cells are there after one week? (3 Points)
- Why do you suppose it only takes bacteria 20 minutes to go through the cell cycle? (4 Points)
- Some drugs destroy the centromere of the chromosome. Predict what might happen in the cell cycles if tissues are exposed to this drug? (4 Points)
- Hypothesize why some cells are in mitosis more often than others. (4 Points)

D7-How Long Does The Cell Cycle Take? (50 Points)

Introduction: Do all of the phases of the cell cycle take the same amount of time? Do all parts of a wedding mass take the same amount of time? Imagine that a photographer took a picture every minute during a wedding mass. Predict how you would determine how long each portion of the mass took. How could this same principle be applied to a picture that contains 100 cells?

Purpose/Objective: Students will observe onion root tips in a picture and then under the microscope. They will count the number of cells in each phase of the cell cycle. Students will calculate how long each phase lasts for a typical onion cell.

Materials:

- Picture of the onion root tip
- Prepared slide of onion root tip
- Microscope

Procedure: Lab

Part A: Introduction (5 Points)

- Using what you already know about the stages of the cell cycle, predict which part you think will take the longest amount of time to complete and which phase will take the least amount of time to complete.

Part B: Procedures (10 Points)

- Go to the side stations and find pictures of onion root tip cells. Count how many cells are in each phase of the cell cycle. We will not count cytokinesis in this activity due to the fact it is difficult to distinguish between cytokinesis and interphase. Fill in Table 1.
- Obtain a microscope and prepared onion root tip.
- Focus on low power and then switch to high power. Remember to use the microscope correctly.
- Look at all of the cells and begin to count how many are in each phase. This is difficult. Work together with your partner and do the best you can. Add these numbers to Table 1.
- An onion cell requires 12 hours (720 minutes) to complete a cell cycle. Use the following equation to determine that amount of time spent in each phase of the cell cycle. Completely fill in Table 1.
    - Phase Time = (# cells in phase/total # of cells) x 720 minutes
- Prepare a Bar Graph showing the relative time spent by a typical onion root tip in the phases of the cell cycle. Include titles and labels for axis.

Part C: Results (5 Points)

Table 1: Counts of Cells in the Cell Cycle Phases

Phase	Picture	Microscope	Total # of Cells	Time in Minutes
Interphase				
Prophase				
Metaphase				
Anaphase				
Telophase				
Totals				720

Figure 1: Bar Graph of the Onion Root Tip Cell Cycle Phases

Complete the bar graph on graph paper, remember to title and label. Attach this graph to this handout.

Part D: Discussion (30 Points)

Answer the following questions in your lab notebook.

- List the phases of the cell cycle in order from the phase that takes the most time to the phase that takes the least time. (4 Points)

- Knowing what occurs during each phase, justify the amount of time it takes for each of the phases. (4 Points)

- The following chart was completed by a lab group last year. Does it agree with your data? Based on your knowledge what would you tell this group of students about their data and yours. Who is correct and why? (4 Points)

Phase	Time (minutes)
Interphase	15
Prophase	20
Metaphase	50
Anaphase	600
Telophase	35

- Use the following data chart to answer the last questions.

Phase	Normal Stomach Cells	Cancerous Stomach Cells
Interphase	**120**	**16**
Prophase	**60**	**15**
Metaphase	**10**	**2**
Anaphase	**3**	**1**
Telophase	**12**	**3**
Total	**205**	**37**

  - Looking at the data, do normal stomach cells seem to follow the same relative time pattern as the onion cell? The cancerous stomach cells? (4 Points)

  - Would you expect the phases of the cell cycle in all living cells to follow the same general time pattern? Why or why not? (5 Points)

  - How does the time spent in each phase of the cell cycle in cancer cells differ from the normal cells? How does the overall time for the cell cycle differ from normal? (4 Points)

  - If the cancerous stomach cells (tumor) remain in the individual, what would soon happen to the normal stomach cells? Why? (5 Points)

D8-Cell Cycle Regulation Simulation

Introduction: The cell cycle is a continuous cycle that moves from one stage to the next. How does the cell know when one stage ends and the next one starts? How does the cell make sure that all the stages occur for the correct amount of time, in the correct order, and that they occur correctly? Proteins called cyclins and enzymes called cyclin dependent kinases (CDKs) work together to orchestrate the events in the cell cycle.

Purpose/Objectives: You will participate in a simulation of the cell cycle. You will learn the names of some of the proteins that regulate the cell cycle. You will understand the steps in the cell cycle and the checks that occur along the way. You will appreciate what happens if the cell cycle does not occur correctly.

Materials:

- Bag (Cell)
- Worksheet

Procedure: Simulation

- Obtain a cell from the teacher.
- You have just received a signal from the environment around you that the cell next to you has died. You must now begin the cell cycle and make a replacement for that cell.
- One at a time; begin the cell cycle at the Ras station. Follow the directions at each station.
- Complete the "Drawing Conclusions" as a class.

Drawing Conclusions (23 points)

- How does the cell know how to grow? (1 point)
- What do you think is the function of the Ras cyclin? (1 point)
- What happened if the cell was too small? (1 point)
- What happened if the cell was too big? (1 point)
- What is apoptosis? (1 point)
- What gets checked at each of the following checkpoints?
    - p53 Station (1 point)
    - ATM/Nibrin Station (1 point)
    - MAD1 Station (1 point)
- What happened if the genetic material was not correct at the p53 station? (2M and 1F) (1 point)
- What happened if the ATM/Nibrin Station discovered that the genetic material had not duplicate correctly? (2ES) (1 point)
- What happened if the MAD1 station discovered the spindle fibers had not formed? (2DX) (1 point)
- What happens if the genes for any of these stations were changed (mutated)? (1 point)
- Where are genes located? (1 point)
- How causes DNA to change? (1 point)
- About 30% of cancers are caused by a change in the Ras gene. Why do you think a mutation in the Ras gene leads to cancer? (3 points)
- Over half of all sporadic (random, non-heredity) cancers have a mutation in the p53 gene. Why do you think a mutation in the p53 gene leads to so many cancers? (3 points)
- Cancer cells have escaped the checkpoints and do not die; they become immortal. Why is this characteristic of cancer a problem for your body? (3 points)

Teacher Resources-Cell Cycle Regulation

Bag Contents at Start

Bag Number	Contents	Result	Quantity
2DS	Short Green, Long Blue	Normal-Reproduces	20
2ES	Short Green, Long Blue	Wrong Material Duplicates, Makes Correction-Reproduces	1
1F	Short Green, Long Blue	Slow Growth, Not Duplicated Correctly-Apoptosis	1
3	Short Green, Long Blue	Too Big-Apoptosis	1
2*	Short Green, Long Yellow	Mutation at Start-Apoptosis	1
2DX	Short Green, Long Blue	No Spindles-Apoptosis	1

Directions Cards for Stations

Ras

- Locate the number on your bag.
- Place that number of marbles (cyclin) in your bag.
- Move to the Ras Cyclin Station.

Cyclin

- Place one more marble in your bag.
- Return to the Ras Cyclin Station.

Chromosome Duplication Station

- Locate the first letter on your bag.
    - Place the following in your bag
    - If D: Short Green, Long Blue, 1 Marble
    - If E: Short Green, Long Yellow, 1 Marble
    - If F: Long Yellow, 1 Marble
- Proceed to the ATM/Nibrin Station

Returning to Chromosome Duplication Station

- Return Long Yellow and get Long Blue
- Proceed to the ATM/Nibrin Station

Mitosis

- Locate the second letter on the bag.
- Place the following in the bag
    - If S: 2 beads
    - If X: nothing
- Proceed to the MAD1 Station

Station Names on Stock Paper

- Ras Station
- Ras Cyclin Station
- Cyclin Station
- p53 Station
- ATM/Nibrin Station
- MAD1 Station
- Chromosome Duplication Station

Cue Cards for Students at Stations

Ras Cyclin Station

- Count marbles.
- If 1 marble: "You are too small, go to the Cyclin Station."
- If 2 marbles: "You are the correct size. Proceed to the p53 Station."
- If 3 marbles: "You are too big! You will die." Give them an apoptosis sticker and tell them to return to their seat.

p53 Station

- Locate the star on the bag.
- If no star: "Your genetic material is correct you may proceed to the Chromosome Duplication Station."
- If star: "Your genetic information is incorrect, and you will die." Give them an apoptosis sticker and tell them to return to their seat.

ATM/Nitrin Station

- Locate the letter on the bag.
- If D: "Your genetic material duplicated correctly, the material is intact, and you are the correct size. Move to the Mitosis Station."
- If E: "Your genetic material duplicated, you are the correct size, but the material is not correct. Return to the Chromosome Duplication Station."
- If F: "Your genetic material did not duplicate completely, and you will die." Give them an apoptosis sticker and tell them to return to their seat.
- Returning E: "Your genetic material duplicated correctly, the material is intact, and you are the correct size. Move to the Mitosis Station."

MAD 1 Station

- Locate the X on the bag.
- If X: "No spindles, no mitosis. You will die." Give them an apoptosis sticker and tell them to return to their seat.
- If no X: "You have spindles, mitosis occurs successfully. You become 2 cells." Give them a Winner-Reproduced Successfully sticker.

D9-What Is In The Name?
Adapted from lessons designed by Northwest Association for Biomedical Research, www.nwabr.org/education/stemcellrequest.html

Introduction: Stem cells consume the news lately and voting citizens in Michigan had to make some decisions about embryonic stem cells during elections. What is a stem cell? What is the difference between totipotent cells, pluripotent cells, mulitpotent cells, embryonic stem cells and adult stem cells? During this activity you will build models and answer questions to help you understand the vocabulary associated with stem cell research. You will soon be going to the polls yourself; it is your duty to be an informed citizen.

Purpose/Objectives: Students will make models of the embryo as it develops to understand the vocabulary listed above. They will view a power point and answer questions.

Materials:

- Worksheets
- Clay (4 colors, 3 tablespoons of each)
- Straw
- Paperclip
- Markers/colored pencils

Procedure: Model Building/PowerPoint
Part A: Models and Notes (30 points)

- Build a **Zygote**: Take one color and form it into a sphere about the size of a ping pong ball (this is the egg). Using the same color make another sphere about the size of a pea (this is the sperm). Mix them together to form a zygote. The zygote is **totipotent**-cells that are undifferentiated and can become any type of cell.
- Early Cell Division: Take the zygote and divide it to two cells. Then divide each of these again and again until you have 16 cells.
- Build a **Morula**: Take the 16 cells and fuse them together into one large sphere. The morula cells are also totipotent. These 2 states (zygote and morula) are days 1-3 in development.
- Complete the first column of the Student Handout 1.1. Set the Morula aside for comparisons.
- Build a **Blastula**: Pick a new color and make a bowl that would be the right size to hold a ping pong ball. Use a straw to make indentions on the inside of the bowl. This represents the cells that will become the placenta. Use some clay the color of the original zygote and make many pea size spheres to represent the **inner cell mass** growing inside the other cells. Place the inner cell mass in the bowl. Normally the bowl would be a hollow sphere **(trophoplast)**. Both the trophoblast and the inner cell mass grew from the morula even though they have different colors. These cells are all **pluripotent**-they have gone through one "fate" decision. The trophoplast cells will only become placental cells and the inner cell mass will become any cell except the placenta. These cells represent

days 4-14 in development. **Embryonic stem cells** come from the inner cell mass and are usually removed in the 4^{th}-5^{th} day of development. These cells can be kept growing in a petri dish for research purposes. The embryo is destroyed when the cells are removed.

- Complete the second column of the Student Handout 1.1. Set the Blastula aside for comparisons.
- Build a **Gastrula**: We are fast forwarding to the 14^{th} day of development, when the Blastula attached to the uterine wall. Make a new trophoplast with the same color. Take the original color again and make a sphere the size of a ping pong ball. Take a third color and surround this sphere. Finally take a fourth color and surround this sphere. Take a paper clip and cut the sphere in half so you can view the inside. This represents the three layers of the gastrula. The gastrula is **multipotent**-the inner cell mass has gone through another "fate" decision and can become a more limited number of cells. The inner layer **(endoderm)** will become the cells of the digestive and respiratory systems. The middle layer **(mesoderm)** will become the cells of the bones, blood and heart. The outer layer **(ectoderm)** will become the cells of the skin and central nervous system. All of these cells are considered **adult stem cells**.
- Complete the third column of the Student Handout 1.1. Set the model aside for comparison.
- Complete Student Handout 1.2 (20 Points) for homework.
- Return all of the clay to the correct bags. Return the final inner cell mass to the teacher.

Exit Ticket

- What is the difference between adult and embryonic stem cells?

- Should research be allowed with adult stem cells, embryonic stem cells, neither, or both? Explain why you believe this. Use what you learned in class today in your answer.

- Jot down parts of the lesson that were confusing or difficult so that I can address them tomorrow.

Exit Ticket

- What is the difference between adult and embryonic stem cells?

- Should research be allowed with adult stem cells, embryonic stem cells, neither, or both? Explain why you believe this. Use what you learned in class today in your answer.

- Jot down parts of the lesson that were confusing or difficult so that I can address them tomorrow.

Student Handout 1.1: Modeling Stem Cell Development

	Totipotent Stem Cells	Pluripotent Stem Cells	Multipotent Stem Cells
Diagrams of the Model	Zygote: Morula:	Blastula/Blastocyst: Label pre-placenta and early embryo	Gastrula: Label early placenta and three tissue layers of early embryo
Approximate days cell division occurs			
Approximate number of cells			
Definitions of important terms	Totipotent: Zygote: Morula:	Pluripotent: Blastula/Blastocyst: Embryonic Stem Cell: Embryonic Stem Cell Line:	Multipotent: Gastrula: Adult Stem Cell:

Student Handout 1.2: Review of Stem Cell Notes (11 Points)

1. What are the two main characteristics of stem cells? (2 Points)

2. What are the major differences between adult and embryonic stem cells? (3 Points)

3. Describe what each of these terms means in reference to stem cells and their capabilities: (6 Points)
    - Totipotent-
    - Pluripotent-
    - Multipotent-

D10-Oh No! Cancer Stem Cells
Adapted from lessons designed by Life Science Learning Center – Cancer Education Project, University of Rochester, 2007.

Introduction: Some people go through months of radiation and chemotherapy and even surgery for tumor removal only to learn later that the cancer has reoccurred. How can this be happening? Just when you thought you were getting the hang of stem cells we discover a new type of stem cell. There is a theory that some cancers arise from cells that are called cancer stem cells. These are cancer stem cells that are undifferentiated and can become any type of cell. Could it be that these cancer stem cells escape cancer therapies and survive to reoccur?

Purpose/Objectives: Students will view a Power Point and complete a worksheet about cancer stem cells. Students will understand cancer stem cell research might lead to more effective cancer therapy treatments. Student will create a comic strip to illustrate their understanding of cancer stem cells.

Materials:

- Worksheet
- Markers/colored pencils
- Blank paper

Procedure: Power Point
Part A: Power Point (10 Points)

- Complete the Power Point Worksheet as we go through the Power Point.

Part B: Comic Strip (25 points)

- Use your creativity to illustrate what you have learned about cancer stem cells. Draw a comic strip that answers questions 3 **or** 6 and 7.

Power Point Worksheet (10 points)

1. Describe two differences between normal stem cells and the other cells in your body. (1 point)

2. In what ways do normal stem cells contribute to maintaining homeostasis? (1 point)

3. Describe two differences between normal stem cells and cancer stem cells. (1 point)

4. How do scientists identify stem cells? (1 point)

5. How might cancer stem cells originate? (1 point)

6. How might cancer stem cells lead to the reoccurance of tumors? (1 point)

7. Why are current radiation and chemotherapy treatments not always effective in preventing the reoccurrence of cancer? (1 point)

8. How might knowledge of cancer stem cells be applied to developing new cancer therapies? (1 point)

9. What questions might scientists ask to help them understand how to develop new cancer therapies that target cancer stem cells? (1 point)

10. A researcher discovered a drug that kills cancer stem cells, but not normal stem cells. Her fellow scientists congratulate her and tell her that she can now consider her job done. The researcher insists that more research is needed because it is important to discover how the drug kills cancer stem cells. Provide one reason why this additional research would be important. (1 point)

D11-Present What You Know (36 Points)

Introduction: Now that you have become an expert in cell reproduction and cancer it is your turn to teach the class. You will be assigned a specific cancer to do research and complete a power point presentation to present to the class. You will include many elements that you have learned in class. You will be assigned to work with a partner and you will share the workload and both are a part of the presentation.

Purpose/Objectives: Students will apply the knowledge they have learned in this unit to develop a presentation about a specific cancer. They will be able to describe details about the causes of the cancer, describe what happens to the cells in this cancer, and describe current therapies and how they relate to the cell cycle of the cancer cells, in addition they will address current research that might include stem cell research.

Materials:

- Computer
- Class Notes
- Books

Procedure: Power Point Presentation

Part A: Researching

- At home and in the media center do research on your assigned cancer in order to answer the questions asked on the Overview Worksheet.
- You will only have one class period in the media center for research so use your time wisely.

Part C: Designing the Presentation (36 Points)

- Design a Power Point presentation that contains at least 5 slides.
    - Title (1 Points)
    - Introduction (7 Points)
    - Causes (7 Points)
    - Cell Cycle Mishap (7 Points)
    - Current Therapies and the Cell Cycle (7 Points)
    - Current Research/Future Therapies (7 Points)
- In the media center and at home construct the presentation.
- You will only have one day in the media center so use your time wisely.
- Upload your presentation to Edline.

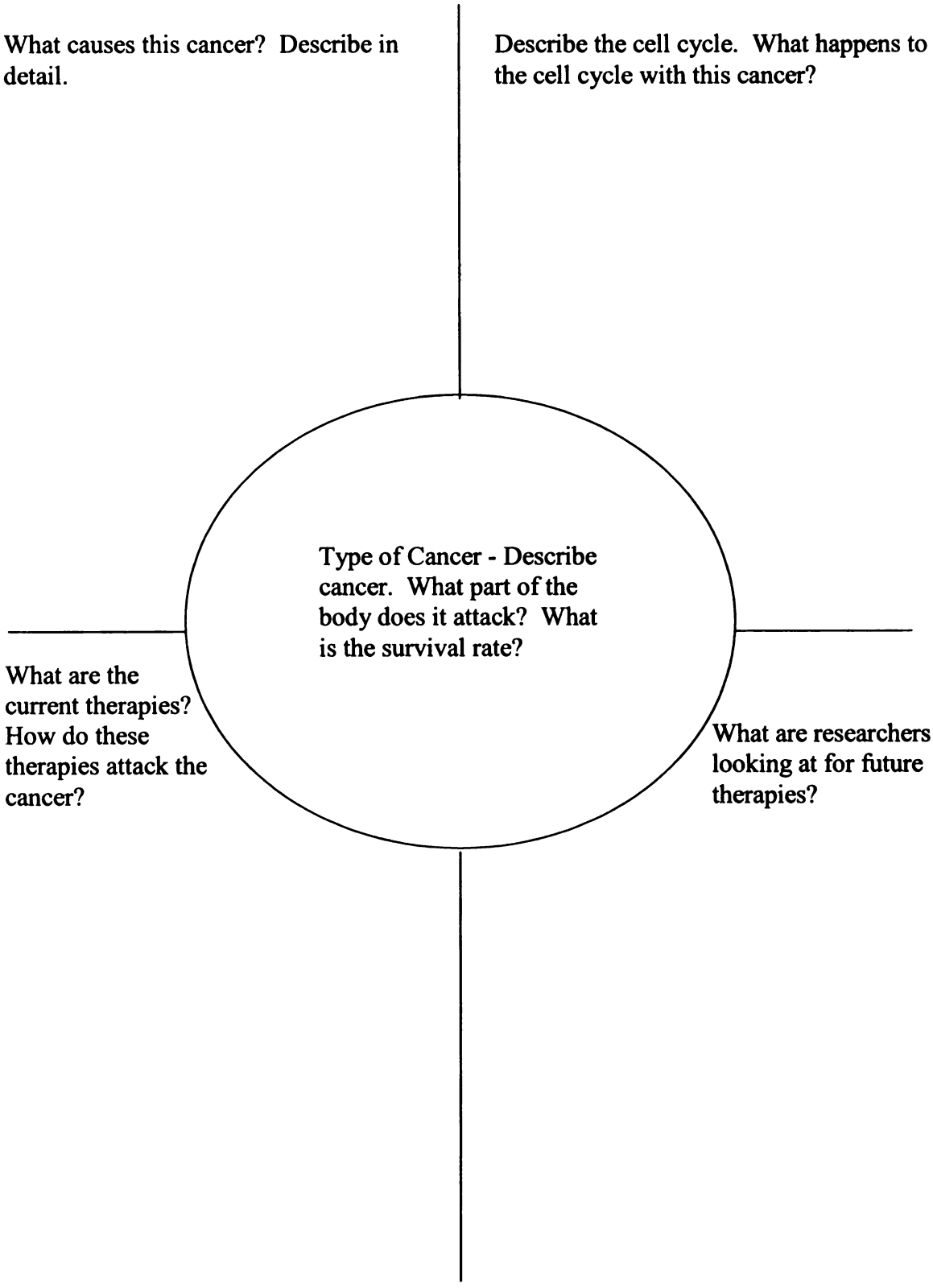
Part C: Presenting

- In the media center you will be placed in groups at computers and you will share your presentation.

Grading Rubric for Cancer Presentations (36 Points)

	7	5	3	1
Introduction	Can describe cancer with detail.	Can describe cancer with some detail.	Can describe cancer with little detail.	Using only the name of the cancer.
Causes	Can describe cause of cancer in detail.	Can describe causes but with little detail.	Can describe few causes and few details.	Understands little about the cause of this cancer.
Cell Cycle Mishap	Completely understands the cell cycle and what goes wrong in the cancer.	Completely understands the cycle but not how it relates to cancer.	Only somewhat understand the cell cycle and cancer.	Knows little about the cell cycle and cancer.
Current Therapies	Understand the therapy and how it works.	Knows what the therapies are, but not clear on how they work.	Can list therapy, but with little understanding.	Not clear on the most current therapy.
Current/Future Work	Can describe with confidence.	Can describe with partial understanding.	Can describe with little understanding.	Has information that is not current.

Overview Worksheet



REFERENCES

ACT (2007). Rigor at risk: Reaffirming quality in the high school core curriculum. Retrieved May 26, 2010, from http://www.act.org/research/policymakers/pdf/rigor_report.pdf.

Blackburn, B. (2005). *Classroom motivation from A to Z how to engage your students in learning.* Larchmont NY: Eye on Education.

Blackburn, B. (2008). *Rigor is NOT a four-letter word.* Larchmont NY: Eye on Education.

Brooks, J., Brooks, M. (1993). *In search of understanding the case for constructivist classrooms*. Alexandria, VA: ASCD.

Beane, A. (2001). Rigor and relevance: Can we have our cake and ear it too? Paper presented at the Annual Conference of the National Middle School Association, Washington.

Bogess, J. (2007). The three Rs redefined for a flat world. *Techniques: Connecting Education and Careers, 82, 62.*

Daggett, W., Nussbaum, P. (2008). *What Brain Research Teaches about Rigor, Relevance, and Relationships and What It Teaches about Keeping Your Own Brain Healthy.* Rexford, NY. International Center for Leadership in Education.

Dienstag, J. (2008). Relevance and rigor in premedical education. *The New England Journal of Medicine*, 359(3), 221-4. Retrieved May 26, 2010, from Research Library Core. (Document ID: 1516218211).

Dougherty, C., Mellor, L., Jian, S. (2006) Orange juice or orange drink?: Ensuring that "advanced courses" live up to their labels. Austin, TX: National Center for Educational Accountability. Retrieved on June 16, 2010 from http://www.nc4ea.org/files/orange_juice_or_orange_drink_02-13-06.pdf.

Duncan, Arne. (2009). States will lead the way toward reform. The 2009 Governors Education Symposium. Retrieved July 21, 2009 from http://www.ed.gov.

National Commission on Excellence in Education. (1983). A *nation at risk: The imperative for educational reform.* Washington, DC: U.S. Department of Education. Retrieved June 25, 2009 from http://www2.ed.gov/pubs/NatAtRisk/risk.html.

No Child Left Behind (NCLB) Act of 2001, Pub. L. NO 107-110, §1208, 115, Stat. 1550, 1551 (2002). Retrieved July 21, 2009 from http://www.ed.gov.

Robelen, E. (2010). Momentum building for hands-on work in science education: Focus is on offering high-quality laboratory learning. *Education Week*, 29(31), 12. Retrieved May 26, 2010, from Research Library Core. (Document ID: 2040166271).

Stone, J., Alfeld, C., Pearson, D. (2008). Rigor and relevance: Enhancing high school students' math skills through career and technical education. *American Educational Research Journal*, 45(3), 767-795. Retrieved May 26, 2010, from ABI/INFORM Global. (Document ID: 1552330011).from http://www.conference-board.org/.

The Conference Board. (2006). Are they really ready to work? Retrieved July 21, 2009.

Washor, E. and Mojkowski, C. (2007). What do you mean by rigor? Educational Leadership, 64 (4), 84-87. Retrieved May 26, 2010.

Wasley, P.A., Hampel, R. L., Clark, R.W. (1997). *Kids and school reform.* San Francisco, CA: Jossey-Bass.