Cancer in the Classroom: A Case Study Analysis

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Abstract

Cancer Biology is a topic that is not often covered in high school science classes. This unit serves to help students develop critical thinking and research skills to gain a better understanding of the biology of cancer formation. In this unit students will learn about the molecular development of cancer and potential risk factors. The unit is based on a case study which focuses on colon cancer. Using this case study students will research the sequential mutations associated with colon cancer, common diagnostic techniques, and treatments. Students will also analyze cancer risk factors to develop a personal cancer risk reduction plan. In the last portion of the unit students will have the opportunity to explore careers involved in the treatment, diagnosis, and support of cancer patients.

Keywords

Biology, life science, cancer, cell cycle, mutations.

Content Objectives

Cancer Biology is a topic not often covered in high school science classes in the School District of Philadelphia. Based on the curriculum sequence, cancer is either discussed briefly while learning about the cell cycle or not at all. The lack of integration of cancer curriculum in the pacing guidelines may be the result of the yearly progression of topics required for standardized testing; however, cancer biology is a topic that we could ~~be~~ integrate~~ing~~ into multiple units in the curriculum. Students are aware of cancer and may even have personal experience with cancer in their families but they are not formally taught about cancer and may have many misconceptions on the topic. This directly relates to the fact that ninth-grade biology students in the SDP are not exposed to relevant disease topics when learning fundamental biological principles. These common misconceptions provide an opportunity for educators to bridge the gap of knowledge while still covering required course content. Cancer as an overarching theme provides students with a mechanism to explore a wide array of biology topics ranging from the deregulation of the cell cycle to mutations and environmental influences on gene expression. A more rigorous approach to exploring cancer could allow students to gain a thorough understanding of the biological processes of disease formation and the relationship between cellular systems and disease progression. **This unit serves to integrate cancer biology topics into a 9th-grade general biology course to help students understand the relationship between cells, cell cycle, cell regulation, mutations, the environment, and cancer.**

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According to a report released in September 2020 by the Drexel University Urban Health Collaborative, "7,972 people in Philadelphia were newly diagnosed with cancer in 2016. This amounts to 478 new cases of cancer for every 100,000 Philadelphians." Cancer incidence was~~ere~~ also examined according to income demographic. The analysis shows a significant increase in both new cancer diagnoses as well as cancer deaths among people in lower income neighborhoods as compared to higher income neighborhoods ("Cancer and Health Disparities in Philadelphia"). In this report on cancer in Philadelphia, the researchers identified the most frequently diagnosed cancers in men to be prostate, lung and colon and in women the three most common types were breast, lung, and colon cancer ("Cancer and Health Disparities in Philadelphia"). Of these top three cancer types for males and females, African Americans have a 20% higher incidence of colon cancer as compared to ~~white~~ Caucasians,~~and they~~ are more likely to develop colon cancer at a younger age, and more likely to die of their disease. African Americans have the lowest five-year survival rate of any racial group in the US in this context. There are significant disparities in access to screening in lower socioeconomic neighborhoods. The report also indicates early screening by colonoscopy is on average only being conducted by 70% of the male and 75% of female participants screened ("Cancer and Health Disparities in Philadelphia") https://www.health.harvard.edu/blog/racial-disparities-and-early-onset-colorectal-cancer-a-call-to-action-2021031722136. Additionally, in an article from the Philadelphia Tribune the average age recommended for screening by the American Cancer Society is 45 and other health organizations have recommendations starting at 50; however, there has been an increase in incidence of diagnosis with colon cancer under the age of 50 since the 1990s (Howard and Karmini). Figures from the colorectal cancer alliance indicate that the rates for people under 55 increased by 2% per year. According to the American Cancer S~~s~~ociety, "In the United States, colorectal cancer is the third leading cause of cancer-related deaths in men and in women, and the second most common cause of cancer deaths when men and women are combined. It's expected to cause about 52,980 deaths during 2021" (American Cancer Society). These figures indicate there is a need to raise awareness around colon cancer screening, diagnosis, and treatment in the US and specifically for our students and their families within Philadelphia. For this reason, I opted to use colon cancer as the type of cancer that will drive the units of study for my curriculum.

Students will begin exploring cancer biology using a colon cancer case study analysis. In these case studies, the students will follow a patient from when they are symptomatic to their diagnosis through treatment. The students will first review a patient's symptoms and~~;~~ medical history/family history, then explore common misconceptions about colorectal cancers. By exploring ~~the concept of~~ cancer misconceptions they will gain a greater understanding ~~for themselves of th~~about the~~e~~ truths and myths about cancer and they will learn about the incidence~~s~~ of colorectal cancer in their communities. During these initial lessons students will also begin to explore cancer initiation at the cellular level, integrating fundamental biological concepts and key themes in biology including the cell cycle, deregulation of the cell cycle,

mutations in genes that cause deregulation of the cell cycle regulators and how this relates to disease progression. Some biology concepts~~components~~ that will be critical for these case studies are implementing sections where the students learn about ~~cell properties and histology and~~ the properties that distinguish a normal cell from a tumor cell. We will also discuss symptoms of colon cancer and learn about~~cover~~ screening techniques that are used to diagnose cancer, ~~and~~ the biological concepts that ~~that demonstrate why~~allow colonoscopies to ~~can~~ detect pre-cancer in the colon, and how blood in the stool may be an early sign of colon cancer.

In the unit's second part students will investigate genetic mutations that arise during replication, transcription, and translation. They will explore the central dogma of molecular biology and examine how errors in these processes lead to mutations which are associated with cancer development. During the lessons, students will apply these concepts to understand the stepwise mutations that lead to colorectal cancer. Although there are both acquired mutations and inherited mutations, students will primarily focus on the inherited gene mutations that cause syndromes associated with colorectal cancer formation. According to the American Cancer Society there are four primary types of inherited mutations: Familial adenomatous polyposis (FAP which is also associated with attenuated FAP and Gardner syndrome), Lynch Syndrome (hereditary non-polyposis colon cancer, or HNPCC), Peutz-Jeghers Syndrome, and MUTYH-associated polyposis (MAP) (American Cancer Society). FAP and the related syndromes as well as Peutz-Jeghers Syndrome are associated with mutations in the tumor suppressor genes APC and STK11 respectively. ~~While~~ HNPCC is caused by a mutation in one of several DNA repair genes. Lastly, MAP is caused by mutations in the MUTYH gene that is involved in DNA proofreading during cell division (American Cancer Society). Since each of these types of cancer is caused by a different type of mutation, at the end of this unit I would like to provide case study evidence and have students compose a CER (claim, evidence, reasoning) prompt. In this prompt they would examine the evidence and provide rationale for diagnosing the individual with the specific mutation responsible for the colorectal cancer in the case study.

In the third part of the curriculum students will research cancer treatment, risk reduction strategies, and cancer careers. In this portion of the curriculum students will analyze current cancer treatment protocols and generate a treatment plan for the case study patient. During this component students will work in small groups to formulate a presentation on the treatment method they selected for the case study patient and provide evidence from a literature search which examines why their methodology would be effective in treating the patient. Students will also evaluate their own risk factors for developing cancer and will be crafting a risk reduction plan. The last component for the third part of the curriculum is exploring careers in cancer. Many students are familiar with oncologists but are far less aware of the role of pathologists, genetic counselors, researchers, chemists, molecular biologists, etc. Exposing students to different career paths in science is critical as they begin planning for their college or technical careers and

beyond. As an end point of this research I would like students to generate a ~~potential careers~~potential career in cancer profile in which they select a career and research job components. In this project the students would identify the job description, education/training requirements, salary/earnings/benefits, and a description of "a typical day in the life" of a person in that career.

Cancer

According to the National Cancer Institute (NCI one of the institutes that makes up the National Institutes of Health - NIH~~IH~~) cancer is the name given to a collection of related diseases. Cancer occurs when the body's cells begin to divide uncontrollably. Cancer can start in any somatic (body) cell or gamete (sex or germ cell). If the cancer forms due to a mutation in the gene of a ~~gamete~~ germ cell it can be passed down to offspring thereby making it an inherited form of cancer. ~~Usually~~ During development, c~~c~~ells grow and divide to form new cells and generate organs in the body and ~~when~~ if these cells become ~~are~~ damaged they enter apoptosis (a cellular death program). ~~In cancerous cells~~When this process is disrupted and damaged~~abnormal~~ cells continue to divide and no longer die thus they grow out of control and form~~ing~~ tumors. ~~Some cancers~~Cancers that occur in organs in the body will form masses or solid tumors, while blood cancers can form masses in many parts of the body. ~~other cancers (such as blood cancers) will not have solid tumors.~~ Tumors ~~Growths~~ can be either benign (noncancerous and will not spread throughout body) or malignant (cancerous). ~~In these~~ M~~m~~alignant tumors ~~the~~ will ~~invasion of~~invade nearby tissues and often travel to distant organs causing ~~can also be associated with~~ metastatic disease. ~~(where cancerous cells travel to other regions of the body).~~

Colon Cancer

~~According to the Mayo clinic colon~~Colon cancer is ~~a~~ cancer that is ~~found i~~located in the large intestine and specifically in the ~~(~~colon- the end of the digestive tract~~)~~. Colon cancer is typically found in older adults but does not discriminate based on age. In colon cancer the ~~the~~ first stage of the disease typically begins as a benign (noncancerous) polyp on the inside of the colon. If the polyps are unchecked or not removed, the benign polyps could progress to malignant cancer by acquiring further mutations. ~~cancer.~~

Cell Cycle

According to the National Cancer Institute (NCI~~IH~~) cancer is a genetic disease that is caused by changes at the genetic level which influence cellular growth. For this reason, cancer is considered to be caused by a deregulation of the cell cycle. The genetic changes can be spontaneous or inherited but will all result in abnormal cell division. During the

normal cell cycle cells proceed through a series of regulated steps in which the cell grows, replicates DNA, grows again, and eventually undergoes nuclear division. This process is divided into G0, G1, S, G2, and M. The cell cycle is regulated by tumor suppressors, proto-oncogenes, and DNA repair genes which help to regulate cell division according to cellular growth signals. Tumor suppressors function to stop the cell cycle when conditions ~~do not support~~de-regulate cell growth while proto-oncogenes function to progress cells through the cycle when conditions support growth. DNA repair genes are involved in repairing damaged DNA in cells. Often times the cell is signaled to enter the G0 (resting or quiescent phase) which can be a temporary or permanent when the cell should not be in a growth phase. ~~Although cells can reenter the cell cycle from this phase many cells will will carry out their normal functions in G0 they die.~~ Cancer cells have abnormal signaling where tumor suppressor genes are inactivated and/or proto-oncogenes are overexpressed. The changes allow the cells to bypass the normal ~~stopping points~~checkpoints in the cell cycle thereby promoting cell division and tumor formation. ~~While cells~~When cells acquire ~~with~~ mutations in DNA repair genes this often leads to even ~~tend to develop~~ more gene mutations which ~~could result in the formation of cancerous cells.~~ will either cause the cells to die or cause them to become cancer cells.

Normal vs Cancer~~ous~~ Cells

Cancer~~ous~~ and normal cells are microscopically different. According to the American Cancer S~~s~~ociety some features that pathologists look for when screening cancer cells include cell shape, cell size, nuclear size and shape, and cellular arrangement. In terms of size and shape, cancer cells are abnormal. Cancer cells can be larger or smaller than normal cells and often appear distorted. Although size and shape may vary depending on the individual ~~cell or cancer~~type of cancer, they ~~one thing that cancers have in common is that the cells are not uniform in shape and~~ can be distinguished from normal cells by the size of their nucleus and the ratio between the size of the nucleus compared to the amount of cytoplasm in a cell among other features. ~~which have a certain shape that is associated with normal cellular function.~~ The nucleus is the control center of the cell and is responsible for storing genetic information in the form of deoxyribonucleic acid (DNA). In cancer cells the nucleus is typically abnormal in terms of size and shape. The nucleus also tends to look larger and darker microscopically because cancer cells contain more DNA. Since the nucleus is larger and takes up more space in the cell the cytoplasm in cancer cells tends to be smaller compared to normal cells. Cancer cells may also have multiple nuclei and nucleoli as compared to a single nucleus and nucleoli in a normal cell.

From DNA to Protein

The central dogma of molecular biology revolves around the process of transcription and translation. Both normal cells and cancer cells use these processes during cellular division to produce the necessary proteins from the DNA template. This entire process

begins with DNA replication during S phase in the cell cycle. DNA replication is a series of enzymatic steps which are used to make a new copy of the DNA helix. The entire process is semi conservative where one strand of the DNA is used to make a new copy of the genetic information for the cell. This DNA is then passed into the cells during division. One of the enzymes involved in this process is DNA polymerase. DNA polymerase is used as a proofreader and is responsible for identifying and replacing errors during DNA replication. Errors during this process could lead to breaks or the integration of incorrect bases in the DNA ultimately resulting in cancer. During the process of transcription DNA is used as a template to convert the genetic information from DNA into RNA. While the process of translation uses~~ the~~ RNA to produce proteins. Errors in the processes of transcription and translation can also be associated with cancer formation. Genes control how proteins are made and proteins have specific cellular functions. The production of abnormal proteins during translation could result in alterations of cellular functions which could be associated with defects in cell cycle and division causing normal cells ~~to become~~to transform into ~~cancerous~~cancer cells.

Mutations

A mutation is simply a change in the DNA sequence. Not all mutations have negative impacts on the cell. However, some mutations are directly associated with the formation of cancers. According to Cancer.net there are two types of mutation- acquired and germline. Acquired mutations are the most common causes of cancer and these occur from damage that occurs (is acquired) over a person's lifetime. Acquired mutations are not found in all cells and cannot be passed down to offspring during reproduction. Some factors that can contribute to acquired mutations include tobacco use, exposure to ultraviolet radiation, viruses, and advanced age. Germline mutations are hereditary mutations that can be passed from parent to offspring in the sperm or the egg. Since these cells are used to produce the entire organism germline mutations will be present in every cell in the body. The statistics from Cancer.net indicate that inherited cancers account for approximately 5- 20% of all cancers. Although mutations ~~happen~~ occur ~~regularly. a~~regularly, a single mutation is not likely enough to cause cancer. Typically, a series of mutations in specific genes are required for cancers to develop which is why cancer is considered a disease of aging since older individuals had more time to accumulate mutations.

Colorectal Cancer Mutations

There are a series of mutations which have been mapped to occur in a stepwise fashion which are thought to be responsible for the development of colorectal cancer (CRC). The process to becoming a cancer can follow three pathways: Chromosomal instability (CIN), microsatellite instability (MSI), or the CpG island methylator phenotype (CIMP)

(Nguyen and Duong). The lessons in this sequence will focus on the CIN pathway because it is the most common pathway for mutations that lead to CRC and is observed in 85% of adenoma-carcinoma transitions (Nguyen and Duong). CRC begins when the normal colorectal epithelium transforms into a benign adenoma. The CIN pathway is typically activated with a mutation in the tumor suppressor gene APC (adenomatous polyposis) which can take many decades to progress. This mutation inhibits a key signaling pathway (Wnt/ ß-catenin) which results in the proliferation, invasion, and metastasis of cancerous cells. In the CIN pathway the early adenoma is transformed to the intermediate adenoma after a mutation in oncogene KRAS (KRAS proto-oncogene GTPase). KRAS is part of a larger signaling pathway that is responsible for cell proliferation, differentiation or survival. Mutations of KRAS in this signaling pathway results in constitutive activation of the downstream targets responsible for cellular proliferation. In other words, the cell receives constant signals to continue dividing. This stage generally persists on average for 2-5 years. The last set of cellular changes in the development of CRC are the deletion of chromosome 18q and the inactivation of TP53 (tumor protein 53). TP53 is a tumor suppressor and a cell cycle regulator that is supposed to trigger cells to stop at G1 or G2 or trigger apoptosis in response to cellular damage. The loss of this function allows damaged cells to progress through the cell cycle. This final step causes the progression to a malignant carcinoma (Nguyen and Duong). TP53 is the most commonly mutated gene in all cancers.

Colon Cancer Symptoms

Colon cancer typically begins with the formation of polyps but the polyps may be too small to produce symptoms. The most common symptoms as listed on the Mayo clinic website include:

- Change in bowel habits (constipation or diarrhea) or stool consistency
- Blood in stool
- Abdominal discomfort (cramps, bloating, gas, or pain)
- Feeling that bowels do not empty
- Weakness and fatigue
- Weight loss that is unexplained

Colon Cancer Treatments

There are various colon cancer treatment options depending on the stage of the cancer. The treatments outlined in this portion are recommendations provided by the Mayo Clinic based on the tumor stage. For early-stage colon cancer the treatment recommendations are minimally invasive. Some techniques recommended on the Mayo Clinic website

include polypectomy, endoscopic mucosal resection, and laparoscopic surgery. The polypectomy is a procedure used to remove polyps that are small and localized. This procedure can often be completed during a colonoscopy. Endoscopic mucosal resection is used to remove larger polyps and some of the lining of the colon. While polyps that cannot be removed during a colonoscopy are removed using laparoscopic surgical procedures. For more advanced stages of colon cancer, the recommendations are more invasive and may include a partial colectomy or ostomy. For the partial colectomy the cancerous portions of the colon are removed and the healthy parts of the colon and rectum are reconnected. The ostomy is performed when the ability to connect the colon and rectum are lost. In this procedure an opening is made in the abdomen and is connected to the bowel as a way to eliminate solid waste from the body. Sometimes this can be temporary while recovering from the surgical procedure and other times this may be permanent. In some cases, the surgical procedures are the first step in treating the cancer. In these case chemotherapy, radiation, immunotherapy, or targeted drug therapies may be required.

Colon Cancer Risks

According to the Mayo Clinic there is an increased risk of colon cancer based on any of the risk factors listed below.

- Older age = >50
- Race= African American
- Personal history of polyps or colorectal cancer
- Other Intestinal conditions = ulcerative colitis and Crohn's disease
- Inherited syndromes = FAP, HNPCC
- Family history of colon cancer
- Low fiber, high fat diets, diets high in red meat and processed meats
- Sedentary lifestyle
- Diabetes or insulin resistance
- Obesity
- Smoking
- Heavy alcohol use
- Abdominal radiation therapy (used for treatment of previous cancers).

Colon Cancer Risk Reducers

According to the Mayo Clinic there are several ways to reduce the risk factors for colon cancer. The first is to eat a healthy and ~~well balanced~~well-balanced diet. This diet should include fruits, vegetables, and whole grains. If a person~~ is~~ drinks~~ing~~ alcohol, it should be

consumed in moderation. The recommendations are one drink a day for women and two for men. Another way to reduce the risk for colon cancer are to stop smoking and maintain a healthy weight by exercising for 30 minutes per day most days of the week.

Teaching Strategies

The teaching strategies that this curriculum unit seeks to utilize are the following teaching tools:

- Case Studies
- Claim Evidence Reasoning
- Graphic Organizers
- Google Sites
- Think-Pair-Share

Case Studies: One key teaching strategy is the implementation of case studies. Using these methods students will explore cancer through a real-world scenario. During the case study students will have the opportunity to observe, analyze, implement, conclude, and summarize their findings in relationship to cancer. The case studies provide a good opportunity for students to engage in discussions and work through problem solving models. Since the cases are based on actual patient data, there is opportunity for the students to role play different aspects of the cancer care professionals from pathologist to oncologists. The case study method puts the student in the role of a problem solver and allows them to explore research from various perspective and have access to phenomenon that is not typically accessible to high school students.

Claim-Evidence-Reasoning (CER): The CER method provides students a way to organize and scaffold their responses. In the claim portion of the CER students make a statement about something that has occurred which is the premise for the rest of the writing prompt. The evidence section is used to gather and present information that is relevant to the claim. This portion of the writing prompt should provide sufficient evidence to prove or disprove the claim. The reasoning portion of the CER is used to connect the claim and evidence sections through justifying their reasoning and applying scientific principles. In this case the students will be using CER to justify their selection of a patient's mutational analysis and subsequent diagnosis.

Graphic Organizers: Graphic organizer can take many formats but are used to help students organize, simply, or clarify information. In these lessons teacher-generated graphic organizers will be used to help scaffold the lesson content to support student

learning. When used correctly graphic organizers can help guide students to categorize concepts, link interconnected ideas, and help students construct knowledge. In this unit KWL charts, T-charts, and guided skeleton notes will all be used to help students make connections among multiple topics related to cancer.

Think-pair-share: This technique provides students the opportunity to think individually about topics and answer questions. After individual processing time students share ideas in small groups with their classmates. This section of the activity focuses on building ~~on~~ oral communication skills and active listening. These activities also help with student focus because they are responsible for engaging in the conversation- which can be avoided in large group discussions- and increase comprehension of the material. In this unit think-pair-share can be used in most lessons and should help students form hypothesis or engage in discussion about their interpretations of the cancer case study information.

Google Sites: Google sites is an online platform that is similar to Wiki. Using this platform each student will create digital portfolios and collaborate on group projects. In this set of lesson plans students will use Google sites to present their findings on their research about diagnostic methodologies~~y~~ used for cancer. Students are able to include docs, videos, links, and many other formats to share their research. Since this will be used as a whole class group assignment, the site will allow students to contribute in knowledge building in the classroom and help other students to understand complex course content.

Classroom Activities

~~The~~ Cancer in the classroom: A case study curriculum is designed to improve student understanding of biological disease processes and increase their awareness of colon cancer. During this unit students will use a case study approach to develop critical thinking skills, apply foundational biology knowledge, and increase their understanding of genetics in relation to disease progression. Using colon cancer as the anchor for the unit students will explore how cancer develops, risk factors for cancer formation, and potential ways to reduce the risk of colon cancer. The curriculum is based on case studies which focus on the diagnosis of a family member with colon cancer. Students will use information based on real-life case studies to understand the biological components, diagnosis, and treatment of colon cancer.

Part I- Cell Cycle Unit
Lesson 1

Essential Question: What is cancer?
Objective: Students will be able to identify common misconceptions about cancer and describe how a normal cell becomes a cancer ~~is formed~~cell.~~.~~

NGSS Standard: RST.11-12.7 - Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.

1. Warm-up: What do you know about cancer? A think-pair-share a~~A~~ctivity. Students will work at their table groups to discuss what they know about cancer. As a table group students will share ~~out~~ the information they know with one another. When they regroup, the class as a whole will ~~and the class will make a~~ generate a document on the interactive whiteboard which details all ~~their~~ prior knowledge on the topic. This will also be a time for you as the instructor to identify any misconceptions the students may have about cancer in general.
2. Activity: Colon Cancer True or False. In this activity students will work as teams to decide which cancer facts are~~and~~ true and which are false. This activity can be completed in a game format or as a white~~-~~board activity. The activity has a range of questions about cancer in general and questions specific to colon cancer. As you go through the activity a slideshow with the correct answer explanations can be displayed on the whiteboard to en~~be~~ sure all students have access to the correct answers. Instructions: The class will work in groups to determine if the following statements are true or false. To complete the activity students will arrange their chairs into lines. Each team will be provided two index cards with the labels true or false. After the teacher reads the statement students will decide if the statement is true or false. The last person passes the index card up the line. As the card is passed each student must agree with the answer. If they do not agree they have the opportunity to pass the card backwards to retrieve the other answer card. The first group to get the card to the front with the correct answer earns one point. Teams will earn points based on the number of correct answers. Questions adapted from Statistics at a Glance: The Burden of Cancer in the United States
3. Introduce students to the Real-World Scenario Case Study- Meet Lea.
   This scenario will be used in all lessons so you can tell the story of Lea's colon cancer case study while teaching students about the background on cancer formation, diagnosis, and treatment.
4. Exit Ticket: What do you believe would be the most useful facts to learn about cancer during the lesson today? Include at least two facts in your response.
5. Homework
   Students will analyze the case study and respond to the questions: If someone asked you what is cancer how would you respond? What do you think causes cancer?

Warm-up

- **Think** (2 minutes): Write down what you know about Cancer
- **Pair**: You will be working with your elbow partner
- **Share** (4 minutes): Discuss what you know about cancer with your partner. Each partner will have 2 ~~minute~~minutes to share their findings. As a partner pair select 2 things you want to share with the entire class.

Cancer True or False Activity

Instructions:

The class will work in groups to determine if the following statements are true or false.

To complete this activity students will arrange their chairs into lines. Each team will be provided two index cards with the labels true or false.

After the teacher reads the statement students will decide if the statement is true or false. The last person passes the index card up the line. As the card is passed each student must agree with the answer. If they do not agree they have the opportunity to pass the card backwards to retrieve the other answer card.

The first group to get the card to the front with the correct answer earns one point.

Teams will earn points based on the number of correct answers.

All statements were generated using information from the American Cancer Society. https://www.cancer.gov/about-cancer/understanding/statistics#:~:text=The%20cancer%20death%20rate%20(cancer,and%20135.7%20per%20100%2C000%20women)

True or False Activity:

Statement 1: Cancer is among the leading causes of death worldwide.

Answer: TRUE

In 2018, there were 18.1 million new cases and 9.5 million cancer-related deaths worldwide.

Statement 2: Cancer is always fatal when not diagnosed early.

Answer: FALSE

The facts according to the American Cancer Society:

- The cancer death rate (cancer mortality) is 158.3 per 100,000 men and women per year (based on 2013–2017 deaths).
- The cancer mortality rate is higher among men than women (189.5 per 100,000 men and 135.7 per 100,000 women). When comparing groups based on race/ethnicity and sex, cancer mortality is highest in African American men (227.3 per 100,000) and lowest in Asian/Pacific Islander women (85.6 per 100,000).
- As of January 2019, there were an estimated 16.9 million cancer survivors in the United States. The number of cancer survivors is projected to increase to 22.2 million by 2030.
- Approximately 39.5% of men and women will be diagnosed with cancer at some point during their lifetimes (based on 2015–2017 data).
- In 2020, an estimated 16,850 children and adolescents ages 0 to 19 will be diagnosed with cancer and 1,730 will die of the disease.

Statement 3: Colorectal cancer is one of the top 3 cancers impacting men and women in the United States.

Answer: TRUE

According to the American Cancer Society Prostate, lung, and colorectal cancers account for an estimated 43% of all cancers diagnosed in men in 2020. For women, the three most common cancers are breast, lung, and colorectal, and they will account for an estimated 50% of all new cancer diagnoses in women in 2020.

Statement 4: Cancer rates are highest in countries whose populations have the highest life expectancy, education level, and standard of living.

Answer: TRUE but for some cancer types, such as cervical cancer, the reverse is true, and the incidence rate is highest in countries in which the population ranks low on these measures.

Statement 5: The overall cancer death rate has increased since the early 1990s.

Answer: FALSE
In the United States, the overall cancer death rate has declined since the early 1990s. The most recent Annual Report to the Nation, released in March 2020, shows that overall cancer death rates decreased by:

- 1.8% per year among men from 2001 to 2017
- 1.4% per year among women from 2001 to 2017
- 1.4% per year among children ages 0–14 from 2013 to 2017

Statement 6: Cancer stage at diagnosis, which refers to extent of a cancer in the body, determines treatment options and has a strong influence on the length of survival.

Answer: TRUE
In general, if the cancer is found only in the part of the body where it started it is *localized* (sometimes referred to as stage 1). If it has spread to a different part of the body, the stage is *regional* or *distant*. The earlier colorectal cancer is caught; the better chance a person has of surviving five years after being diagnosed. For colorectal cancer, 37.5% are diagnosed at the local stage. The 5-year relative survival for localized colorectal cancer is 90.6%.

Statement 7: Cancer can be effectively treated using modern medicine.

Answer: TRUE
There are many approaches including radiation, chemotherapy, and surgical approaches that are used to treat cancer.

Statement 8: Cancer is an infectious disease

Answer: FALSE
Although there are a few cancers that are caused by viruses the viruses cause changes in normal cell functions. Cancer in general is not able to be passed from one person to another in the way that an infectious disease is passed.

Statement 9: Cancer is caused by gene mutations.

Answer: TRUE
Cancer is caused by deregulation of the cell cycle. There are many mutations that can result in the formation of cancer. Many of these mutations are associated with loss of function of tumor suppressor genes or over activation of proto-oncogenes.

Statement 10: Cancer cells can be distinguished from normal cells by looking at their shape under the microscope.

Answer: TRUE
Cancer cells generally have abnormal shapes compared to normal cells. Cancer cells may have differences in the cytoplasm, nucleus, and chromatin as compared to normal cells.

Meet Lea (Case Study):
Lea is a 55-year-old female of African American descent. She started experiencing constipation and noted blood in her stool. These symptoms caused Lea some concern and she went to see her primary care physician. Lea has a history of being overweight and high blood pressure and she is currently taking medication to manage her blood pressure. During the office visit Lea had blood drawn and the blood work indicated she was slightly anemic. Lea was advised to schedule a colonoscopy due to the constipation, blood in stool, and anemia. During her previous colonoscopy she did not have any abnormal findings. Lea planned her colonoscopy for the next month. However, within a week Lea was in the emergency room due to abdominal pain and severe constipation. She was admitted to the hospital for continued evaluation. During her hospital visit further evaluation led to the diagnosis of colon cancer.

Lea has two teenage children, Diana and Nicole, who are very concerned about her hospitalization and recent diagnosis. Diana and Nicole do not know very much about cancer and are hoping to get more information from the doctor's regarding their mother's condition. Before they meet with the doctor the girls decide to find out more about their biggest question: What is Cancer?

Exit Ticket: What do you believe would be the most useful facts to learn about cancer during the lesson today? Include at least two facts in your response.

Homework: Using your background knowledge and the case study respond to the questions: If someone asked you what is cancer how would you respond? What do you think causes cancer?

Lesson 2

Essential Question: What changes in the cell cycle are associated with cancer formation?
Objectives: Students will be able to identify examine how deregulation of the cell cycle leads to cancer. Students will be able to explain the role of tumor suppressors and proto-oncogenes in the regulation of the cell cycle. Students will be able to distinguish between images of healthy cells and images of cancerous cells.
PA Common Core Standards: 3.1.B.A Examine how interactions among the different molecules in the cell cause the distinct stages of the cell cycle which can also be influenced by other signaling molecules. BIO.B.1.1.1 Describe the events that occur during the cell cycle: interphase, nuclear division (i.e., mitosis or meiosis), cytokinesis.

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

1. Warm-up: Students generate a KWL chart on what they know, want to know, and have learned about cancer. Students should work to complete the first two columns on the KWL chart leaving the last column blank for the end of the unit. Allow students 5-7 minutes to complete chart and share the r~~r~~esults with the class.
2. Background on Cancer Presentation- cell cycle and the role of tumor suppressors and proto-oncogenes in cell cycle regulation. This presentation should be used to explain the normal process of the eukaryotic cell cycle and explain the function of tumor suppressors (as brakes) and proto-oncogenes (as the gas petal) in the process.
3. Analogy Activity- During the presentation teachers will introduce the analogy of the brakes and gas petals in the car for tumor suppressors and proto-oncogenes. Students will work in small groups to form their own analogies for the process.
4. Students will view animations/ images of healthy and cancerous cells. Students will analyze the microscopic appearance of the cells and discuss the differences in the cell morphology focusing on the irregularities in the cytoplasm, chromatin, and nucleus of cancer cells.
5. Exit Ticket: Explain two ways you can differentiate between healthy and cancerous cells microscopically.
6. Homework: Write a response to the following question: How does the cell cycle relate to cancer formation? In this response include the role of tumor suppressors and proto-oncogenes.

Lesson 3/4:

Essential Question: What screening techniques are used to detect cancer?

Objective: Students will investigate early detection plans and explore diagnostic tools used in colon cancer detection.
NGSS Standards: HS-PS4-5 Communicate technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically). RST.11-12.7 - Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.

1. Warm-up: What are some common diagnostic tools you have heard about that are used to diagnose cancers?
2. Small Group Activity: Assign students to a diagnostic tool research topic. Students will work in small groups to generate a google site which explains each type of diagnostic tool used for the detection of colon cancer. The groups can focus on biopsy, colonoscopy, molecular testing of the tumor, blood tests, computed tomography (CT or CAT) scan, magnetic resonance imaging (MRI), ultrasound, or positron emission tomography (PET) scan. For each of the components the students should identify the type of material/equipment used, the purpose of the testing in relation to colon cancer screening, and how the type of diagnostic testing can be used to inform the doctors about the patient's condition.
3. Student presentations: Students will spend 3-5 minutes presenting their findings about their assigned diagnostic technique. Students will also have the information on the Google site to refer to at a later time to answer questions for the next component of the lesson.
4. Diagnostic Tools Analysis Questions: Students will answer a series of questions which are designed to help students determine the most effective preventative and diagnostic screening tools for colon cancer. 1. How could a stool sample be used to help identify colon cancer in a patient? 2. What is the most effective way to detect colon cancer early? 3. What is the most definitive way to diagnose colon cancer? 4. Select 2 diagnostic tools and compare then. Explain the advantages and disadvantages of each tool.
5. Case Study Analysis: Given the patients symptoms students will design a diagnostic plan for Lea. Students will suggest the sequence of diagnostic tools they would use to diagnose Lea as healthy or having colon cancer.

Part II- Genetics Unit

Essential Questions: What are mutations? How are mutations formed during the process of replication, transcription, and translation?

Objective: Students will analyze the role of errors during replication, transcription, and translation in the formation of cancer.

NGSS Standards: HS-LS3-2 Make and defend a claim based on evidence that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors.

PA Common Core Standards: 3.1.C.C2 Use molecular models to demonstrate gene mutation and recombination at the molecular level. BIO.B.1.1.1 Describe the events that occur during the cell cycle: interphase, nuclear division (i.e., mitosis or meiosis), cytokinesis. BIO.B.1.2.1 Describe how the process of DNA replication results in the transmission and/or conservation of genetic information. BIO.B.1.2.2 Explain the functional relationships among DNA, genes, alleles, and chromosomes and their roles in inheritance.

Lesson 1

1. Warm-up: How do genes related to cancer? What type of cell would need to carry the mutation for it to be passed down from parent to offspring (somatic of gamete)? Do you think cancer can be familial (passed down in a family)?
2. Central Dogma of Molecular Biology slideshow: During the slideshow teachers will explain the central dogma of molecular biology. These processes will include replication, transcription, and translation. In these ~~lessons~~lessons' teachers will discuss how errors in each step could lead to the formation of mutations. Teachers will explain the difference between somatic and germline mutations and how germline mutations could lead to the formation of cancer in offspring.
3. Identifying mutations Practice: Students are provided copies of normal DNA sequences and Lea's DNA sequences to compare. The students will work in small groups to identify if any nucleotide changes exist between the provided sequences. Students will use codon charts to determine if the proteins produced would be affected. Following the ~~analysis~~analysis, the class will have a discussion on their findings.

Lesson 2

1. Warm-up: What is your definition of a mutation? What are some impacts of mutations on organisms?

2. Introduction to colon cancer genetics slideshow: During the slideshow teachers will explain how mutations arise in genes. The focus of this presentation will be stepwise mutations that occur in colon cancer. Students will learn about the stepwise mutations (APC, KRAS, SMAD4, and p53) that drive the formation of colon cancer.
3. Mutation Analysis Activity Part II: Students will examine the mutations from the previous class. Based on information provided in Lea's case study students will identify which gene is mutated and which stage of cancer Lea likely has based on her mutation profile.
4. Exit Ticket: Do you think it is useful to have a genetic profile on cancer patients? Why or why not? Explain.
5. Homework: Using the information provided write a letter to Lea describing your findings. Explain the mutation(s) she has in her genetic profile and the correlation (if any) of the stage of disease she has.

Lesson 3

1. Warm-up: What does it mean for a disease to be inherited? Do you think Lea has an inherited form of colon cancer? Explain your answer.
2. Inherited colon cancer slideshow: Teachers will explain the four primary types of inherited mutations: Familial adenomatous polyposis Lynch Syndrome, Peutz-Jeghers Syndrome, and MUTYH-associated polyposis. The slideshow will explain how each type of mutation is inherited and which part of the cell is impacted.
3. Case Study CER- Using the evidence from the previous class and Lea's case study students will compose a CER (claim, evidence, reasoning) prompt. In this prompt they would examine the evidence and provide rationale for diagnosing the individual with the specific mutation responsible for the colorectal cancer in the case study. In this prompt students will use multiple lines of evidence to describe why they selected the particular type of hereditary cancer for Lea.

Part III- Risk Reducers

Essential Questions: What are the most common cancer treatment methods? How can I reduce my risk of cancer? What are potential cancer careers?

Objectives: Students will evaluate cancer therapies. Students will evaluate cancer risks and cancer risk reduction strategies. Students will investigate cancer careers.

NGSS Standards: HS-LS1-6 Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own

investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future

HS-PS4-5 Communicate technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).

RST.11-12.7 - Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.

Lesson 1/2

1. Warm-up: What are some cancer treatment therapies you have heard of? What are some benefits and risks of cancer treatment?
2. Cancer Treatment Slideshow: Teachers will explain the four treatment types used for cancer. The slideshow will explain how when/how each treatment is used.
3. Cancer Case Study Treatment Small Group Research Assignment: During this component student will work in small groups to formulate a presentation on the treatment method they selected for the case study patient and provide evidence from the class presentation and a literature search which examines why their methodology would be effective in treating the patient.

Lesson 3

1. Warm-up: What do you believe are risk factors for developing cancer? Do you believe you can lower your chances of getting cancer? Why or why not? Explain.
2. Cancer Risk Slideshow: Teachers will explain the major cancer risk factors and discuss ways to prevent cancer formation.
3. Cancer Risk Reduction Activity: Students will evaluate their own risk factors for developing cancer and will be crafting a risk reduction plan.

Lesson 4/5

1. Warm-up: What types of jobs have you heard of that relate to cancer? Do you think all jobs relating to cancer need to be in the medical field? Why or why not? Explain.

2. Cancer careers slideshow: Teachers will introduce students to various careers that are involved with cancer patient care (pathologists, genetic counselors, researchers, chemists, molecular biologists, etc.).
3. Cancer Careers Profile Activity: Students to generate a ~~potential careers~~potential career in cancer profile in which they select a career and research job components. In this project the students would identify the job description, education/training requirements, salary/earnings/benefits, and a description of "a typical day in the life" of a person in that career. The end product should be a poster that can be displayed in the classroom or a digital product for the website.

Resources

Component 1 Readings

1. Misconceptions

Unknown. "Know the Facts." *Colorectal Cancer Alliance*, 2021, https://www.ccalliance.org/colorectal-cancer-information/facts-and-statistics. Accessed 14 March 2021.

"What is colorectal Cancer." *American Cancer Society*, 2021, https://www.cancer.org/cancer/colon-rectal-cancer/about/what-is-colorectal-cancer.html. Accessed 14 March 2021.

"Statistics at a Glance: The Burden of Cancer in the United States." *American Cancer Society, 2021, https://www.cancer.gov/about-cancer/understanding/statistics#:~:text=The%20cancer%20death%20rate%20(cancer,and%20135.7%20per%20100%2C000%20women).* Accessed 18 April 2021.

2. History of cancer research

"Milestones in Cancer Research and Discovery." *National Cancer Institute (NIH)*, 31 August 2020, https://www.cancer.gov/research/progress/250-years-milestones. Accessed 14 March 2021.

Blackadar, Clarke B. "Historical review of the causes of cancer." *World Journal of Clinical Oncology*, vol. 7, no. 1, 2016, pp. 54-86. *NCBI*, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4734938/. Accessed 14 March 2021.

3. Cancer development (tumor suppressor genes/ oncogenes)

Weinberg, Robert. "How Cancer Arises." *Scientific American*, 1996, pp. 62-70.

Lee, Eva Y.H.P, and William J. Muller. "Oncogenes and Tumor Suppressor Genes." *Cold Spring Harbor Perspectives in Biology*, vol. 2, no. 10, 2010, p. a003236. *NCBI*, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2944361/. Accessed 14 March 2021.

4. Healthy vs Cancerous Cells (morphology)

Mason, Laura. "Cancer Cells Vs Normal Cells." *Cancer Research from Technology Networks*, 4 December 2020, https://www.technologynetworks.com/cancer-research/articles/cancer-cells-vs-normal-cells-307366. Accessed 14 March 2021.

O'Connor, C.M, and J.U Adams. *Essentials of Cell Biology*. Cambridge, NPG Education, 2010. *Scitable by Nature Education*, https://www.nature.com/scitable/ebooks/essentials-of-cell-biology-14749010/122997842/

"What is Cancer." *National Cancer Institute (NIH)*, 9 February 2015, https://www.cancer.gov/about-cancer/understanding/what-is-cancer. Accessed 19 April 2021.

"What do doctors look for in biopsy and cytology specimens." *American Cancer Society*, 2014, https://www.cancer.org/treatment/understanding-your-diagnosis/tests/testing-biopsy-and-cytology-specimens-for-cancer/what-doctors-look-for.html. Accessed 19 April 2021.

5. Detecting Cancer

Chen, Xingdong, and Jeffrey Gole. "Non-invasive early detection of cancer four years before conventional diagnosis using a blood test." *Nature Communications*, vol. 11, no. 3475, 2020. *nature.com*, https://doi.org/10.1038/s41467-020-17316-z.

Nguyen, Ha This, and Hong-Quan Duong. "The molecular characteristics of colorectal cancer: Implications for diagnosis and therapy (Review). *Oncology letters*, vol. 16 no. 1, 2018. *Spandidos publications*, *https://www.spandidos-publications.com/10.3892/ol.2018.8679*.

"How Cancer Is Diagnosed." *National Cancer Institute NIH*, 2019, https://www.cancer.gov/about-cancer/diagnosis-staging/diagnosis. Accessed 14 March 2021.

Tze, Christina, et al. "Understanding colorectal cancer in Malaysia: A mini-review and pioneering colorectal cancer awareness, screening and treatment project." *Journal of Cancer Treatment and Diagnosis*, 2017. *Journal of Cancer Treatment and Diagnosis*, https://www.cancertreatmentjournal.com/articles/understanding-colorectal-cancer-in-malaysia-a-minireview-and-pioneering-colorectal-cancer-awareness-screening-and-treatment-projec.html. Accessed 14 March 2021.

Component 2 Readings

6. Genetic mutations and cancer

Cavagnari, Mariana Cavagnari, et al. "Impact of genetic mutations and nutritional status on the survival of patients with colorectal cancer." *BMC Cancer*, vol. 19, no. 644, 2019. *BMC Cancer*, https://bmccancer.biomedcentral.com/articles/10.1186/s12885-019-5837-4. Accessed 14 March 2021.

"What is a gene mutation and how do mutations occur?" *US National Library of Medicine*, 2020, https://medlineplus.gov/genetics/understanding/mutationsanddisorders/genemutation/. Accessed 14 March 2021.

7. Inherited versus spontaneous mutations (transcription/translation)

Brown, Anna-Leigh, et al. "Finding driver mutations in cancer: Elucidating the role of background mutational processes." *PLOS Computational Biology*, vol. 15, no. 4, 2019, p. e1006981. *PLOS*, https://journals.plos.org/ploscompbiol/article?id=10.1371/journal.pcbi.1006981. Accessed 14 March 2021.

"The genetics of Cancer" *Cancer.Net* March 2018. https://www.cancer.net/navigating-cancer-care/cancer-basics/genetics/genetics-cancer. Accessed 20 April 2021.

8. Colon cancer gene mutations

Lee, Sei-Jung, and C. Chris Yun. "Colorectal cancer cells – proliferation, survival and invasion by lysophosphatidic acid." *Int J Biochem Cell Biol*, vol. 42, no. 12, 2010, pp. 1907–1910. *National Institutes of Health*, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2975809/pdf/nihms244944.pdf.

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Teaching, Model. "Claim-Evidence-Reasoning (CER)." *Model Teaching Education for Better Educators*, 29 January 2019, https://www.modelteaching.com/education-articles/writing-instruction/claim-evidence-reasoning-cer. Accessed 14 March 2021.

Component 3 Readings

9. Cancer treatments

Pucci, Carlotta, et al. "Innovative approaches for cancer treatment: current perspectives and new challenges." *Ecancermedicalscience*, vol. 13, no. 961, 2019. *NCBI*, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6753017/. Accessed 14 March 2021.

Miller, Kimberly, et al. "Cancer treatment and survivorship statistics, 2019." *CA: A Cancer Journal for Clinicians*, vol. 69, no. 5, 2019, pp. 363-385. *ACS Journals*, https://acsjournals.onlinelibrary.wiley.com/doi/10.3322/caac.21565. Accessed 14 March 2021.

10. Careers in cancer

"Health Professionals Associated with Cancer Care." *American Cancer Society*, 2021, https://www.cancer.org/treatment/finding-and-paying-for-treatment/choosing-your-treatment-team/health-professionals-associated-with-cancer-care.html. Accessed 14 March 2021.

11. How to reduce your risks?

McDowell, Erin. "10 jobs that are linked to a higher risk of cancer." *Insider*, 27 July 2020, https://www.businessinsider.com/jobs-linked-to-higher-risk-of-cancer-2019-7. Accessed 14 March 2021.

Chan, Andrew, and Edward Giovannucci. "Primary Prevention of Colorectal Cancer." *Gastroenterology*, vol. 138, no. 6, 2010, 2029–2043.e10. *NCBI*, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2947820/. Accessed 14 March 2021.

"Colon Cancer." *Mayo Clinic*, 2021, https://www.mayoclinic.org/diseases-conditions/colon-cancer/symptoms-causes/syc-20353669. Accessed 21 April 2021.

Appendix

When thinking about how the unit plan implements the Pennsylvania science standards and Next Generation Science Standards, each of the following unit sections use the corresponding standard(s):

~~A description of how your unit implements the academic standards~~

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

HS-LS3-2 Make and defend a claim based on evidence that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors.

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

HS-PS4-5 Communicate technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).

RST.11-12.7 - Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.

PA Common Core Standards:

Standard - 3.1.B.A Examine how interactions among the different molecules in the cell cause the distinct stages of the cell cycle which can also be influenced by other signaling molecules.

Standard - 3.1.C.C2

Use molecular models to demonstrate gene mutation and recombination at the molecular level.

BIO.B.1.1.1 Describe the events that occur during the cell cycle: interphase, nuclear division (i.e., mitosis or meiosis), cytokinesis.

BIO.B.1.2.1 Describe how the process of DNA replication results in the transmission and/or conservation of genetic information.

BIO.B.1.2.2 Explain the functional relationships among DNA, genes, alleles, and chromosomes and their roles in inheritance.