



HeLa Cells, Cervical Cancer, and the HPV Vaccine

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Introduction

Imagine that you were my seventh grade student and I told you that there was a woman who died of cervical cancer in 1951, but whose cells are alive today. Sounds astonishing, even incomprehensible to many, but this is the case with the story of Henrietta Lacks.

Henrietta Lacks was a poor African-American tobacco farmer from Virginia. She was married with four children at the time. They were having a difficult time financially and decided that it was time for a change. She moved to Baltimore with her family so that her husband, David Lacks, could work in the steel industry. "The work was tough, especially for black men, who got the jobs white men wouldn't touch."¹ The black workers at Sparrows Point, the steelmaking and shipbuilding community in which they lived, made about eighty cents an hour at most, usually less, while white workers got higher wages. While the pay was minimal, this was a considerable amount more than what they were making farming tobacco in Virginia.

A short time after giving birth to her fifth child, Henrietta was diagnosed with cervical cancer. She had been complaining about feeling a knot in her womb. When she finally went in for an examination, after some prompting from her close friend and cousin, it was found that she had cervical cancer. She became a patient at Johns Hopkins Hospital during her cancer treatment, since it was the closest place to her that would treat African-Americans at the time. "David drove Henrietta nearly twenty miles to get there, not because they preferred it but because it was the only major hospital for miles that treated black patients."²

This was the time of Jim Crow and there was segregation all around, including hospitals. Jim Crow Laws affected every aspect of daily lives. Although black men had been given full citizenship in 1868 with amendment XIV,³ in 1896, the U.S. Supreme Court established separate but equal in Plessy v. Ferguson.⁴ This decision came to mean that any law that was established led to different rules for blacks and whites. These laws came right after the Reconstruction Era, a period following the civil war where an attempt was made to redress the inequalities of slavery and its political, social and economic legacy.⁵ Reconstruction lasted only twelve years, and before long, Jim Crow was the law of the land. Based on the theory of white supremacy, from schools to playgrounds to hospitals, segregation was the law. While it was stated that these institutions were separate but equal, it was never that way. The facilities for blacks were mostly always inferior to that of whites. Henrietta Lacks was a cancer patient during this time.

Henrietta Lacks' cervical cancer cells were taken without her consent during a biopsy and became the first cultured human cells, since they divide indefinitely in a lab. Her cells were unique since they did not stop multiplying. Normally, cells in culture will go through several rounds of mitosis and eventually begin to die out. Cells in the body also divide, but stay within their organs and specialize. Cancer cells proliferate rapidly compared to normal cells. They do not stop proliferating when prompted by cues. They do not differentiate normally and remain as immature cells. They do not specialize or die. This is problematic because as they continue to proliferate, they grow into tumors, and this, a malignant tumor, is what was found in Henrietta's cervix.

These cells that grew indefinitely in a cultured dish, became known as HeLa cells, He for Henrietta and La for Lacks. The cells could be used to conduct many experiments since the cells rapidly reproduced. According to Smithsonian.com, these cervical cancer cells were essential in providing the cells that aided in developing the polio vaccine by Jonas Salk, they went up in the first space mission to see what would happen to cells in zero gravity, and "many scientific landmarks since then have used her cells, including cloning, gene mapping and in vitro fertilization."⁶

Her story is extraordinary, if not for what her cells have given to scientific research, then because her family was completely oblivious to the fact that her cells are alive today. For her family, it is a story of discovery, revisiting the past and trying to understand the current situation of HeLa cells. Henrietta Lacks' family was not aware that her cells were used for scientific research until the author of the book, *The Immortal Life of Henrietta Lacks*, began to contact the family after hearing about HeLa cells in one of her biology college courses. When Rebecca Skloot began to explain to Henrietta's adult children about the HeLa cells, understandably, they had a very difficult time comprehending.⁷

While I would love to continue telling the story of Henrietta Lacks, I will make my connections to science, in particular the field of biology. While the book tells her story, in what seems to be a fictional narrative, it also covers a long list of content presented in the Next Generation Science Standards (NGSS) for Life Science. It is my intent in this unit and throughout my teaching to connect learning with historical or relevant, present, societal content. Taking science and looking at it through a historical or social lens provides opportunities for understanding. Not only are my students allowed to view the technological and medical advances that have taken place throughout our history, but they are also able to learn how these advancements did not always reach groups of people equally.

Primarily, I will concentrate on how certain racial groups have not always been treated fairly when it comes to medical research. For example, in the book, the author tells the story of Henrietta and the racism she experienced as she received treatment for her cervical cancer. She had to walk through the back door of Johns Hopkins Hospital and was held in the wing where all the people of color were admitted.

If she would have been a white woman being treated for cervical cancer at Johns Hopkins, her tissue may have never been taken without her consent and we would not have HeLa cells. While people of color have not always benefited from breakthroughs in medical research, they have been instrumental in developing it.

The book makes reference to the Tuskegee Syphilis Experiment, which was conducted between 1932 and 1972 by the US Public Health Service. Even after penicillin became the drug of choice to combat syphilis, the men in the study were not offered the antibiotic because it would affect the results of the study.⁸ They recruited hundreds of African-American men with syphilis, then watched them die slow, painful, and preventable deaths.⁹ One of Martin Luther King's most famous quotes is "Of all the forms of inequality,

injustice in health care is the most shocking and inhumane.”

School Background and Rationale

I work in the Back of the Yards neighborhood in Chicago. Our school, William H. Seward Communication Arts Academy, has just under 800 students and is a pre-kindergarten through eighth-grade school. For the first time since I began working here, our schedule will include 90 minute blocks, two times a week, plus an hour on Fridays. I am looking forward to this schedule because it will allow more time for labs.

Our school is composed of 98% Latino/a and 100% low-income students. Forty-seven percent of our students are English language learners. It is a vibrant community composed of mostly Mexican immigrant families. Although the neighborhood is plagued with violence, violence does not define our neighborhood. Our students are bright, inquisitive, and in the process of becoming active members of our global society. They truly care about the world they live in and are constantly coming up with ideas of how to make our world better. To me, it is important for them to see people of color who have taken part in the scientific field. I received the following email from a student during a weekend this past school year regarding cancer:

“For a really long time scientists have tried attacking cancer cells. I had a dream about how it would be better if we would find a way to improve our white cells by creating a type of vaccine for them and creating immunity. It is easier to end a disease than to prevent it. It would be like making a flu shot. With the technology we have, it shouldn't be hard. The plan is to program our own DNA so it can pass on from generation to generation eventually ending cancer and making it impossible for it to reproduce. Our bodies will create antibodies that will attack the cancer cells.”

At first, his dream did not make much sense to me. It sounded simplistic and confusing. After taking the biomedical engineering seminar, I now see that his dream, in a way, was describing the prevention of cervical cancer by administering the HPV vaccine. If students are dreaming about ways to cure cancer, then I feel an obligation to teach them about it and include it as part of our curriculum. This questioning and thought process by our students is needed to guide them in their continuous search for answers. I will do what I can to keep their active minds engaged in science and the civic responsibility that comes with it.

Content Background

Ultimately, in this unit, besides inspiring our students to become change agents, I would like to make a connection to two previous units I have taught. While my unit is not directly about Henrietta Lacks, my interest in cervical cancer arose from that nonfiction piece. I will use this unit as a precursor to introduce the unit based on her book. While reading excerpts from the prologue of her book, we will tie the science content that is presented in the narrative to labs on cell structure, cell membranes, diffusion and osmosis, DNA extraction, mitosis, organ systems and others.

Another related unit is from the Chicago Public School's seventh-grade curriculum for sexual health, since it

does introduce the HPV (human papillomavirus) as a sexually transmitted infection. The Chicago Public School's curriculum on sexual health introduces HPV by first explaining the difference between a sexually transmitted disease caused by a bacteria and one caused by a virus. This is a great opportunity to take this lesson and tie it into science. Here, I present the information given by the sexual health curriculum and do an activity on the difference between bacteria and a virus. I use this background knowledge to further investigate the connection between HPV and cervical cancer. In my readings, I have learned that the majority of cases of cervical cancer are caused by the human papillomavirus (HPV). It is also important to note that some of the research on cervical cancer has been done using Henrietta's own HeLa cervical cancer cells. I find this fascinating. To think that she had no clue how significant her cells would become in the scientific field.

Content Objectives

The International Baccalaureate mission statement begins with the phrase, IB aims to develop inquiring, knowledgeable and caring young people who help create a better and more peaceful world through intercultural understanding and respect.¹⁰ Since we are an IB candidate school, with a high stress on the implementation of project based learning and in accordance with the NGSS (Next Generation Science Standards), our 7th graders learn about life science using an inquiry based model approach while making global connections. I am concentrating on the following strand, Heredity and Variation of Traits: Develop and use a model to describe why structural changes to genes (mutations) located on chromosomes may affect proteins and may result in harmful, beneficial, or neutral effects to the structure and function of the organism.¹¹ I am also using the National Sexuality Education Standards. The goal of the standards is to provide a clear and consistent core content for sexuality that is developmentally and age appropriate.¹² Research has highlighted the need to provide effective, sexuality education to young people. In my opinion, Chicago has done a wonderful job of putting a curriculum together that addresses these standards.

In their study of this unit, students understand that human cells contain DNA structures that dictate the function of the cell. They understand that mitosis is a cell division process that produces cells that are genetically identical. That at times, mistakes happen during mitosis and that this could be insignificant or extremely significant. They are able to explain what a virus is and how it causes an infection. Also, they are able to make the connection between the human papillomavirus (HPV) and cervical cancer. They understand the importance of vaccines and have an appreciation for the biomedical engineering behind them. Finally, they research and hold a forum on the importance of funding organizations, such as Planned Parenthood, so that they can continue providing cancer prevention services. They also prepare a public service announcement that informs their audience about the importance of getting the HPV vaccine.

My ultimate goal is to teach the NGSS while focusing on Social Justice issues. I want my students to learn the content but to also feel a sense of responsibility to the world around them. I want my students to look at scientific related events with a critical eye and to make any necessary changes needed to make our world a better place to live in.

Content

The Cell

Cells have been around for at least 3.5 billion years. It is believed that eukaryotic cells evolved from prokaryotic cells. There are different theories on how the first cells came to be, from being carried to Earth by meteorites, to being created at deep sea vents, to being synthesized by lightning in a reducing atmosphere.¹³

There are two categories of biological cells, prokaryotic and eukaryotic. Prokaryotic cells are unicellular, and unlike eukaryotic cells, they do not have a nucleus or membrane-like organelles. All cells, except red blood cells, contain DNA. The majority of its DNA, which is usually one circular strand, is found in the nucleoid. Bacteria and archaea are prokaryotic cells. Typically, prokaryotic cells are much smaller and simpler than eukaryotic cells.

Unlike prokaryotic cells, eukaryotic cells have different compartments with specialized functions. Eukaryotic cells contain a nucleus with the DNA information needed to carry out the cell's functions. There are other membrane bound organelles within the cell, like mitochondria and lysosomes, for example. While all cells replicate, prokaryotic cells replicate by binary fission, while eukaryotic cells replicate by mitosis or meiosis. It is eukaryotic cells that I will concentrate on in this unit.

The Virus

A virus is a particle that reproduces by attaching itself to a host cell. Under guidance of the viral genome—either DNA or RNA—the virus uses the host cell to make more viruses. Viruses need a host cell because without it, they cannot reproduce. This is the reason they are considered non-living. They do use the same genetic code as living cells, however. This allows them to reprogram the host cell, allowing for the making of more viruses.

Viruses are small, much smaller than bacteria or our regular cells. They are tiny packages of nucleic acid and protein. The DNA or RNA is found inside a protein shell, called a capsid. Some viruses have a membrane called the envelope. They are extremely diverse and have different kinds of genomes, and infect different kinds of hosts. When viruses attach themselves to the host cells, they reprogram the cell to become a virus-making cell. There are about 10^{31} viruses on earth at any given time but most of these viruses are found in oceans where they attack bacteria and other microbes.¹⁴

The Viral Infection

A viral infection means that many viruses are using the body's cells to make copies of themselves. The viral life cycle is the process in which this occurs. Generally, the virus attaches itself to the cell; after that, the virus enters the cell. Once the virus is inside the cell, the DNA or RNA is copied and its genes make viral proteins. New viral particles are assembled from the genome copies and viral proteins. These new viral particles exit the cell and are ready to infect other cells and continue the process. Human papillomavirus (HPV) is the most common sexually-transmitted infection in the US.¹⁵

In 1983 and 1984 in Germany, physician Harald zur Hausen found that two HPV strains, HPV-16 and HPV-18, caused cervical cancer in women. By identifying this, they were able to make a vaccine that would target

these strains. Harald zur Hausen started his research on HPV after reviewing medical reports that discussed cases of HPV genital warts that progressed to cervical cancer in female patients, and in 1976, he published his hypothesis that HPV caused cervical cancer in the article, "Condylomata Acuminata and Human Genital Cancer".¹⁶

This is one of the reasons that Pap smear tests are so important. The Pap smear was named after Georgios Papanikolaou, the doctor who determined that this was an effective way to test for cervical cancer. The Pap smear test which was developed in 1928 is a screening that is able to test the woman's cervix and detect abnormal cells taken from the lining. Most of the time, the test is able to detect any change that occurs in the cells of the cervix. Most cervical cancers develop over a long period of time, therefore having regular check-ups is key to prevention. The test will be able to determine if there is a change in the cervix before the cancer even forms. According to the American Cancer Society, changes in the cervix are often caused by the human papillomavirus.¹⁷

The Cancer

According to the Cancer Treatment Centers of America, we have about 40 trillion cells and those cells constantly go through the process of mitosis in order to duplicate and form new cells. Mitosis is a process where cells divide and produce more cells that are genetically identical to themselves. Since cells wear out, they need to keep reproducing themselves. Mitosis begins with a mother cell which divides and produces two new identical cells, daughter cells. This process replaces old cells with new ones. Mitosis splits its chromosomes in a series of steps.

There are four basic phases in mitosis: prophase, metaphase, anaphase, and telophase. Cytokinesis, the step where dividing the cell to make the two new daughter cells, begins in anaphase or telophase. These phases occur in sequential order. Right before a cell begins mitosis, the cell is in interphase and has copied its DNA. The cell has also made a copy of its centrosome, making it a total of two. In early prophase, the mitotic spindle begins to form; the spindle's job is to organize the chromosomes during mitosis, and the nucleolus disappears. In late prophase, the spindle begins to capture and organize the chromosomes. Then comes metaphase, here the spindle has captured and lined up all the chromosomes in the middle of the cell and is ready for them to divide. During anaphase the sister chromatids separate from each other and are pulled toward opposite ends of the cell. In telophase the cell is nearly done dividing. Remember, cytokinesis takes place around anaphase or telophase, so the two cells are now beginning to divide.¹⁸

Not all cells divide at the same rate. Cells in the brain do not divide very fast, on the contrary, cells in the lung, gut, and bone-marrow have more divisions during mitosis than normal. Sometimes, something in the cell division goes wrong and cells begin to grow out of control. Cancer cells proliferate even more rapidly, while a normal cell would eventually stop proliferating.¹⁹ Therefore, when we speak of cervical cancer, it is this out of control cell division in the cervix. They are heterogeneous cells that do not stay contained. When those cells continue to grow, they accumulate and form a mass called a tumor. Cancer is graded according to its stage.

The Tumor, Node and Metastases (TNM) is a staging system that classifies tumors found in the body. The T is used on a scale of 0 to 4. A 0 indicates that the tumor has not invaded the local environment and a 4 means that a tumor has spread into another organ.

While most cells know their boundaries, cancer cells do not. Cancer cells can spread throughout the body through the lymphatic system. The lymphatic system helps rid the body of toxins, waste and other unwanted

materials. The primary function of the lymphatic system is to carry lymph, a fluid containing white blood cells, which make T-cells, throughout the body. Dead cells are collected in the lymph. Lymph nodes are found throughout the body and contain many cells, in particular white blood cells. They act as filters for immune activity. In the lymph nodes, cells help fight bacteria and viruses. The tonsils, adenoids, spleen, and thymus are all part of the lymphatic system.²⁰ N0 indicates that no tumor cells have entered the local lymph nodes, whereas N4 indicates excessive involvement.²¹

If the tumor spreads to a different site from where it originated, it is said to have metastasized. This is a sign that the tumor is in advanced stages. The letter M represents how much the tumor has metastasized. M0 meaning no metastasis and M1 indicating that metastasis is present.

The Vaccine

In the early twenty first century, pharmaceutical companies Merck & Co. and GlaxoSmithKline created HPV vaccines protecting against HPV-16 and HPV-18. These vaccines have reduced the number of HPV infections by fifty-six percent in the US.²² There are two vaccines, Gardasil and Cervarix. While Gardasil protects against four strains of the human papillomavirus- HPV 6, 11, 16, and 18, Cervarix protects against two, HPV 16 and 18. HPV 6 and 11 cause 90 percent of all genital warts. HPV 16 and 18 cause about 70 percent of all cervical cancers and are associated with about 80 percent of anal cancers.²³

In the United States, HPV vaccination rates have been strongly and inversely correlated with cervical cancer mortality rates and median income. Because cervical screening coverage is inversely associated with poverty and deprivation, ensuring equitable HPV vaccine delivery and high coverage in populations that are less likely to have opportunities for cervical screening as adults remains a priority.²⁴

Global Perspective

Globally, cervical cancer is the third most common cancer among women. There are an estimated 529,000 new cases and 275,000 in the year 2008. More than 85% of the cervical cancer cases occur in developing countries. Also, 88% of the cervical cancer deaths that occur globally occur in developing countries.²⁵ Although there is a vaccine, the cost of it is too much for many women in these developing countries to afford.

Not only is cervical cancer represented disproportionately among women on a global scale, but there is a large disparity here within the United States. The incident rate of cervical cancer is about twice as high among Latina and African-American women living in the U.S. than among white women. Furthermore, the death rate for Latinas and African-American women who die of cervical cancer is also 50% more than their white counterparts.²⁶ According to the Association of Reproductive Health Professionals, these disparities are thought to be due to low rates of Pap testing and failure to follow up with treatment after abnormal Pap testing among Latinas. Widespread poverty, which leads to decreased access to medical care, diagnosis at a later stage of disease, and unequal treatment for African American women is also an explanation given by them. I would even suggest that due to the history of negative medical practices against African Americans in this country, there is a wide distrust among the African American community and some of the medical practices in the United States.

In looking at cervical cancer from a global perspective, it is impossible to ignore the disparities that exist in cervical cancer rates among women of different regions. As close to home as our southern border, statistics show that in the border region of Texas cervical rates are 30 percent higher than the national average.

According to NPR, “while methods of preventing cervical cancer in the United States continue to advance and shift, disparities persist. Women with the fewest years of schooling are the least likely to be screened. And African-American and Hispanic women are disproportionately represented among those who develop the cancer.” In the Cervical Cancer Global Review, there is a global call for action in low income and middle income countries.

Planned Parenthood

According to Dr. Cecilia Norris, a primary care physician in Iowa City, “If you’re uninsured, like many of my patients, Planned Parenthood is the only remotely affordable option (for women’s healthcare) in town.”²⁷ About 40 percent of Planned Parenthood’s revenue for services, not including abortions, such as contraception, sexually transmitted infection testing and cancer screening, come from the government, mostly through Medicaid. There has been recent talk by the GOP to defund Planned Parenthood and use money for community healthcare clinics instead. If this becomes the case, these community health care centers would have to scale up their family planning departments.²⁸ According to PBS Newshour, Planned Parenthood says its yearly workload includes 4.5 million tests and treatments for sexually transmitted diseases and 900,000 cancer tests and treatments. Eighty percent of Planned Parenthood’s clients earn 150 percent of the federal poverty level or less.²⁹ Proponents of Planned Parenthood argue that a decrease in funding will only harm those who need the healthcare services it provides the most.

Teaching Strategies

During the past year I was fortunate to be part of a program titled MSUrban STEM. The program was a partnership with WIPRO, an IT company, and Michigan State University. In this program, the approach to teaching centered around giving equal thought to pedagogy, content, and 21st century technology, such as using social media to make learning public, for example. The approach to teaching strategies that I take in this unit is to use the content knowledge that I have learned in this seminar, the pedagogical approaches that I have learned in my 18 years of teaching, and lastly the constant reminder to integrate technology as an essential strategy in my teaching. The book, *Stuck in the Shallow End*, talks about the inequalities in computer science fields among people of color. The careful and intertwined integration of the three provide an opportunity for my students to learn content with lessons that are prepared with high expectations that will allow them to compete in the current age of technology.

I use Piktochart to have the students make a public service announcement. I use a tutorial such as insidecancer.org or Brainpop.com to help explain the development of cancer. Students use Chromebooks for research on preparing for a debate on the funding of Planned Parenthood, its purpose, and the type of services it provides.

All this while keeping in mind the essential question, “Does the history of racism, in particular during the Jim Crow Era, negatively affect the health of African Americans and other minority groups today? What are some of the things we can do to combat that disparity?”

Classroom Activities

Since the natural process for teaching organ systems for me has been to start with the cell and move to organs, then organ systems, I usually begin with the cardiovascular system, followed by the respiratory system. For this unit, I am rethinking the order in which I will teach the organ systems. I feel that teaching the lymphatic system in the context of teaching about cancer may make it more comprehensible. Therefore, the general sequence of this unit will be from cells to cell structure and function, including mitosis, to the lymphatic system. We will end with a public service announcement on the HPV vaccine and a debate on whether Planned Parenthood should continue to be federally funded.

Cell

When introducing eukaryotic cells to the students, it is important to have something concrete that they can compare it to so that they can understand the function of the cell parts and functions. I have seen various versions of the following activity but the one that I will describe here was introduced to me during a weeklong professional development with the Museum of Science and Industry. As the students are introduced to the vocabulary of the cell parts, they find a matching word from parts of a factory that has a similar function. With index cards, they match a cell part with a factory part on the other side and write why they are similar. For example, the word lysosome matches with the words maintenance crew because they are both responsible for breaking down, cleaning up and repairing items in the factory, just like lysosomes do inside the cell. After matching the cell parts to the factory parts, students can practice and play a guessing game with their partner before taking a quiz. The reading excerpt that we read from *The Immortal Life of Henrietta Lacks* is on page 43.

Virus vs. Bacteria

Students watch the video, Bacteria and viruses: What's the differences? on TED-Ed. While they are watching the video, they are given a Venn diagram to fill out the similarities and differences between a bacteria and a virus. After the students have completed their Venn diagram, and we have a discussion on the similarities and differences between the two, we continue with a concentration on the virus. Students are assigned to groups. They write a comic book script with a virus that attacks the body as the main antagonist. If needed, for further understanding, after they write their script, they can act out how a virus attacks a cell with their assigned group. The idea is to get students to begin asking what/who the protagonist of their script could be.

Mitosis

The students make a stop-motion video to represent the process of cell division. Students work in partners to make still shots of a cell in the process of division. They are given various materials to choose from their Makers Space containers to create models of mitosis in action. They design each of the mitosis steps and then using one of the free stop-motion apps on their phone or on one of the school's iPads, they make the stop-motion video. We begin to have discussions of what can happen when there is an error in the duplication. The reading excerpt that we read from in *The Immortal Life of Henrietta Lacks* is on page 44.

Lymphatic System

After students become familiar with cells and their functions, we move on to the lymphatic system. I give the

students a large paper with the outline of the human body. They create a board game that carries lymph around the body with the lymph nodes as places where we want to stop and pick up extra points. During this activity, students sketch the circulation of the lymph throughout the body. Students use their textbook to gather the information needed. They include lymph nodes (capsule, cortex and medulla), the thymus, tonsils and spleen. They also incorporate b-cells and t-cells into their game. As an assessment, students write a paragraph on how the lymphatic system functions.

Debate

Students will do research on Planned Parenthood and the services it provides. Some of the questions they will answer are, what percentage of federally funded money goes to cervical cancer testing? What are the demographics of women who use Planned Parenthood by socio-economic status and race? What are some of the negative (or positive) effects that can happen if Planned Parenthood were to stop receiving federally funded money? They will take a stand on whether Planned Parenthood should continue to be federally funded or not. One way to present their information during the debate is to put their newly found information into graphs using plotly.com.

Ad Campaign PSA for HPV

Using Piktochart, students will create a public service announcement poster that will educate their audience on the importance of the HPV vaccine. On Piktochart, students are able to use a world map that they can use to represent the incidence of cervical cancer rates and deaths by country or region. Since we are an IB candidate school, our students are required to do a community project that benefits our community. Since they have learned that cervical cancer affects Latina women at a higher rate than white women, and our school is 98% Latino/a, I will encourage some of the students to take this project on and extend it as their community project. One way they can extend it by holding an informational session to provide a valuable resource to our community.

Endnotes

1. Rebecca Skloot, in *The Immortal Life of Henrietta Lacks*
2. Ibid, 26
3. Ibid, 15
4. Constitutional Rights Foundation
5. PBS
6. Encyclopedia Britannica
7. Rebecca Skloot, *The Immortal Life of Henrietta Lacks*
8. Center for Disease Control and Prevention
9. Rebecca Skloot, *The Immortal Life of Henrietta Lacks*, 59
10. IB Policy Handbook
11. NGSS Standards
12. National Sexuality Education Standards
13. Bedau, Mark A., and Carol E. Cleland, "The Origin of Life: A Review of Facts and Speculation"
14. Khan Academy

15. Onhealth.com
16. The Embryo Project Encyclopedia
17. American Cancer Society
18. Khan Academy
19. Class Notes
20. LiveScience.com
21. Mark W. Saltzman, *Biomedical Engineering: Bridging Medicine and Technology*
22. The Embryo Project Encyclopedia
23. ARHP Association of Reproductive Health
24. C.M. Wheeler, "Less is More: A Step in the Right Direction for Human Papillomavirus (HPV) Vaccine Implementation"
25. Indian Journal of Medical Oncology
26. ARHP.org
27. Ameliatd, "How Defunding Planned Parenthood Could Affect Healthcare"
28. Ibid
29. Alan Fram Associated, "5 things to know about Planned Parenthood fight in Congress"

Appendix: Implementing District Standards

Next Generation Science Standards

Students who demonstrate understanding can:

MS-LS3-1. Develop and use a model to describe why structural changes to genes (mutations) located on chromosomes may affect proteins and may result in harmful, beneficial, or neutral effects to the structure and function of the organism.

Disciplinary Core Ideas

LS3.B: Variation of Traits

In addition to variations that arise from sexual reproduction, genetic information can be altered because of mutations. Though rare, mutations may result in changes to the structure and function of proteins. Some changes are beneficial, others harmful, and some neutral to the organism.

International Baccalaureate Key Concept:

Systems

Related concepts:

Function and Models

Global Contexts:

Fairness and Development:

What are the consequences of our common humanity?

Students will explore rights and responsibly; the relationship between communities; sharing finite resources with other people and other living things; access to equal opportunities; peace and conflict resolution.

Bibliography

Ameliatd. "How Defunding Planned Parenthood Could Affect Health Care." FiveThirtyEight. March 09, 2017. Accessed August 04, 2017. <https://fivethirtyeight.com/features/how-defunding-planned-parenthood-could-affect-health-care/>

Bedau, Mark A., and Carol E. Cleland. "The origin of life: a review of facts and speculation." *The Nature of Life*: 121-28. doi:10.1017/cbo9780511730191.012.

"Cancer Biology – Inside Cancer: A Multimedia Guide to Cancer." Cancer Biology – Inside Cancer: A Multimedia Guide to Cancer. Accessed August 18, 2017. <http://www.insidecancer.org/>

"Cancer Treatment Centers of America - Integrative Cancer Care." Accessed August 18, 2017. http://www.bing.com/cr?IG=6B78CECC95E84C44A6F54BF369EEE212&CID=3B4BFC1CFF5C69820D39F6FEFE5A6802&rd=1&h=FHpON6QtcFx8VAEw6_1pe516wJRI3du0oF6WCyZKnFs&v=1&r=http%3a%2f%2fwww.cancercenter.com%2f&p=DevEx,5061.1

"Comprehensive Cancer Information." National Cancer Institute. Accessed August 18, 2017. <https://www.cancer.gov/>

"Cracking the Code of the Human Genome." Smithsonian.com. Accessed August 18, 2017. <http://www.smithsonianmag.com/specialreports/human-genome-180947985/>

"Globocan." Globocan. Accessed August 18, 2017. http://globocan.iarc.fr/Pages/fact_sheets_cancer.aspx

"Journal of the National Medical Association®." *Journal of the National Medical Association* 102, no. 3 (2010): 1113. doi:10.1016/s0027-9684(15)30764-1.

Levesque, Roger J. R. "Human Papillomavirus (HPV) and HPV Vaccines." *Encyclopedia of Adolescence*, 2011, 1340-342. doi:10.1007/978-1-4419-1695-2_435.

Mishra, Gauravia, Surendras Shastri, and Sharmilaa Pimple. "An overview of prevention and early detection of cervical cancers." *Indian Journal of Medical and Paediatric Oncology* 32, no. 3 (2011): 125. doi:10.4103/0971-5851.92808.

Press, Alan Fram Associated. "5 things to know about the Planned Parenthood fight in Congress." PBS. September 04, 2015. Accessed August 04, 2017. <http://www.pbs.org/newshour/rundown/5-things-know-planned-parenthood-fight-congress/>

Robbins, Stanley L., Ramzi S. Cotran, Vinay Kumar, Abul K. Abbas, and Jon C. Aster. *Pathologic basis of disease*. Philadelphia, PA: Saunders Elsevier, 2015.

Saltzman, W. Mark. *Biomedical engineering: bridging medicine and technology*. Cambridge: Cambridge University Press, 2016.

Skloot, Rebecca. *The Immortal Life of Henrietta Lacks*. Crown/Archetype, 2010.

Stern, Peter L., and Henry C. Kitchener. *Vaccines for the prevention of cervical cancer*. Oxford: Oxford University Press, 2010.

"Types of Cancer Treatment." National Cancer Institute. Accessed May 06, 2017.
<https://www.cancer.gov/about-cancer/treatment/types>.

"What Is Cancer?" American Cancer Society. Accessed May 06, 2017.
<https://www.cancer.org/cancer/cancer-basics/what-is-cancer.html>.

Wheeler, Cosette M., William C. Hunt, Jack Cuzick, Erika Langsfeld, Amanda Pearse, George D. Montoya, Michael Robertson, Catherine A. Shearman, and Philip E. Castle. "A population-based study of human papillomavirus genotype prevalence in the United States: Baseline measures prior to mass human papillomavirus vaccination." *International Journal of Cancer* 132, no. 1 (2012): 198-207. doi:10.1002/ijc.27608.

Wheeler, Cosette Marie. "Less Is More: A Step in the Right Direction for Human Papillomavirus (HPV) Vaccine Implementation." *JNCI Journal of the National Cancer Institute* 103, no. 19 (2011): 1424-425. doi:10.1093/jnci/djr407.

Zimmermann, Kim Ann. "Lymphatic System: Facts, Functions & Diseases." LiveScience. March 11, 2016. Accessed August 18, 2017.
<https://www.livescience.com/26983-lymphatic-system.html>

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