HPV: Unraveling the Link between the Virus and Cancer

A Teacher-Authored Curriculum Unit
Hutch Fellowship for Excellence in STEM Teaching (HTF)
Fred Hutch Cancer Center

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The Hutch Fellowship for Excellence in STEM Teaching (HTF) is a program for secondary science and STEM educators seeking an in-depth, biomedical research experience at Fred Hutch Cancer Center in Seattle, WA. The Hutch Teacher Fellowship provides support for up to two paid summers of cancer-focused biomedical research experience in a host lab, cancer-focused curriculum design activities, and scientific communication projects, with additional school year follow-up. As part of their Fellowship experience, our teacher-researchers design innovative curriculum materials inspired by their research experience in a Fred Hutch lab. They then pilot these materials with their students over two school years and use student feedback to revise, expand, and polish their curriculum materials with the goal of sharing them with other STEM educators. This unit was shared by its author at our HTF Curriculum Showcase events in May 2026. Final materials will be published to the SEP Curriculum website. The HTF program is part of the Pathways to Cancer Research program supported by a Youth Enjoy Science grant from the National Cancer Institute and philanthropic donations. For more information about the HTF program, please contact Dr. Kristen Bergsman, bergsman@fredhutch.org.

Unit Title: HPV: Unraveling the Connection between the Virus and Cancer (11 lessons + 1 social justice lesson)

Unit Author: Danielle Thal

Intended Course: HS General Biology (could be used in AP Biology)

Description: This unit was inspired by the author's HPV research in the lab of Dr. Denise Galloway. Modeled after *SEP's Intro to Cancer: Leukemia & Hina's Story unit storyline*, the *HPV and Cancer* unit explores the link between a virus and cancer. Students learn about viruses and how our immune system creates antibodies to protect us when we are exposed. They learn about the HPV vaccine and create a Public Service Announcement to teach others about preventing HPV caused cancers. Before participating in this unit, students must have learned about molecules, cells, and transcription/translation of proteins.

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HPV: Unraveling the Link Between the Virus and Cancer

An HTF-Authored Curriculum Unit

What is the relationship between viruses and cancer, and how does understanding of this connection inform HPV prevention strategies?

Fred Hutch Cancer Center

Synopsis:

This is a unit about cancer caused by a virus. The human papillomavirus (HPV) can cause cervical, vaginal, anal, penile, and oropharyngeal cancer. This cancer is highly preventable through the use of a vaccine administered to young people, preferably before becoming infected.

This unit is based on the Frontiers: *Intro to Cancer*: *Leukemia & Hina's Story* unit (2023) from Fred Hutch Cancer Center, found here, and was designed for an introductory biology class.

Student Pre-Knowledge:

Before starting the unit students should know…

- Cells and cell types/cell specialization
- Cell organelles, especially cell membrane, nucleus, ribosome, cytoplasm
- Biomolecules (especially proteins and nucleic acids)
- Cell cycle - mitosis but not meiosis
- DNA structure, transcription and translation
- Protein folding
- Viruses - a general definition

What Students Figure Out:

By the end of the unit, students figure out that…

- Cancer is a set of diseases characterized by uncontrolled cell growth. This unit will focus on skin cancer because that is the type of cancer caused by HPV.
- Cancer can be caused by a number of things, in this case by a virus.
- Cells move through the cell cycle in regular patterns. Cancer disrupts these patterns.
- Viruses infect cells and use their machinery to replicate themselves.
- Vaccines are safe and effective methods to protect against infections by a virus.
- The immune system is made up of specialized cells that function to protect the body against pathogens.
- The human body is made of interconnecting systems that function to maintain homeostasis.

Unit Study Resources:

- **Extended Quizlet set with questions**
- **Simple Quizlet set**
- **Incremental Modeling Tracker** (see curriculum unit for this student handout). An incremental modeling tracker is a helpful tool for students to use to track their learning. You can choose the level of detail that should be prefilled before giving it to students. Be sure to delete any rows for lessons that you will not include in your program of study.

Social Justice Standards from the Teaching Tolerance Anti-Bias Framework

- **DI.9-12.8** I respectfully express curiosity about the history and lived experiences of others and exchange ideas and beliefs in an open-minded way.
- **DI.9-12.9** I relate to and build connections with other people by showing them empathy, respect and understanding, regardless of our similarities or differences.
- **DI.9-12.10** I understand that diversity includes the impact of unequal power relations on the development of group identities and cultures.
- **JU.9-12.12** I can recognize, describe and distinguish unfairness and injustice at different levels of society.
- **AC.9-12.20** I will join with diverse people to plan and carry out collective action against exclusion, prejudice and discrimination, and we will be thoughtful and creative in our actions in order to achieve our goals.

Anchoring Phenomenon:

Cancer is a social justice issue. During Lesson 1, students learn about the story of Henrietta Lacks and they engage in a discussion about bioethics. The remaining social justice lessons are designed as standalone lessons that can be incorporated throughout the unit where they fit your schedule best. These are found in Lesson X.

Unit Driving Question:
What is the relationship between viruses and cancer, and how does understanding of this connection inform HPV prevention and treatment strategies?

Unit Storyline Table:
The following information was provided by the HTF program in a curriculum design template based on the Frontiers: Intro to Cancer: Leukemia & Hina's Story unit (2023) from Fred Hutch Cancer Center .

Storylining is an approach to designing NGSS-aligned curricula that was taken up by the designer of this unit.

> "A storyline is a coherent sequence of lessons, in which each step is driven by students' questions that arise from their interactions with phenomena. A student's goal should always be to explain a phenomenon or solve a problem. At each step, students make progress on the classroom's questions through science and engineering practices, to figure out a piece of a science idea. Each piece they figure out adds to the developing explanation, model, or designed solution. Each step may also generate questions that lead to the next step in the

storyline. Together, what students figure out helps explain the unit's phenomena or solve the problems they have identified. A storyline provides a coherent path toward building disciplinary core idea and crosscutting concepts, piece by piece, anchored in students' own questions" (NextGen Storylines)

In this unit, students engage with a sequence of lessons and labs that is driven by students' emerging questions about the scientific phenomenon of cancer being a social justice issue.

The Unit Storyline Table featured in this document communicates the storyline that drives the unit. For each of the lessons that make up this unit, the table displays the following information:

- **Lesson-level Investigative Question** This section lists the questions that students will investigate while engaging in the learning activities that make up the lesson. Also included is the question(s) that students will likely ask toward the end of the lesson, which will lead them into the lesson that follows.
- **Lesson-level Investigative Phenomenon** This section is written to provide teachers with the background knowledge necessary for understanding the content in the unit. For further information, consult the references list at the end.
- **What Do We Figure Out and What Do We Do?** This section includes three parts. First, it describes what students will figure out as they engage in the learning activities that make up the lesson. Second, it describes the learning activities and what students will do. Third, it presents opportunities for formative assessment of student learning.
- **NGSS Connections** This section identifies connections between the lesson's learning activities and learning standards, with a focus on the Next Generation Science Standards. Color-coding is used to denote the three dimensions of science learning: **science and engineering practices (SEPs)**, **disciplinary core ideas (DCIs)**, and **crosscutting concepts (CCCs)**.
- **Why Do We Care?** This section calls out personal connections between the lesson's content and students' own lives. It also lists career connections that could be further explored as an extension activity.

In addition to the information described above, icons are used within the table to denote lessons that engage students in the following foundational scientific practices, which were prioritized by the designer of this unit:


Opportunities for Discourse & Argumentation

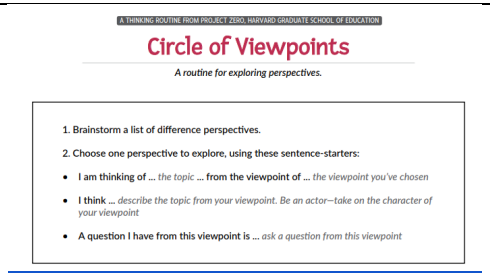

Analyzing Data


Productive Uncertainty


Scientific Modeling

What is the relationship between viruses and cancer, and how does understanding of this connection inform prevention and treatment strategies?				
Lesson-level Investigative Question	**Lesson-level Investigative Phenomenon**	**What Do We Figure Out? What Do We Do?**	**NGSS Connections / Social Justice Standards**	**Why Do We Care?**

Lesson 1: Introduction to Cancer 75 minutes **What is cancer?** **How do the ethical, scientific, and personal perspectives on the use of HeLa cells shape our understanding of medical research and its impact on society?** **Navigation to the next lesson:** *How do cells divide and grow, and how does cancer disrupt this process?*  	Cancer is a set of diseases characterized by uncontrolled cell growth. Depending on the cells that are affected, cancer may result in solid tumors found in one part of the body or a liquid tumor in cancers of the blood. In the next few lessons, students will learn how cancer is a disruption of the cell cycle. This disruption can be caused by a number of things: - genetics - radiation - viruses/bacteria - exposure to chemicals called carcinogens, such as those found in cigarette smoke - obesity - alcohol use Over the course of this unit, we will focus on cancer caused by the human papillomavirus (HPV). This virus has been linked to cervical, penile, vulvar, anal, and oropharyngeal cancers. While all people will be touched by cancer in their lifetimes, it is a disease that still disproportionately affects those living in poverty and those with marginalized backgrounds. Students will also explore cancer as a social justice issue.	**What do we figure out?** ● Cancer is a set of diseases characterized by uncontrolled cell growth ● Many things can cause cells to divide out of control, including viruses ● HPV can cause cervical, vulvar, vaginal, anal, penile, and throat cancer ● Cancer affects people unequally and those with marginalized identities often fare worse. **What do we do in this lesson?** **Part 1:** ● HeLa cells- Circle of viewpoints activity ● Introduce final project **Assessment/evidence of learning:** ● Use of PollEverywhere/ Mentimeter/Google Forms/ etc. to gauge student opinions using the prompt “I used to think…and now I think” regarding the use of HeLa cells. ● Student discussions.	**NGSS:** **Building toward HS-LS1.2** In this unit, students will learn about the connection between viruses and cancer. In the first lesson, students learn that cancer causes uncontrolled cell growth, disrupting the structure and function of cells and structures that they form. Students will engage in discourse to explore the ethics surrounding the use to HeLa cells and they will explain how their ideas about ethics in medicine have changed. **Constructing Explanations and Designing Solutions** (HS-LS1-2) **Structure and Function** (HS-LS1-1) Structure and Function (HS-LS-1, HS-LS-2) **Social Justice Standards:** **-DI.9-12.8** I respectfully express curiosity about the history and lived experiences of others and exchange ideas and beliefs in an open-minded way.	**Personal Connection:** 1 in 3 people will have cancer in their lifetime (CDC, 2019) so all of us will be touched by cancer in some way. **Career Connection:** Dr. Denise Galloway, microbiologist and expert in pathogen associated malignancies

			**-DI.9-12.9** I relate to and build connections with other people by showing them empathy, respect and understanding, regardless of our similarities or differences. **-DI.9-12.10** I understand that diversity includes the impact of unequal power relations on the development of group identities and cultures. **-JU.9-12.12** I can recognize, describe and distinguish unfairness and injustice at different levels of society.	
What is the relationship between viruses and cancer, and how does understanding of this connection inform prevention and treatment strategies?				
Lesson-level Investigative Question	**Lesson-level Investigative Phenomenon**	**What Do We Figure Out? What Do We Do?**	**NGSS Connections / Social Justice Standards**	**Why Do We Care?**

Lesson 2: The Cell Cycle

75 minutes

This lesson is based on Frontiers Intro Lesson 3

How do cells divide and grow, and how does cancer disrupt this process?

Navigation to the next lesson:
How do cells become specialized or differentiated?

Specialized cells spend different amounts of time in each part of the cycle, but they follow the same basic pattern:

- G_1 - The first growth phase, the cell is growing and making copies of organelles.
- S phase - the cell replicates DNA.
- G_2 - The second growth phase, the cell continues to grow and make proteins; the cell prepares for mitosis.
- M phase - the cell divides through the process of mitosis.
- Prophase - DNA condenses into chromosomes.
- Metaphase - chromosomes line up in the middle of the cell.
- Anaphase - the chromosomes are pulled by microtubules to opposite ends of the cell.
- Telophase - the chromosomes are now on opposite sides of the cell, the nucleus begins to reform around each set and a cleavage furrow forms.
- Cytokinesis - the cell membrane forms around the two new daughter cells.

At the end of mitosis, the two new cells restart the cycle in G_1.

Depending on the cell type, the cell will continue through the cycle and divide once again. Or the cell may enter a new phase, called G_0, where it is not preparing to divide and is instead just doing its cell job. Some cells remain in G_0 permanently.

What do we figure out?

- Cells replenish themselves through the cell cycle.
- The cell cycle has checkpoints to ensure that damage can be repaired.
- Cancer disrupts these checkpoints so that cells grow and divide too quickly.
- Doctors can diagnose cancer by counting how many cells are dividing in a micrograph (mitotic index).
- One checkpoint is the protein p53, which slows the cell cycle to repair damaged DNA. This protein is mutated in many cancers.

What do we do in this lesson?
Teachers will modify this lesson depending on how much time you have. One or more activities can be omitted, or the slides can be assigned as pre reading while students complete the activities in class. Depending on students' comfort or past learning with the cell cycle, this lesson can be done as a lecture or students can work through the presentation in groups and take notes on the provided Cornell notes template. Slides can be deleted as needed.

NGSS:

Building toward HS-LS1-4
In this lesson students learn how cells complete the cell cycle to make more cells. Then they find out about cell cycle checkpoint proteins, which can slow down or stop the cell cycle when mistakes are detected. Students will calculate a mitotic index and present data that they can use to explain that those tissues with cancer have a higher mitotic index.

Constructing Explanations, Developing and Using Models

HS-LS1-3 Stability and Change

HS-LS1.B Growth and Development of Organisms

Personal Connection:
Students learn what happens in cells to cause them to become cancerous. This can help them to understand what is happening when a family member has cancer.

Career Connection:

- Dr. Lee Hartwell
- Dr. Richard Adeyemi, microbiologist

	Another important part of the cell cycle is the end of the natural life of that cell, apoptosis, or programmed cell death. Cell organelles will be neatly packaged in parts of cell membrane that will then be digested by cells of the immune system. This is a healthy process that does not disrupt homeostasis in the organism. Necrosis refers to a process where cells die due to disease or environmental disturbances. The cell will explode, releasing parts of the cell to the environment. This process can disrupt homeostasis in the body. p53 is a protein known as the guardian of the genome because it protects and repairs damaged DNA. If damage to the DNA is too severe, p53 initiates apoptosis. The p53 molecule consists of 4 arms that give DNA a big hug while repairing damage and regulating transcription. The cell cycle is controlled by a series of proteins called cyclins, which ensure that the cell spends just the right amount of time in each stage. Cells also have proteins called growth factors, which can make proteins required for growth. Some cancers can keep growth factors turned on so that the cell continues to grow, or they can alter the expression of cyclins so that the cell moves through the cell cycle too quickly. p53 is mutated in over 50% of human cancers. In others, its pathway is inactivated (Hernández Borrero & El-	Activity 2.1: Rearrange the steps of the cell cycle A- Interphase S B- Prophase C- Anaphase D- Metaphase E- Telophase F- Interphase G1 Handout 3.1 from the Frontiers: Intro to Cancer unit has the activity that you can print, or you can print the slide from the presentation. Activity 2.2: Calculate mitotic index based on images from this video, taken from an old McGraw Hill virtual lab. Complete a CER to discuss results. Activity 2.3: Analyze graph: role of p53 in cancer from HHMI BioInteractive Optional resources: Video: p53 and cancer Read: Bowhead whales and DNA repair **Assessment/evidence of learning:** Answer the following question using the Claim Evidence Reasoning format:		

	Deiry, 2021). In this way, cells with damaged DNA can continue to grow and divide.	What is the difference between the mitotic index in cancerous tissues vs. regular tissues, and how can this be used as a diagnostic tool?		

What is the relationship between viruses and cancer, and how does understanding of this connection inform prevention and treatment strategies?				
Lesson-level Investigative Question	**Lesson-level Investigative Phenomenon**	**What Do We Figure Out? What Do We Do?**	**NGSS Connections / Social Justice Standards**	**Why Do We Care?**

Lesson 3: Cell Differentiation 60 minutes This lesson is based on Lesson 4 from Frontiers: Intro to Cancer **How do dividing cells become differentiated?** **Navigation to the next lesson:** *How does a tumor form in the skin?* 	Stem cells are undifferentiated cells that are capable of becoming specialized. This differentiation happens when some genes are turned on, while others may be turned off (called differential activation of genes). Embryonic stem cells are the least differentiated and could become any cell type in the body (except for cells of the placenta). These are called pluripotent. Adults also have stem cells, called multipotent stem cells. These cells can differentiate, but they can only become a specific cell type. The two categories of multipotent cells are those that become blood cells and those that become bone, muscle, cartilage, fat, or skin. Keratinocytes are skin stem cells found in the basal layer of skin, a thin layer of cells found in between the dermis and the epidermis. As these cells complete mitosis, one daughter cell will continue dividing in the basal layer while the other will begin the process of differentiating. The differentiating cell will move up through the epidermis, becoming flattened. The top layer of skin, that you can feel now if you rub your arm, is the cornified layer, and this consists of cells that have lost most of their organelles and become hardened to create an impenetrable barrier. This barrier serves as the first line of defense of the immune system by preventing pathogens from entering the body.	**What do we figure out?** • Stem cells are undifferentiated cells; they do not have a specialized function yet. • Genes in stem cells will be turned on at different times, causing them to become specialized. • There are different 'levels' of stem cells, i.e., some can become any cell type while others can only become certain cell types. • Blood stem cells are called hematopoietic stem cells and can differentiate into a range of blood cells that have their own specialized functions (students will learn more about the functions of blood cells in lesson 6). • Skin stem cells are called keratinocytes and can differentiate into skin cells. **What do we do in this lesson?** • See the corresponding lesson, including the teacher's guide, from the Frontiers: Intro to Cancer unit • Students use clay as a model stem cell which becomes differentiated after receiving signals from genes (based on	**NGSS:** **Building toward HS-LS1-4, HS-LS1-2** Students build on the last lesson about the cell cycle by using a model to explore how cells differentiate. Students start by watching a video of zebrafish development to explore the concept that cells aren't simply dividing, but they are becoming more specialized too. Then students create a clay model of a blood cell which becomes more specialized as certain genes are turned on or off. **Developing and Using Models** (HS-LS1-2, HS-LS1-4) **Systems and System Models** (HS-LS1-2) Models can be used to simulate systems LS1.A Structure and Function. LS1.B Growth and development of organisms.	**Personal Connection:** We are all complex systems made of many interacting parts. In order for these systems to function well, each needs specialized cells. These specialized cells start out as stem cells, which are undifferentiated cells that become specialized after receiving instructions from genes. **Career Connection:** Dr. Folashade Otegbeye, Stem Cell Transplant Physician and Researcher

	HPV infects the keratinocytes by entering small breaks in the skin barrier. Once cells enter the differentiating stage, viral gene expression is upregulated and the virus starts to replicate itself. As the skin cells are differentiating, HPV proteins L1 and L2 are expressed and virions are assembled. L1 and L2 are the proteins that will eventually make up the viral protein coat. When infected skin cells reach their final stage of differentiation and die by natural causes, shedding of the virus particles occurs. This is when the virus can be passed to another person through skin to skin contact. In most strains, the viral DNA is maintained as an episome - a piece of nucleic acid in the cell. However, in high-risk HPV the viral DNA becomes integrated into the host DNA, and this is what leads to upregulation of E6 and E7. These are the proteins associated with cancer because they prevent the host cell from suppressing tumors. When E7 is expressed, it prevents terminal differentiation of keratinocytes.	student clothing). Work through the differentiation activity with the presentation or students may work through the Google site independently. Gluten free clay is available for students with allergies. ● Students can keep track of their work on this handout. This contains important information about blood cells that students will review again in Lesson 6 - the immune system. **Assessment/evidence of learning:** ● Compare and contrast the differentiation of blood cells and skin cells. Can be a discussion or a grade assessment. ● Completion of this handout.		
What is the relationship between viruses and cancer, and how does understanding of this connection inform prevention and treatment strategies?				
Lesson-level Investigative Phenomenon	**Lesson-level Investigative Phenomenon**	**Lesson-level Investigative Phenomenon**	**Lesson-level Investigative Phenomenon**	**Lesson-level Investigative Phenomenon**

Lesson 4: Cell Cycle Checkpoint Game 75 minutes This lesson is based on Frontiers: Intro to Cancer Lesson 5 **How does a tumor form in the skin?** **Navigation to the next lesson:** *What is a virus and how can it cause cancer?*  	This game is a review of the last two lessons. However, in this version students will model skin cells. The development of skin cancer is slightly different from the development of blood cancer, which is what the Frontiers: *Intro to Cancer - Leukemia & Hina's Story* unit was originally based on. In skin cancer caused by HPV, infected cells have entered the differentiation stage. They are moving up through the epidermis and becoming more flattened while losing organelles. This is the stage of the viral life cycle where the virus starts expressing its capsid proteins and assembling virions. When the skin cells reach the final differentiating stage they die and start flaking off. This is when the virus starts shedding and can be spread to others. Normally cells in the differentiation stage do not undergo mitosis, but those that are infected with HPV will continue to divide. In a regular cell, the p53 protein would detect that the DNA had been damaged by the virus and initiate apoptosis. Since HPV degrades p53, apoptosis does not happen and the infected cells do not die/flake off like they normally would. Because of the inhibition of tumor suppressor proteins, skin cells infected with HPV can also continue to go through mitosis throughout all of the layers, and not just the basal layer.	**What do we figure out?** ● Students proceed through a typical cell cycle and they see that, because of checkpoint proteins, the cycle proceeds slowly and orderly. ● When students are allowed to bypass the checkpoint proteins, chaos ensues and students see that cells divide quickly and they have many abnormalities, such as mutated DNA or extra/not enough organelles. ● Students learn that checkpoint proteins provide negative feedback on cell processes in that they slow down division based on signals within the cell. ● Students see how the structure of the skin is made of layers and layers of cells stacked upon each other. **What do we do in this lesson?** ● Students will complete the steps of the cell cycle checkpoint game as instructed. ● SEP teachers can check out a copy of the cell cycle checkpoint game from Fred Hutch SEP. However, this version of the game is	**NGSS:** **Building toward HS-LS1-4, HS-LS1-2** Students model the process of the cell cycle and see what happens when this process is allowed to continue unchecked. Students see that skin is made of many layers of skin cells stacked upon each other, but only those in the basal layer will divide, while those above the basal layer will differentiate. This cell division is controlled by checkpoint proteins that serve to protect the genome from mutations and initiate apoptosis if any are present. **LS1.A, LS1.B - Structure and Function, Growth and Development of Organisms** **Stability and Change: Feedback (**HS-LS1-3) **Developing and Using Models** (HS-LS1-4, HS-LS1-2)	**Personal Connection:** The skin is the largest organ in the body and the first round of defense against pathogens. Students learn how this organ renews itself and stays healthy. **Career Connection:** Dr. Manu Setty, computational biologist.

		about skin cells and not blood cells. ● Then students will Student Handout 4.1 to add to their knowledge about p53. **Assessment/evidence of learning:** ● Students complete the reflection form together. Engage students in discussion at the small group or whole class level.		
What is the relationship between viruses and cancer, and how does understanding of this connection inform prevention and treatment strategies?				
Lesson-level Investigative Phenomenon	**Lesson-level Investigative Phenomenon**	**Lesson-level Investigative Phenomenon**	**Lesson-level Investigative Phenomenon**	**Lesson-level Investigative Phenomenon**

Lesson 5: Introduction to Viruses and HPV 45 minutes **What is a virus and how can it cause cancer?** **Navigation to the next lesson:** *How does the immune system protect us against viruses and other pathogens?* 	A virus is an infectious agent that consists of nucleic acids surrounded by a protein coat. Viruses only have DNA or RNA, and must use host cell machinery (such as ribosomes) to complete protein synthesis and replicate themselves. All viruses have a life cycle that follows the same basic steps: attachment to a host cell, penetration, uncoating, gene expression/replication, assembly, and release. Viruses are very small - a human hair is about 4000 times larger than the smallest virus! They must be small in order to enter a cell and start replicating. HPV is a DNA virus with a small double stranded DNA circular genome. This genome encodes 8 proteins: 6 early and 2 late. The late proteins, as their name suggests, are made later in the viral life cycle and these encode the viral protein coat. These will be important later, as they are what researchers have used to develop the HPV vaccine. Two of the early proteins are important in our study of cancer: E6 and E7. E6 degrades the tumor suppressor protein p53 while E7 inhibits Rb, which is a protein that prevents the division of the cell. The action of these two causes uncontrolled cell growth and division. Scientists know this because they can turn genes off in a cell and see what	**What do we figure out?** • HPV is a virus that infects the skin. • HPV has a genome made of DNA that codes for 8 proteins, 2L and 6E proteins. • The L proteins are significant because we can use them to make vaccines and to study HPV in the lab. • The E proteins are significant because they interact with the host tumor suppressor genes, which leads to uncontrolled cell division. **What do we do in this lesson?** • Students work through Student Handout 5.1 to gradually build their understanding of viruses. • When students finish the handout, the teacher will go through the basics of HPV biology while introducing more complicated concepts, including the role of the L and E proteins. This is optional but available if your students are ready for an extension of their learning. **Assessment/evidence of learning:**	**NGSS:** **Building toward HS-LS-1** Students learn about the structure of a virus, which is a piece of nucleic acid in a protein coat. They learn about the genome of HPV and which proteins are made. Students work together on a handout that combines information from multiple sources in order to construct an explanation of viruses. Students learn about how scientists study viruses in the lab using pseudoviruses. **Constructing explanations and designing solutions HS-LS-1** **HS-LS-1 All cells contain instructions in the form of DNA.** **Science is a human endeavor**	**Personal Connection:** Viruses are extremely common and all of us will suffer their wrath during our lifetimes. Some viral infections are mild and we do not even know that we are infected, while others can cause extreme illness. HPV is responsible for 5% of all human cancers worldwide (Bissett et. al, 2016).

	proteins are made as a result. When they turned HPV E6 off, host cells started to make p53 again. E5 is also an important protein. It encourages binucleate cells, where cells can fuse together. When this happens with oncogene expression (as it does with E6 and E7), tumor formation can result. In the case of HPV, the virus infects skin cells called basal keratinocytes. The skin stem cells can either continue dividing or will differentiate to become skin cells called prickle cells. These cells continue to differentiate as they move further away from the basal layer, eventually losing many of their organelles and flaking off. Once cells enter the differentiating compartment, viral gene expression is upregulated and the virus starts to replicate itself. As the skin cells are differentiating, proteins L1 and L2 are expressed and virions are assembled. L1 and L2 are the proteins that will eventually make up the viral protein coat. When infected skin cells reach their final stage of differentiation and die by natural causes, shedding of the virus particles occurs. This is when the virus can be passed to another person through skin-to-skin contact. The type of cancer caused by HPV is squamous cell carcinoma. HPV inhibits p53, which would normally cause apoptosis in a cell with damaged DNA. Since p53 is inhibited, skin cells	• Handout to be completed in small groups, includes comparing diagrams, watching a video, and exploring an interactive from HHMI. • Group discussion with slides of HPV.		

	continue to grow and do not die when they should, and a tumor is formed. In most strains, the viral DNA is maintained as an episome - a piece of nucleic acid in the cytoplasm of the cell. However, in high-risk HPV the viral DNA becomes integrated into the host DNA, and this is what leads to upregulation of E6 and E7. These are the proteins associated with cancer because they prevent the host cell from suppressing tumors. It is important to note that not all strains of HPV cause cancer. Some strains can be cleared by the immune system, while others will go on to cause genital warts. However, HPV is associated with "99% of cervical cancers (there is no evidence of significant genetic predisposition for cervical cancer), 90% of anal cancer, 65% vaginal cancers, 50% vulvar cancers, and 45-90% oropharyngeal cancers" (Petca et al., 2020).			
What is the relationship between viruses and cancer, and how does understanding of this connection inform prevention and treatment strategies?				
Lesson-level Investigative Phenomenon	**Lesson-level Investigative Phenomenon**	**Lesson-level Investigative Phenomenon**	**Lesson-level Investigative Phenomenon**	**Lesson-level Investigative Phenomenon**

Lesson 6: Introduction to the Immune System 90 minutes **How does the immune system protect us against viruses and other pathogens?** **Navigation to the next lesson:** *How does someone know that they are infected with HPV?*  	The immune system is broken up into two parts: the innate immune system and the adaptive immune system. The innate system is what we are born with and its role is to eliminate pathogens before they make us sick. The first (and biggest) line of defense is the skin, which blocks pathogens from entering the body in the first place. Once pathogens enter the human body, there are a number of specialized cells present to attack and neutralize them, as well as to remember them for future encounters. For this unit, we will focus on the sequence of events leading up to the production of antibodies, as that leads into the next lesson on the ELISA test and lays the foundation for understanding how vaccines work. The immune system also plays a role in detecting and eliminating cancer cells. The immune system also has cells that respond to parasites and to non-harmful antigens such as allergens. First, a pathogen (virus or bacteria) will encounter a phagocyte, a big white blood cell that eats other cells. The cells of the immune system recognize that this is a foreign cell because of the molecular patterns on the outside of the foreign cell that are different from the cells of the host. These molecular patterns are proteins	**What do we figure out?** • There are many cells in the immune system that must work together to protect us. • Pathogens are non-self microbes that can make us sick. The immune system identifies them by the presence of surface molecules called antigens. • In this lesson, the first cell of the immune system encountered is a dendritic cell, which is a large white blood cell that eats pathogens and then displays their antigens on the surface. • This then activates helper T cells, which have several functions including killing infected cells and activating B cells. • When B cells are activated, they will divide to create plasma cells and memory cells. • Plasma cells secrete proteins called antibodies, which recognize specific antigens and work to neutralize them before they can make us sick. **What do we do in this lesson?** • Complete the Lesson 6 Notes sheet while reviewing the presentation.	**NGSS:** **Building toward HS-LS1-2** In this lesson, students learn about the systems of cells that function to create antibodies to provide specific immunity against pathogens. They learn that this happens through a sequence of events, as cells activate one another in a pathway. Students review their knowledge by creating a flowchart of the sequence of events in the creation of antibodies. Students can write each event on an index card and then practice putting them in the correct order. **LS1.A Structure and Function.** **Developing and Using Models** (HS-LS1-4) **Cause and Effect, Systems and System Models** **HS-LS1-1** Genes code for proteins **Structure and Function** (HS-LS1-1)	**Personal Connection:** We all know what it is like to suffer from the effects of a pathogen (a cold or flu from a virus, or food poisoning from a bacteria). Students will learn about the system of cells dedicated to protecting us from these pathogens and maintaining homeostasis. **Career Connection:** Dr. Brain Till, Immunotherapy investigator.

	embedded on the outside of the pathogen called antigens. For this lesson, we are looking at phagocytes called dendritic cells. Once a pathogen has been ingested by a phagocyte, the phagocyte will display parts of that pathogen's antigens on its cell surface. This will activate the T cells. Depending on the type of T cell, they might activate B cells, or they will directly kill infected cells and emit cytokines. Cytokines are chemical messengers with many functions, including regulating gene expression. In the case of invasion by a virus, cytokines can prompt infected cells to undergo apoptosis and it can signal uninfected cells to decrease protein synthesis. Both of these actions can prevent the virus from replicating itself and infecting other healthy cells. When B cells are activated, they will become antibody secreting plasma cells. They will create proteins, called antibodies, which have a shape to match that of the antigen. When the antibodies encounter the antigen, they will attach themselves to the antigen (imagine pieces of a puzzle fitting together), which will make it easy for other parts of the immune system to find and destroy the pathogen. Antibodies work in a number of different ways, but antibodies against	• To enrich your understanding, read the Viral Attack comic book from Arizona Science Center Pathways Design Team. • If you have access to the book POGIL Activities for AP Biology, there is a great POGIL activity for learning the process of creating antibodies. **Assessment/evidence of learning:** • Student discussions during the lesson. • Students will create a flowchart outlining the sequence of events that leads to the production of antibodies. This is part of the notes sheet but can be turned in as an exit ticket.		

	HPV are neutralizing antibodies, which means that they neutralize the virus before it can infect cells. The B cells also create memory cells, which continue to make the antibodies against a specific antigen. Next time the immune system encounters that pathogen, the antibodies can attach to it right away without having to go through the steps above to create the antibodies. This is called adaptive immunity.			
What is the relationship between viruses and cancer, and how does understanding of this connection inform prevention and treatment strategies?				
Lesson-level Investigative Phenomenon	**Lesson-level Investigative Phenomenon**	**Lesson-level Investigative Phenomenon**	**Lesson-level Investigative Phenomenon**	**Lesson-level Investigative Phenomenon**

Lesson 7: Detection of HPV: ELISA Prelab 60 Minutes **How does someone know that they are infected with HPV?** **Navigation to the next lesson:** What does a test for HPV look like?  	There are a few ways that HPV can be detected. The most common is through cytology, which is a screening method done by looking at cells. In this case, cells will be removed from the cervix during a pap test and viewed underneath a microscope to see if any of the cells look abnormal. If abnormal cells are detected, HPV-DNA testing will be done to identify the specific strain of HPV present. Clinicians can use a test called the PCR test to sequence the DNA present to see if it belongs to a high-risk strain. After the age of 30, it is recommended to do a co-test, which combines the pap smear and the DNA test. This type of regular screening is an efficient way to reduce mortality from cervical cancer, and people with a cervix should start being screened once they become sexually active. Your doctor will then tell you how often to repeat the test. Unfortunately, there is not a regular screening method available for people without a cervix, and they will generally only be tested for HPV once they present with symptoms. Another way to test for the presence of HPV (or other pathogens) is with the ELISA test. This test confirms the presence of antibodies against a specific antigen. If a person has been exposed to HPV and their immune system has made antibodies in	**What do we figure out?** • Scientists can determine if someone has been exposed to HPV by the presence of anti-HPV antibodies in their blood. • By adding a series of reagents to a special plastic well, students can observe a color change that will confirm that anti-HPV antibodies are present. **What do we do in this lesson?** • ELISA pre lab activity from Bio Rad: ELISA paper model activity • Note - update the instructions on the slides to match the ELISA kit that you are using (i.e., if you're using 96 well plates vs. 12 well strips, etc.) • The steps of the lab have questions for students to answer, prompting them to think deeper about why they are performing each step (to avoid just 'going through the motions' without learning anything). The answers to each question are in the speaker notes. Teachers can choose to go through the prelab as a class, prompting students to answer the questions in pairs or to the whole	**NGSS:** **Building toward HS-LS1-1** Students use a paper model to run through the steps of an ELISA test, to familiarize themselves with the procedure. Students will review previous units on transcription and translation when learning that genes expressed by B cells can mutate easily to make proteins that are specific to antigens. These antigens, primary antibodies, and secondary antibodies stick to one another through their intermolecular interactions. **Planning and carrying out investigations** HS-LS1-3 **HS-LS1-1** Genes code for proteins **Structure and Function** (HS-LS1-1)	**Personal Connection:** Before engaging in the hands-on aspect of a lab, students will appreciate getting to understand why the lab works the way that it does so that they can explain their results. **Career Connection:** • Momoko Osuga, MLT(ASCP) Medical Laboratory Technologist

	response, these antibodies will be present in their blood serum (and in some cases their saliva, although this test is not as sensitive).	group. Or teachers can make another copy of the presentation with the speaker notes deleted, and have students work through the presentation / questions in groups. These questions are also on the Student Handout 7.1 lab handout, that students should have access to as they are completing the prelab activity. ● If you have access to prepared slides, students can view normal and abnormal cells through a microscope. **Assessment/evidence of learning:** ● Class discussion / completion of Student Handout 7.1 prelab questions, explaining the need for each step.		
What is the relationship between viruses and cancer, and how does understanding of this connection inform prevention and treatment strategies?				
Lesson-level Investigative Phenomenon	**Lesson-level Investigative Phenomenon**	**Lesson-level Investigative Phenomenon**	**Lesson-level Investigative Phenomenon**	**Lesson-level Investigative Phenomenon**

Lesson 8: ELISA Lab 75 minutes **How can we use antibodies to test for the presence of HPV?** **Navigation to the next lesson:** *How does a person contract HPV, and how can they prevent this from happening?*   	An assay is a scientific procedure to determine the amount of something that is present in a sample. In biomedicine, we use an assay to determine the presence of antibodies. An ELISA test will confirm the presence of antibodies against the antigen of interest. An ELISA is one of many tests for HPV. More common tests include a pap test to screen for abnormal cells and an HPV DNA test using PCR technology. The steps of this ELISA lab are summarized briefly below: 1. The antigen (in this case simulated HPV) is added to a plastic well, where it will bind to the material. 2. Serum from the patient is added to the well. If the patient has antibodies against this antigen, they will bind together. 3. Next, secondary antibodies are added to the well. These antibodies are bound to an enzyme. The secondary antibodies bind to the patient's antibodies. 4. A non-colored substrate is added to the well. The enzyme that is attached to the secondary antibody will catalyze a reaction on the substrate that will change the color so that there is an immediate positive result.	**What do we figure out?** ● By applying molecules in a specific order to a special plastic well, we can detect the presence of antibodies against a specific antigen. **What do we do in this lesson?** ● Students will do the modified ELISA lab from the Fred Hutch SEP website using Student Handout 7.1. ● Distance learners or those without access to an ELISA kit can perform a virtual ELISA through HHMI. ● This lab assumes that students have used pipettes before. If they haven't, you will want to include a lesson on pipetting. **Assessment/evidence of learning:** ● Activity 8.2: CER ELISA lab ● Student Handout 7.1: Completion of prelab questions from Lesson 7, completion of data table during Lesson 8	**NGSS:** **Building toward HS-LS1-1** Students complete the procedure. Students will review previous lessons on transcription and translation when learning that genes expressed by B cells can mutate easily to make proteins that are specific to antigens. These antigens, primary antibodies, and secondary antibodies stick to one another through their intermolecular interactions. The data for this procedure is qualitative but students should still be able to explain what a color change means. **Analyzing and interpreting data** HS-LS1-3 **HS-LS1-1** Genes code for proteins **Structure and Function** (HS-LS1-1)	**Personal Connection:** Students have the opportunity to apply their learning to an authentic context. **Career Connection:** ● Nobel Prize Winner Rosalyn Sussman Yalow

	5. If the serum does not contain antibodies, nothing will attach to the antigen in the well and the color change reaction will not occur.			
What is the relationship between viruses and cancer, and how does understanding of this connection inform prevention and treatment strategies?				
Lesson-level Investigative Phenomenon	**Lesson-level Investigative Phenomenon**	**Lesso-level Investigative Phenomenon**	**Lesson-level Investigative Phenomenon**	**Lesson-level Investigative Phenomenon**

Lesson 9: Transmission (and prevention) of HPV 60 minutes **How does a person contract HPV, and how can they prevent this from happening?** **Navigation to the next lesson:** *How does a vaccine against HPV work?*  	While our skin appears to be one continuous sheet of tissue, it actually has what are called microabrasions, or small breaks in the skin. HPV is transmitted through skin-to-skin contact between an infected person and a noninfected person. It can also occur through skin to mucosa contact. The most common method of transmission is through sexual activity, including vaginal, anal, and oral sex. However, penetration does not need to occur, just skin to skin contact (including through fingers) which can include non-sexual forms of contact. Because it is so easy to transmit, experts estimate that 80% of all people will have an HPV infection in their lifetime (Choi, 2019). There are ways that people can decrease their chances of being infected with HPV, or decrease the chance of developing cancer from HPV: - Abstinence from any form of sexual contact is the only 100% effective way of preventing an HPV infection through sexual contact. - Keeping numbers of sex partners low - although a person can contract HPV after only one sexual experience, the chances are lower when keeping numbers of partners low. - Avoiding smoking - smoking is a risk factor that increases the chance of getting HPV because it suppresses	**What do we figure out?** ● Sexually transmitted infections are caused by microbes that are passed from one person to another during sexual activity. ● There are a number of ways to protect oneself from contracting an STI, from abstinence to condom use. ● HPV is a virus transmitted during sexual contact that can lead to cancer; there is a vaccine to protect against strains that cause cancer. **What do we do in this lesson?** ● Set the tone of the lesson with a reminder of classroom norms, as some of the content can feel uncomfortable for some students. ● Start the class with a low stakes assessment to see what students already know about STIs and prevention. There is a Google Form within the lesson materials that can be used, but other options include Kahoot or Quizlet. If you use the form - make a copy before you edit. ● Go through the presentation to discuss the	**NGSS:** **Building toward HS-ETS1-1.** Students will analyze graphs that show the impact of the HPV vaccine on incidences of cervical cancer in the US. They will also look at graphs showing the median age of diagnosis of cancers caused by HPV in biological men and women. Students will explore other methods of protection from STIs, including HPV, and they will start to think about research-based methods to prevent cancer caused by HPV, which they will share with others for their final project. **Constructing Explanations and Designing Solutions** **Influence of Science, Engineering, and Technology on Society** **ET.S1.B Developing Possible Solutions**	**Personal Connection:** HPV is so common that 80% of all sexually active people will contract it at least once during their lifetime. HPV is also responsible for 5% of cancers worldwide. According to the World Health Organization, "Evidence consistently shows that high-quality sexuality education delivers positive health outcomes, with lifelong impacts. Young people are more likely to delay the onset of sexual activity – and when they do have sex, to practice safer sex – when they are better informed about their sexuality, sexual health and their rights."

	the immune system and damages DNA. Studies have found higher rates of cervical cancer and throat cancer caused by HPV in people who smoke (Schabath et al., 2011). - "The study found that women whose partners used condoms during all instances of sexual intercourse were 70 percent less likely to become infected with HPV than those who used condoms only five percent of the time." (*Condoms Help Prevent HPV*, n.d.) Condoms and dental dams are not 100% effective, even when used properly, because they do not cover all areas of exposed skin, but will still reduce the chances of transmission. Since HPV also causes oral cancer, they should be used during oral sex. HPV also causes anal cancer, so condoms should be used to prevent transmission of HPV during anal sex. - HPV vaccine: "Since HPV vaccines were introduced, infections with HPV types that cause cancer and genital warts have dropped by 71% in teen girls" (Choi, 2019). - Regular screening by pap test for people with a cervix - while this test will not prevent getting HPV, it will alert people who have it so that they do not spread it to others. It is also the most effective way to catch an infection before it can turn into cancer *(January Is Cervical Health Awareness Month:*	correct answers with students ● A helpful resource from UW on STIs **Assessment/evidence of learning:** ● Teachers can duplicate the Google Form and give students time to retake the quiz. They can compare their own scores to see how much they learned and what areas they still need to focus on. ● Student discussions.		

	Get Screened at Planned Parenthood, n.d.).			

What is the relationship between viruses and cancer, and how does understanding of this connection inform prevention and treatment strategies?				
Lesson-level Investigative Phenomenon	**Lesson-level Investigative Phenomenon**	**Lesson-level Investigative Phenomenon**	**Lesson-level Investigative Phenomenon**	**Lesson-level Investigative Phenomenon**

Lesson 10: Vaccines 75 minutes **How does a vaccine against HPV work?** **Navigation to the next lesson:** *How can I share my learning with others?*    	There are 7 different types of vaccines, all designed to elicit an immune response. The HPV vaccine is known as a subunit vaccine that consists of L1 proteins. These are the proteins that make up the protein coat of HPV. The vaccine does not contain any viral DNA so it cannot make a person sick, but the immune system can still recognize the presence of foreign proteins and create specific antibodies in response. When HPV vaccination increased, rates of cervical cancer decreased (Hirth, 2018). However, there is still a relatively low uptake of vaccine uptake. As of 2021, and based on a sample size of 18,000 teens aged 13-17, completed vaccination rates were at 61.7% for biological males and females (*TeenVaxView | Adolescent Vaccine Coverage Interactive Data | NIS | CDC*, 2021). There are especially low rates of vaccine coverage in the southern US, where rates of cervical cancer are also higher. According to Hirth, 2018, there are several reasons for this low coverage: - HPV vaccines are not required for school. - Healthcare providers are not recommending the vaccine, or they are only recommending to people with a cervix or older teens - Parents are concerned that the vaccine will lead to more risky behavior - Cost.	**What do we figure out?** ● There are many kinds of vaccines; the HPV vaccine is a virus-like particle. ● There are several reasons that parents cite for not giving the HPV vaccine to their children. ● There are minor side effects associated with the vaccine, but it is a very safe and effective vaccine for most people. **What do we do in this lesson?** ● Discussion: vaccine hesitancy - what do we think and what does the data say? ● Use the Lesson 10 Vaccines Notes Template to take notes on the presentation. ● Read the Activity 10.1 Student Handout with the case study about Amanda Johnson and discuss it in groups, using the Feelings and Options thinking routine (from Harvard). ● Can review graphs from previous lesson relationship between cervical cancer incidence and vaccination. ● Finish the lesson/unit by engaging students in the GSCE Thinking Routine (from Harvard). Students have been using the IMT	**NGSS:** **Building toward HS-LS-1.1, HS-ETS1-3** Students will apply their knowledge of transcription and translation to the production of virus-like particles by yeast cells. These particles form the HPV vaccine, which is a highly effective and safe protection against cancer caused by HPV that should be given to people before they are exposed to HPV. Students apply what they have learned about the immune system to an explanation of how this vaccine works to create antibodies against HPV. Students will look at data showing the % of vaccine uptake and will discuss reasons why they think it is lower than 100%, before they see survey data with reasons cited by parents. By engaging in the Feelings and Options routine, they empathize with the characters of a case study to think about reasons why a person would not take the HPV vaccine and they brainstorm possible solutions to this problem.	**Personal Connection:** The WHO estimates that there are 500,000 cases of cervical cancer per year, and 270,000 deaths worldwide. In the US, screening programs are common so the disease is less prevalent. However, the economic burden is still high and treating cervical cancer is more expensive than treating other conditions (Samara & Khleif, 2009). Oropharyngeal cancer associated with HPV is expected to have a lifetime cost (combined cost of treating all people who develop this type of cancer) of $38.1 million (Hirth, 2018). The HPV vaccine is safe and provides long term protection to those who are vaccinated. **Career Connection:** Dr Parth Shah

		to create a linear representation of their learning. This routine gives them the opportunity to draw connections between topics non-linearly, similar to using a mind map. This activity can be done as a way to wrap up the content and prepare for the PSA or a final test if you give one. There is a template for this activity on the last page of the IMT. You can do this as part of Lesson 10, or the following lesson, depending on timing. **Assessment/evidence of learning:** ● Student discussions. ● Much of the learning from this lesson will be reflected in the student choice of PSA topic. **Possible extensions** ● Protein folding - L1 protein folds into T7 icosahedral VLP, looks like a virus but does not contain genetic material, can still be recognized by antibodies as non-self	**Constructing Explanations.** **Science is a Human Endeavor.** **ET-S1.B Developing Possible Solutions.**	
What is the relationship between viruses and cancer, and how does understanding of this connection inform prevention and treatment strategies?				
Lesson-level	**Lesson-level**	**Lesson-level**	**Lesson-level**	**Lesson-level**

Investigative Phenomenon	Investigative Phenomenon	Investigative Phenomenon	Investigative Phenomenon	Investigative Phenomenon

Lesson 11: Final project: PSA 75 minutes **How can I share my learning with others?**    	See Lesson 10 description regarding HPV vaccine hesitancy and effectiveness statistics **Note:** This project should be introduced early in the unit so that students know what they are working up to. Give students time throughout the unit to work on the PSA so that this work period is all they need to complete it.	**What do we figure out?** ● A public service announcement is a piece of media designed to share helpful information with the public. **What do we do in this lesson?** ● Work period to complete Public Service Announcement ● Encourage students to use links in the speaker notes of the presentations as resources when researching the information that they want to share, as there is a lot of vaccine disinformation and AI generated articles that are not scientifically accurate. ● Share this resource from Purdue for students who would like to use their own resources. ● This lesson from the NIH is a 35-minute lesson on evaluating health information. ● Students should also consult their IMT and the mind map that they made during the last lesson. **Assessment/evidence of learning:**	**NGSS:** **Building toward HS-ETS1-1, HS-ETS1-2** Throughout the unit, students have learned that HPV is a virus that might cause cancer in some cases. They have learned how the vaccine is an effective method to prevent this cancer, and they learned some reasons why people don't take the vaccine. Students have learned the science behind how the vaccine works. The goal of this project is for students to share how science can be used to solve problems that affect people. **Constructing Explanations and Designing Solutions** **Defining Problems and Developing Solutions** **Influence of Science and Technology on Society**	**Personal Connection:** One of the reasons cited for not taking the HPV vaccine (and also not engaging in regular screening) is lack of doctor recommendation. Building awareness of these measures will save lives.

		• Lesson 11 Student Handout: HPV and Cancer Project Task Sheet		
What is the relationship between viruses and cancer, and how does understanding of this connection inform prevention and treatment strategies?				
Lesson-level Investigative Phenomenon	**Lesson-level Investigative Phenomenon**	**Lesson-level Investigative Phenomenon**	**Lesson-level Investigative Phenomenon**	**Lesson-level Investigative Phenomenon**

Lesson X Anchoring Phenomenon Cancer is a social justice issue.    	These lessons are designed to be brief connections to the unit that can be woven in according to your teaching schedule. Connections to specific lessons are listed, but they can be used whenever you have an extra 10, 20, or 30 minutes.	**What do we figure out?** ● Cancer is a social justice issue. ● All people can have cancer, but outcomes are worse for those in marginalized communities. **What do we do in this lesson?** ● Lesson X Slide Deck: Using Data to Explore Trends and write a research question: students will explore the cancer data explorer and ask questions that can be answered with this type of data. ❖ Connects to Lesson 9: prevention or Lesson 10: vaccines ❖ 20 minute activity ● Lesson X Slide Deck: Access to Screening. The importance of regular screening - students will learn about the effectiveness of regular screening and discuss reasons why people might not get screened, then they will learn about recently approved self-testing kits.	**NGSS:** **Building toward HS-ETS1-1, HS-ETS1-2** Throughout the unit, students have learned that HPV is a virus that might cause cancer in some cases. They have learned how the vaccine is an effective method to prevent this cancer, and they learned some reasons why people don't take the vaccine. Students will learn that not all people have the same access to screening and vaccination, and they will explore data that demonstrates that certain communities are more negatively affected than others regarding cancer care. Students should incorporate this information into their public service announcements. **Constructing Explanations and Designing Solutions** **Defining Problems and Developing Solutions** **Influence of Science and Technology on Society** **Social Justice Standards:**	**Personal Connection:** Science is a human endeavor that has impacts on our lives beyond science class.

		❖ Connects to Lesson 7 or 8: ELISA lab ❖ 30 minute activity ● Lesson X: Exploring Cancer Data is an activity from the unit Cancer Health Inequities from SEP at Fred Hutch Cancer Center. This activity is originally designed as a jigsaw activity, but here it is designed to be used as short 'bell ringer' activities at the beginning of lessons. These can be used in lieu of the Visible Thinking Routines at the beginning of lessons. Many have additional resources attached that can be assigned for homework. ❖ Connects to any lesson ❖ There are 5 10 minute activities ● Vaccine misinformation on social media: The SEP website has an activity on vaccine disinformation on social media. It is specific to Covid 19 mRNA vaccines, so students will have the opportunity to learn about another type of vaccine.	**-DI.9-12.8** I respectfully express curiosity about the history and lived experiences of others and exchange ideas and beliefs in an open-minded way. **-DI.9-12.9** I relate to and build connections with other people by showing them empathy, respect and understanding, regardless of our similarities or differences. **-DI.9-12.10** I understand that diversity includes the impact of unequal power relations on the development of group identities and cultures. **-JU.9-12.12** I can recognize, describe and distinguish unfairness and injustice at different levels of society. **-AC.9-12.20** I will join with diverse people to plan and carry out collective action against exclusion, prejudice and discrimination, and we will be thoughtful and creative in our actions in order to achieve our goals.	

		❖ 90 minute activity ❖ Connects to Lesson 10- vaccines but can be done any time before the final project. **Assessment/evidence of learning:** ● Student discussions ● Students are encouraged to incorporate what they have learned into their final project		

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Additional Programs & Curriculum Resources from Fred Hutch Cancer Center

Teacher Programs

Fred Hutch Cancer Center offers a variety of programs for Science & STEM teachers:

- Science Education Partnership (SEP)
- Hutch Fellowship for Excellence in STEM Teaching (HTF)
- Partners in Science 2.0 @ Fred Hutch (PS2@FH)

Open-Source Curriculum

At Fred Hutch, we support engaging, challenging and relevant classroom learning experiences for all students by providing access to high-quality instructional materials developed by teachers and scientists. Our *Intro to Cancer: Leukemia & Hina's Story Unit* has received national recognition as a "Quality Example of NGSS Design" by the NextGenScience Peer Review Panel. SEP's free, open-source lessons and units are geared towards high school biotech and biology teachers and focus on giving students opportunities to explore biotechnology and the social dimensions of research science.

- SEP Curriculum

Programs for Students

We offer paid internships and introductory programs for high school and undergraduate students throughout our organization. Each program offers valuable learning opportunities that support academic and career goals.

- High School Programs
- Undergraduate Student Programs