Charlotte Teachers Institute
Collaborative Teacher Education

Are you really going to put that there?

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This curriculum unit is recommended for:
AP Environmental Science/ Grades 11th, and 12th

Keywords: genetics, genes, inheritance, epigenetics, DNA methylation, environmental justice, environmental racism, Toxic Substance Control Act (TSCA), Resource Conservation and Recovery Act, toxicity, Polychlorinated biphenyl (PCB)

Teaching Standards: See Appendix I for teaching standards addressed in this unit.

Synopsis: This unit will focus on how environmental regulations (or lack of regulations) can lead to environmental contamination which may potentially affect the human population through modifications in DNA that impact human health. In the beginning students will learn about environmental racism and environmental racism. Using maps, news articles, videos, journal articles and case studies, students will analyze the disparity in the quality of the soil, water and air among different populations. Students will also learn about various environmental laws and regulations; the history behind them and the effect they have on the environment. Students will also look at pollution and study how pollution can damage DNA. Then students will learn about the events that spurred the environmental justice movement in Warren County, NC from the point of view of some of the key players. In the end, students will create an awareness campaign for an environmental injustice that they have identified.

I plan to use this curriculum unit in my AP Environmental Science (APES) class (11th and 12th graders). This unit is designed to be taught in seven class days; however each lesson can be taught as a stand alone activity. Also, this unit can be taught as an overarching theme throughout the year. This curriculum unit incorporates several concepts including toxicology, water quality, ecology, public health, and environmental regulations.

Introduction

Rationale

According to the College Board, the AP Environmental Science course is designed to help students understand the interrelationships of the environment and the analyze how human activity can contribute to environmental problems. When students leave my classroom in the spring I want them to have a greater appreciation for the environment. I not only want them to analyze their lifestyle choices, but I want them to think about ways that they can change to community around them. I do not expect all of my students to become environmentalist or crusaders, but I want them to be aware of how the health of the environment today can have an impact on their great grandchildren.

A few years ago the entire country was focused on Flint, MI. At first many people were saddened at the misfortune the citizens of Flint faced. People could not imagine Americans not having access to water that is safe for drinking, cooking and bathing in their own homes. In the months that followed the initial news cycle, that initial sadness turned to anger once news broke that many local politicians knew about the potential dangers in the Flint water supply years before it became public knowledge. Even though many officials knew that the water in Flint, MI was dangerous, they made little to no efforts to fix the problem. Many just wanted to know "Why?". In this country we elect people into office so that they will act in our best interests, so for many it was almost impossible to understand how elected officials could act this way in THIS country. While Flint, MI may have been the top story for a while, we as a country eventually moved on, but Flint is still struggling and still facing the same problem today, roughly 3 years after it first gained national attention. For many the situation is worse because without media attention aid disappears, the water still is not safe, but free bottled water is not rolling into town by the truckload. People are forced to make do with what they have, meanwhile, children continue to be poisoned and their mental capacity continues to deteriorate.[g]

The issues in Flint, MI briefly captured the attention of the nature, but unfortunately it is not an isolated incidence. All across the country there are environmental health disasters that are largely preventable if proper policies and regulations were in place to protect the local citizens. When we take a close look at the race and socioeconomic status of those directly impacted, you cannot ignore the fact that minorities and the impoverished are impacted disproportionately. Decades before the Flint water crisis. Decades before the Flint, MI water crisis, the State of North Carolina purchased land to construct a hazardous waste landfill in Warren County, NC in an area in which the many of the citizens were experiencing poverty and the majority of the population was Black. The protests that occurred as a result served as the catalyst that ignited the Environmental Justice movement. In this unit students will take an in depth look at local and federal environmental regulations and focus on how money, power and race influence those regulations. Students will also look at how the resulting man-made environmental disasters impact human health and how that could potentially genetically alter a community forever.

Student and School Background

Cato Middle College High School is a magnet high school located in east Charlotte on the campus of Central Piedmont Community College- Cato Campus. Admission is based on GPA (2.5 minimum) and standardized test scores (SAT, ACT or ACCUPLACER) Students at Cato are dual enrolled in CMS and CPCC. The school serves approximately 230 students (100 11th grade, 100 12th grade, 30 13th grade). The majority (67%) of the students belong to a minority ethnic group (33% black, 33% hispanic). Thirty-three percent of the students are classified as intellectually gifted. As a result all of the students in my AP Environmental Science class are high achieving. This course is usually taught as a year long course, meeting every other day for 90 minutes a day. However, this year this course is only taught in the spring semester, meeting every day. We are a 1:1 school so all students have access to technology, and teachers are encouraged to incorporate technology into our daily lesson plans.

Curriculum Objective

Starting in elementary school students are taught that their DNA determines everything about them. In high school they learn that some people have genes that predispose them to certain diseases, and exposure to things like the sun (ultraviolet radiation), and tobacco may damage DNA, but the damage is never discussed as having a generational effect, and the impact that the environment has on DNA is rarely emphasized. A large portion of the Environmental Science AP exam focuses on pollution and environmental legislation, this curriculum unit is an engaging and relatable way for them to explore these topics. Using case studies and primary scientific literature, students will learn about the connections between environmental health, DNA methylation, and human health.

Content Background

DNA

DNA, formally known as deoxyribonucleic acid is the genetic material that is found in almost every living organism on earth. In 1944, years before James Watson and Francis Crick published their groundbreaking paper which described the structure of DNA, Oswald Avery, Maclyn McCarty and Colin Macleod conducted an experiment that demonstrated that DNA was likely responsible for the transfer of genetic information.[1] In their paper, Watson and Crick state that DNA is comprised of four complementary base sequences, adenine, thymine, guanine and cytosine.[2] This finding alone is groundbreaking because it means that all of the information needed to create and maintain life is found in these four nucleic acids. From previous research Watson and Crick deduced that adenine would always pair with thymine and cytosine always paired with guanine, but they figured that the exact order of the bases pairs was not specific.[3] In the more than 60 years since Watson and Crick, the world has learned so much about the structure of DNA the role it plays in individuals and in the world around us.[17] We now know that the order or sequence of base pairs in DNA is directly linked to the sequence of amino acids which ultimately determines the traits that will be expressed by an individual. The exact order of those four base pairs determines whether an organism will become a flower or an elephant. The nitrogenous bases observed by Watson and Crick are actually part of a nucleotide which is a phosphate sugar attached to a nitrogenous base. The phosphate group attached to a sugar group form the backbone of DNA.[4]

Probably the most notable finding of Watson and Crick is that DNA is a double helix. DNA has the ability to replicate itself and each strand is able to serve as a template for future strands.[2] DNA is found in the nucleus of the cell and this is where DNA replication takes place. During replication an enzyme called helicase untwists and unzips the DNA double helix, as this is occurring another enzyme called DNA polymerase "reads" the now single stranded DNA and creates a new complement strand of DNA. The ability of DNA to replicate itself makes it possible for cells to make identical copies of themselves, which is needed for tissue repair.[5]

Genetics and Inheritance

All living organisms have DNA, and all DNA is comprised of the same four nucleotides. Species and individuals differ due to the order of the nucleotides. Recent studies have found that 99% of the genetic code is identical in all humans, and only 1% is responsible for the vast array of hair color, eye color, heights, skin tones, sizes, birth defect, diseases, etc found in the human population.[6]

Through his work with pea plants, Gregor Mendel notice 3 basic rules of inheritance, often referred to as Mendel's Laws of Heredity. According to Mendel's first law; the Law of Segregation, genes are inherited in paired units known as alleles and individuals are randomly given one allele from each parent.[7] This why family members often resemble each other. Based on the Law of Independent Assortment, genes are inherited independently of each other. This is why you may have you dad's nose but your mom's height. Mendel final law is the Law of

Dominance, which explains that there are two forms a gene, dominant and recessive, and wherever present the dominant form will be expressed.[7] For example some conditions like Huntington's and brachydactyly are dominant, and an individual only has to get an affected allele from one parent in order to develop the condition.[8, 9] However, in the case of conditions like hemophilia and red-green color blindness are recessive and an individual must receive an affected allele from each parent in order to have the recessive trait.[10]

Genes are segments of DNA that code for specific traits and they are located on chromosomes. Humans have 23 pairs of chromosomes, getting 23 from each parent (46 total). Usually genes and traits are passed from parents to their offsprings in a relatively predictable pattern; however, sometimes mistakes are made and unexpected traits arise.[11] DNA is constantly replicating itself, so it is not surprising that mistakes are occasionally made. Cells have safeguards in place that catch replication errors (nucleotide excision repair), but sometimes the errors are not corrected. The majority of our DNA does not code for anything and is sometimes referred to as "junk DNA", and mutations in these sections of DNA usually are not catastrophic. When the mutation occurs in a segment of DNA that codes for something it may result in serious consequences including disease or deformity.[12]

Nature v. Nurture

Since its discovery, DNA has been viewed as this rigid blueprint that codes for everything about an individual. In recent years scientists have found genes that are linked to heart disease, breast cancer, obesity, diabetes and other widespread diseases.[13, 14] Some people argue that expression of these genes means that an individual will ultimately suffer from the disease, while others argue that the gene is only one piece of a very complicated puzzle. For example a mutation in BRCA1 is linked to breast and ovarian cancers, but having the mutation does not mean that one will develop cancer, and individuals without the mutation may still develop breast or ovarian cancer.[15] So then the question becomes is DNA the sole predictor and determinant of our traits, or are there other factors to consider. In the last few decades a debate has arose as the whether genetics (nature) or the environment (nurture) plays the biggest role in our traits. If DNA codes for everything in our body, then it would make perfect sense that there would be a gene that would cause an aliment like heart disease; however, it is also likely that poor eating habits, lack of exercise, and bad habits like smoking may play a large role as well.[8]

Epigenetics

As mentioned previously our DNA codes for our traits; however, as time passes we are discovering that it is not that simple. Monozygotic twin studies have revealed that the environment does affect genetic phenotypes. But if DNA controls gene expression, how does the environment alter expression? Some environmental factors such as direct UV exposure actually cause DNA damage which leads to certain phenotypes; however some environmental exposures alter gene expression, but does not damage or change the DNA sequence.[16] This is the focus of epigenetics, and it is often looked at as the link between nature and nurture. Epigenetics is the study of how the environment alters genes expression without changing the genetic codes. Throughout our life we are exposed to various chemicals that become part of our epigenome; while these chemical compounds do not damage the DNA, they do attach to DNA, which

ultimately modifies gene expression. The most common type of epigenetic modification is known as DNA methylation. During DNA methylation, methyl groups (CH_3) are attached to segments of DNA, ultimately silencing the gene. Since methylation leaves DNA intact, the DNA sequence of someone before and after an exposure is the same, thus making it impossible to link a chemical compound to phenotype by just analyzing the DNA sequence.[10]

Pollution and its Effects

The pesticide dichlorodiphenyltrichloroethane (DDT), is a known man-made endocrine disruptor.[17] In the 1930s wildlife biologists began noting unusual behavior in certain bird populations across the country. After studying these birds for a few years Charles Broley hypothesized that these birds were consuming fish contaminated by DDT run-off, which ultimately lead to neurological, behavioral and reproductive changes.[18] Subsequent researchers arrived at similar conclusions; which eventually lead to Rachel Carson's book *Silent Spring*. In her book Carson highlights how pesticides are harming the environment, and she cautions that if the pesticide industry does not act responsibly they could ruin the planet for future generations. As a result of the public outcry and additional environmental research, in 1972 the EPA issued a cancellation order for DDT.[19]

During the Vietnam War between 1962 and 1971 the United States sprayed roughly 20,000,000 gallons of the herbicide commonly known as Agent Orange across Vietnam, Cambodia and Laos. The use of Agent Orange was part of Operation Ranch Hand, in which the US military aimed to kill the vegetation in Vietnam in an attempt to deprive the Viet Cong of food and coverage.[20] In the years following the Vietnam War, previously healthy individuals who were indirectly exposed to Agent Orange, began to present a variety of health effects ranging from skin discoloration to paralysis and leukemia. Children who were exposed prenatally were born with mental disabilities, cleft palates, hernias, polydactyly and various neural tube defects.[21]

Environmental Regulations

Environmental factors like pollution can damage DNA or alter gene expression, which can cause adverse health effects in humans.[10] As a way to ensure human health and environmental health, the government and regulatory agencies regulate what chemicals can be used, how they can be used, and how they must be disposed. Sometimes the regulations are proactive, but they are often enacted after research shows an association between exposure to a particular chemical and an adverse health effect. Toxic Substances Control Act (TSCA) was established in 1976, and this act prohibited the use or distribution of any new chemical substance without approval from the Environmental Protection Agency (EPA).[22] Critics argue that TSCA falls short in two major ways; 1.) TSCA does not classify chemicals by toxicity, it just enables manufacturers to use and sell the compound, and 2.) TSCA only applies to new compounds, all compounds that were in use in 1976 are considered safe unless significant evidence is presented to raise concern. In 2016, congress passed a bill that requires the EPA to test the tens of thousands of unregulated compounds. In theory this sounds great and it is a start, but the EPA is only required to test

twenty compounds at a time, and they have seven years to complete each test.[22] At this rate it will take over 1000 years to test them all.

When a chemical is found to be toxic, it is not necessarily banned for usage. Usually the EPA may limit its usage, prevent future manufacturing or regulate its disposal. This is the case with polychlorinated biphenyl (PCB). PCB is a compound that once had many commercial and industrial uses; but it is linked to many human health conditions. In 1979 PCB was banned, but it is still present in an industrial setting. Instead of required everyone to get rid of PCB, the EPA established disposal guidelines for PCB. Proper disposal is time consuming and expensive. Between June and August of 1978, two individuals hired by the Ward Transformer Company in Raleigh, North Carolina, Robert Burns and his son, "disposed" of 31,000 gallons of PCB-laden fluid by intentionally leaking it onto hundreds of miles of highway. When the contamination was discovered, cleanup ensued and the state of North Carolina announced plans to construct a hazardous waste site near Afton, NC in Warren County, an impoverished area with a large African American population. Local residents opposed this action and mounted one of the first protests to link an environmental issue with the Civil Rights movement. Ultimately, a hazardous waste site for PCB-contaminated soil was constructed in Warren County and in 1993 it was discovered millions of gallons of water from the landfill was threatening to breach the liner, necessitating further cleanup.[23]

Instruction Guide

Topic: Environmental Justice

Essential Question: To what extent is socioeconomic status linked to environmental pollution?

Objective:

- Students will understand environmental justice.
- Students will be able to identify/ create feasible solutions to combat environmental injustice.

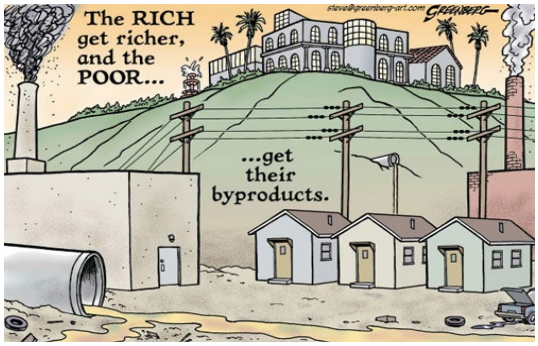
Key vocabulary: environmental justice, coal ash, hazardous waste

Classroom Management

Prior to the beginning of this lesson, students should be familiar with environmental legislation, regulation and various policies; specifically those related to air pollution. Specific regulations include: Clean Air Act (CAA)[24], National Ambient Air Quality Standards (NAAQS)[25], National Emission Standards for Hazardous Air Pollutants (NESHAP)[26] and the Clean Power Plan (CPP)[27]. In this activity learning is primarily inquiry based and is primarily student driven, the primary role of the teacher is to redirect. This activity can be completed in one 90 minute class period.

Activity

Introduction/ Hook (20 - 30 minutes): As an introduction students are asked to analyze the political cartoon shown below. If needed students can use this chart (Appendix II) to help them analyze the cartoon. Give students between 5 to 10 minutes to analyze the cartoon and draw their own conclusions. After the allotted time students should share their observations with the class, and the teacher should facilitate the class discussion. Ideally this can be used as a warm-up or bell ringer activity. This is just a brainstorming activity and there are no right or wrong answers; however, teachers should make sure students are grasping the main points of the cartoon. Students should observe that the poor region has waste, smoke from the factories; while the rich live above the pollution. They may come to the conclusion that the poor often suffer as a result of the activities and needs of the rich. At the end of the class discussion the teacher will introduce the term environmental justice, and ask students how this term applies to the cartoon.



"Editorial Cartoons: Poverty/Environmental Justice." Teaching Tolerance. July 14, 2017. Accessed May 28, 2018. https://www.tolerance.org/classroom-resources/tolerance-lessons/editorial-cartoons-povertyenvironmental-justice.

Critical Analysis- Florence Impact on North Carolina (60 minutes): Students are divided into groups of 3 or 4, and the teacher poses the question "Which group (poor or rich) was impacted the most by Hurricane Florence?". Using only their prior knowledge students should share their thoughts with their group members. Then each group is given various articles about Hurricane Florence and how it impacted North Carolina (public health concerns [a], coal ash pollution [b], climate change [c], poverty [d], beach devastation [e]). Students use the information in these articles to form a more detailed response to the previous question. Each group then presents their full argument to the class with specific examples from the text. (Optional idea: Make this activity competitive, and tells students that the group with the most convincing or persuasive argument wins.) Conclude this lesson with this final question: "Can anything be done to mitigate/ prevent the environmental burden of those experiencing poverty?". Write down student suggestions on poster board and keep them posted throughout the entire curriculum unit.

Topic: Public Health

In this lesson students explore how problems can become public health issues. This activity may also be used to highlight how money and power can influence environmental regulations.

Essential Questions

- How can environmental regulations curtail public health issues?
- What prevents lawmakers from enacting legislation that could protect their constituents?

Objective

- Students will be able to identify environmental injustice.
- Students will be able to link environmental injustice to public health.

Classroom Management

This lesson can be completed in 45 minutes (20 minute video, 25 minutes for reflection and discussion). Students will watch this YouTube video[o] that examines the effects of hog waste in Dublin county NC. The provided guided notes sheet (Appendix III) will help students pull out the main points of the video. Following the video assign one student to lead the class discussion. As the students discuss the video, make sure they fully understand the issue, and also make sure they spend some time discussing the local politician's ties to Smithfield and what that could mean when it comes to regulations. For the final question (Propose a resolution), make sure each student gives a solutions or provides input. As an extension activity (resources not provided) students can discuss how the hog farms were impacted by the hurricanes to hit eastern North Carolina and how that may have affected the surrounding community.

Topic: Environmental Racism

The previous two lessons focused on how natural disasters impact communities and highlighted poverty versus affluence; this lesson focuses on man-made/ industrial pollution often impacts minorities at a disproportionate rate. Student will also explore the motivation behind these disparities.

Essential Question

Can the environmental quality of an area be predicted by the primary race of the majority of the citizens?

Objective

- Students will understand environmental racism.
- Students will be able to use data from maps and graphs to identify incidences of environmental racism.
- Students will be able to analyze environmental issues from different perspectives.
- Students will be able to identify/ create feasible solutions to combat environmental racism.

Key vocabulary: environmental racism, environmental bias, ambient air pollution, stakeholder

Classroom Management

Prior to class students are assigned two articles; one article is about a school in New Orleans, LA proposed to be built on a toxic dump [f], the other is about the Flint, MI water crisis [g]. Students should annotate each article according to the standards set by the teacher. Teachers can assign the guided notes sheets provided to accompany the articles. Students will use these articles to help them decipher the graphs and maps in this activity. This activity can be completed in a 90 minutes class period.

Activity

Introduction/ Hook (30 minutes): As a warm-up activity students are shown this map from Teaching Tolerance, and each student is given a blank sheet of paper and they are told to jot down their thoughts, or what stands out to them about the map. After 5 minutes students exchange papers with someone. Students read the thoughts of their classmate and then comments on the observations of their peer. After another 5 minutes, students trade papers with another student, read all of the comments and then responds. After time is called, students return papers to the original author, and the original author is given 3 minutes to read through all of the comments. As a class students should discuss the points identified by their classmates. It may be helpful to identify one student as the facilitator. The discussion is expected to be student driven; however the teacher may have to encourage students to be more critical of what they see. Conversation prompts include:

- Why are power plants built in those areas?
- What are the short and long term health effects linked to these power plants?
- Do you think power plants are built in minority communities, or are minorities communities built around power plants?
- What are some of the similarities you can infer between Connecticut , New Orleans and Flint, MI?
- What can be done to stop this disparity?

Critical Analysis- Environmental Racism (60 minutes): The map in the warm-up shows that ethnic minorities may experience environmental bias. In Connecticut sources of air pollution are likely to be located in communities where minorities live. As a result of the introduction activity students should understand that pollution sources are not always placed in minority communities, but sometimes minority communities are developed in polluted areas. This issues is not specific to Connecticut , and examples can be found throughout the country. The article "Reading, Writing, & Arsenic: New Orleans School Planned atop Toxic Dump" illustrates an example of a minority community being developed in a polluted area, and "Flint Residents Angry over Health Issues Caused by Switch in Water Supply" details a prime example of pollution being placed in the minority community. In this activity, student will critically analyze the situation in either New Orleans or Flint, MI. Students are divided into groups and are assigned one of the two cities. Having previously read the article, students have to identify 3 stakeholders in the situation. Each group will create a chart that lists the stakeholders, the motivation and desires of the identified stakeholders, as well as their power or status in the community. Then students will look at the resolution or current status of the issue, and using the information on their chart they will try to decipher what led to or was responsible for the outcome. Groups can post their charts around the room, and in the time remaining students will walk around and see how other groups interpreted the situation. Before dismissal the teacher should ask the recurring question for this unit: "What can be done to mitigate the burden?".

Topic: Epigenetics

At this point student should understand that polluted water, soil and air can cause health problems; however they probably do not fully understand how. This curriculum unit is designed for 11th and 12th graders, so it is assumed that they have taken a biology course. Therefore they should have some basic knowledge and how genetics works. In this lesson students will be introduced to the field of epigenetics, but this lesson is in no way a comprehensive look at epigenetics.

Essential Question

To what extent does our environment determine are traits?

Objective

- Describe how epigenetic modifications lead to changes in gene expression.
- Explain how epigenetic factors could lead to different gene expression patterns in identical twins.
- Describe how the environment can alter the epigenome

Key vocabulary: epigenetics, epigenome, mutagen, DNA, histone, methylation, genetic, inheritance, methylation

Classroom Management

This lesson is designed to take 3 days (45 minutes a day). However, activities can be consolidated if needed. Similar to the other lessons, teacher involvement is minimum. Students will be guided by the case study [h], videos, an article from Singh et al [j], and their general curiosity. The case study has five parts, each part should be distributed separately. Prior to the start of this lesson students are assigned Part I from the case study (Identical Twins, Identical Fates? An Introduction to Epigenetics). Students are expected to read Part I, answer the questions and be prepared to discuss.

Critical Analysis- Twin Studies

As a warm-up the teacher can ask the students to explain genetic variation and the difference between monozygotic and dizygotic twins. This is a good way to gauge prior knowledge. The teacher then leads the discussion about Part I of the case study. In Part I we are introduced to a healthy twin (Elise) who is concerned about her twin (Shannon) who has an undisclosed diagnosis. As part of the class discussion the teacher could ask any of the following:

- Is Elise's concern for her own health justified?
- Would Elise's risk change if she and Shannon monozygotic versus dizygotic?
- Do monozygotic twins suffer from the same illnesses?

Following the class discussion in groups of 3 - 4 students will work through Part II. In Part II students learn that Shannon suffers from schizophrenia. The question set guides students to think about what may cause schizophrenia. Most students will either say that it is a result of genes or DNA. If the discussion stops there, push then to consider why Shannon has schizophrenia but Elise does not. Listen to what is being said but do not tell them if they are right or wrong, since they will learn more about genetics later in the case study. At home students will read Part III and watch this TED-Ed video on epigenetics by Carlos Guerrero-Bosagna.[i] The video talks about histones, and your students are probably not familiar with these, so make sure to explain histones at the beginning of class. Explain how histones affect gene expression and how the environment can modify histones. In class students are given Part IV and the 2003 fron Singh *et al.*[j] Students should read the Singh article, and use it to answer the questions for Part IV. More than likely students will be intimidated by the journal article and will try to answer the questions without reading the article, but encourage them to read the article. At home students can work on Part V. To wrap up this lesson the teacher will lead the

class discussion about what happened, thoughts on Elise's risk, treatments that actually alter the epigenome, what could account for the variation in the epigenomes of Elise and Shannon. To connect this lesson with the others in this unit the class will discuss how epigenetics may be linked to the cases the class has examined in Flint, MI, New Orleans, Connecticut and North Carolina.

Topic: Afton, Warren County, NC

In this activity, students will use everything they have learned throughout this unit to identify an environmental injustice, analyze the situation from the perspective of various stakeholders, predict or identify any resulting health effects, and outline possible resolutions.

Classroom Management

This lesson is expected to take 2 full class days (90 minutes per day).
Critical Analysis- Warren County, NC: Students are divided into groups of 3 - 4. Each group is given a folder that contains documents related to the environmental crisis that happened in Warren County (see below). Prior to this lesson students have not learned about Warren County, and the teacher will not provide any information. As a group students will read through the documents and try to figure out the problem and the players. Since students have no prior knowledge they will struggle and it it will take them a while to piece together all of the components of the story; this may take around 45 minutes. One person from each group will share with the class what their group was able to determine from the documents. Then the class will watch a short video that outlines the controversy, but does not show the final outcome. Next students will analyze the situation from the perspective of different stakeholders. In each group one person will play the role of Governor Jim Hunt, Reverend Ben Chavis, an Afton resident, and the USEPA. After students have researched the viewpoint of their stakeholder, the group will come together to figure out a solution. Students need to argue their ideas from the viewpoint of their assigned shareholder in 1982. The following day each group will share what their group decided and why. The the teacher will reveal the actual resolution to the class.

Warren County Articles

- "Carolinians Angry Over PCB Landfill"[m]
- Documents form the general accounting office

Topic: Environmental Injustice Everywhere- Culminating Activity- *(Final Assessment)*

Essential Question

What is the relationship between environmental problems and power?

Objective

- Students will understand that environmental hazards disproportionately affect some populations more than others.

The activity is intended to be completed outside of class. In this activity students will identify an incidence of environmental injustice. Then they will research the situation, write a paper (~2 pages) and create a product (poster, PSA, or an opinion piece for a publication) that brings awareness to the topic. In the paper, student will identify the following:

- The source of the pollution (Does a major highway cut through your town, exposing residents to a lot of noise and fumes? Is there a landfill or a hazardous waste disposal area? Is there a power plant that is noisy and puts smoke into the air?).
- Identify who lives in the area of concern.
- What type of health concerns are associated with this issue?
- What legislation is in place?
- What would a more environmentally just situation look like?
    - Predict any resistance to your resolution

This activity will be assessed using the accompanying rubric. (Appendix IV)

Appendix I

AP Environmental Science Course Topics

Pollution

A. Pollution Types
    a. Air pollution
    (Sources — primary and secondary; major air pollutants; measurement units; smog; acid deposition — causes and effects; heat islands and temperature inversions; indoor air pollution; remediation and reduction strategies; Clean Air Act and other relevant laws)
    b. Noise Pollution
    (Sources; effects; control measures)
    c. Water pollution
    (Types; sources, causes, and effects; cultural eutrophication; groundwater pollution; maintaining water quality; water purification; sewage treatment/septic systems; Clean Water Act and other relevant laws)
    d. Solid waste
    (Types; disposal; reduction)

B. Impacts on the Environment and Human Health
    a. Hazards to Human Health
    (Environmental risk analysis; acute and chronic effects; dose-response relationships; air pollutants; smoking and other risks)
    b. Hazardous chemicals in the environment
    (Types of hazardous waste; treatment/disposal of hazardous waste; cleanup of contaminated sites; biomagnification; relevant laws)

C. Economic Impacts
    (Cost-benefit analysis; externalities; marginal costs; sustainability)

This curriculum unit (CU) will focus on how environmental regulations (or lack of regulations) can lead to environmental contamination which may potentially affect the human population through modifications in DNA that impact human health. Ideally this CU will be used to address AP Environmental Science topic VI (pollution). Through learning about hog farms in NC and the PCB landfill in Warren County, NC students will make connections between solid waste disposal and water pollution. Student will also conduct case studies that investigate the long term health effects of exposure to air, water and land pollution. Ultimately students will see how economics, socioeconomic status, and race play a role in environmental regulations.

Appendix II

	Rich	Poor
Where do the people in each group live?		
What is the landscape like in the two groups?		
What other objects do you see in each area?		
Summarize (in 1 paragraph) what your observations may mean:		

	Rich	Poor
Where do the people in each group live?		
What is the landscape like in the two groups?		
What other objects do you see in each area?		
Summarize (in 1 paragraph) what your observations may mean:		

Critical Analysis of an Article

This worksheet will guide you through a critical reading of the assigned article.

Logic and Argument:

1. The main argument of this article is: (Paraphrase as accurately as possible.)

2. The most important information in the article is: (What supporting evidence, facts, experience, or data do the authors provide to support their argument?)

3. The key concept(s) we need to understand in the article are: (What important ideas do you need to understand in order to understand the author's line of reasoning?)

4. The main assumption(s) underlying the author's thinking is/are: (What are the authors taking for granted [that might be questioned]?)

5. If we take this line of reasoning seriously, the implications are: (The "so what?" question: Why does this argument matter? Why should we care? What consequences are likely to follow if people take the authors' line of reasoning seriously?)

6. What are your reactions to this argument? Are you convinced? Why or why not?

7. What questions do you have about this article? Do you need more information? Is part of the argument unclear? Is there something the authors haven't considered? What would you ask the author(s) if you spoke with him/her/them?

Adapted from Critical Thinking: Concepts & Tools by Paul and Elder & Empire State College

Appendix III: Writing Center

Special Report Examines Effects of Hog Waste on Dublin County, NC, Residents

1. How many hog farms are in Duplin County, NC?
2. Where is the hog waste stored?
3. What are some of the health effects caused by exposure to hog waste?
4. How does using/ spraying the hog waste impact the daily lives of the residents of Duplin County?
5. Explain the lagoon system of waste management. Why may some people view it as unfair?
6. What is the role of the State Environmental Management Commission?
7. How does the Clean Air Act (CAA) relate to the situation in Duplin County?
8. What is the position of the state legislator from Duplin County? Who was a big contributor to his campaign?
9. Enforcement or legislation? In your opinion, which one is the bigger problem in this situation? Why?
10. In your own words, explain how the hog farms Duplin County are an example of environmental injustice?
11. Propose a resolution the problem.

Appendix IV

RUBRIC: Are You Really Going to Put That There?

	4	3	2	1
Topic	Selected an appropriate environmental issue, demonstrates sufficient background knowledge, and identifies an affected population.	Selected an appropriate environmental issue, and identifies an affected population, but fails to provide sufficient background information.	Relevant environmental issue is selected; however background information is inaccurate.	Selected topic does not focus on an environmental issue with a social justice component.
Human Health Impact	Clearly identifies how the chosen issue will adversely impact humans. Information is supported by facts from reliable sources.	Clearly identifies how the chosen issue will adversely impact humans. Information is supported by facts from unreliable sources.	Identifies how the chosen issue will impact human health, but is mostly speculations and not supported by facts.	No link to human health is made
Regulations and Policies	Clearly identifies current legislation that is relevant to the issue. Demonstrates an understanding of the relationship between policy and the issue.	Identifies current legislation that is relevant to the issue, and demonstrates limited knowledge of policies	Mentions legislation, but it is not appropriate for the issue.	Makes no link to current policies
Resolution	Demonstrates critical thinking and full understanding of the issue by presenting a feasible and well thought out resolution, including responses to foreseeable resistance.	Presents a possible solution, but does not provide responses for opposition.	Proposed resolution is improbable.	No resolution suggested, or resolution does not properly address the issue
Research Quality	Included facts, conclusions, and opinions from reliable sources. Included opinions of subject-matter experts.	Included facts, conclusions, and opinions from reliable sources.	Included a mixture of facts from reputable sources and opinions from unreliable sources	Included more opinion than fact. Information was taken from unreliable sources.
Writing	Writing is clear and relevant, with no grammatical and/or spelling errors – polished and professional. Reference section properly formatted.	Most ideas are stated clearly and are related to the topic, with only minor grammatical and/or spelling errors. Reference section adequate.	Many ideas require clarification and/or are off-topic or have marginal relevance to the assignment. Many grammatical and/or spellings errors	Paper does not meet the criteria for the assignment (too short or incomplete, too long, and/or completely off-topic). Reference section missing.

			throughout the paper. The paper is very challenging to read due to poor writing flow. Improper reference section.	
Product	Product is professional in appearance and fully conveys the problem, and successfully offers a viable solution.	Product is adequate, but fails to offer viable solution.	Product is not professional in appearance or does not effectively bring awareness to the issue.	Product is missing

Teaching Resources

Atkin, Emily. "Hurricane Florence Is a Public Health Emergency, Too." The New Republic. September 13, 2018. Accessed October 27, 2018. https://newrepublic.com/article/151180/hurricane-florence-public-health-emergency.
Hurricane Florence disrupted hog farms, coal ash ponds,and Superfund sites, leading to a public health issues. This is a great article that breaks down the public health concerns associated with Hurricane Florence.

"Hurricane Florence Adds Coal Ash Spills to Pollution Cases Facing Duke Energy." The Daily Tar Heel. Accessed October 27, 2018. https://www.dailytarheel.com/article/2018/09/duke-energy-lawsuit-update-0926.
This article focuses on how Hurricane Florence exacerbated the already problematic coal ash pollution of local water sources.

Aton, Adam. "Florence's Floods Reveal Exposure of Rural Areas to Climate Change." Scientific American. September 18, 2018. Accessed October 27, 2018. https://www.scientificamerican.com/article/florences-floods-reveal-exposure-of-rural-areas-to-climate-change/.
This article explains how climate change has lead to an increase in severe weather conditions.

Gabbatt, Adam, and Oliver Laughland. "In North Carolina, It's the Poorest Who Bear the Brunt of Flooding." The Guardian. September 18, 2018. Accessed October 27, 2018. https://www.theguardian.com/world/2018/sep/17/north-carolina-florence-flooding.
This article examines how socioeconomic status impacts overall environmental health of a community.

Shaw, Al. "After Florence, North Carolina Must Rebuild Vulnerable Beaches Once Again." Pacific Standard. September 27, 2018. Accessed October 27, 2018. https://psmag.com/environment/north-carolina-must-build-its-beaches-again.
This article examines how socioeconomic status impacts overall environmental health of a community.

Mock, Brentin. "Reading, Writing, & Arsenic: New Orleans School Planned atop Toxic Dump." Grist. November 19, 2013. Accessed May 28, 2018. https://grist.org/cities/reading-writing-arsenic-new-orleans-school-planned-atop-toxic-dump/.
This article is about a school in New Orleans, LA that is proposed to be built on a toxic dump. This article is a good way to get students thinking about what should happen to polluted lands.

Newsela | Flint Residents Angry over Health Issues Caused by Switch in Water Supply. Accessed October 27, 2018. https://newsela.com/read/flint-residents/id/14320/.
This Newsela article can be modified for any lexile level. It is a general article about the health implications of the Flint water crisis.

"Identical Twins, Identical Fates?" National Center for Case Study Teaching in Science (NCCSTS). Accessed June 07, 2018. http://sciencecases.lib.buffalo.edu/cs/collection/detail.asp?case_id=656&id=656.
This case study introduces the concept of epigenetics. It examines how monozygotic twins express different phenotypes despite having the exact same DNA.

YouTube: What is epigenetics- Carlos Guerrero-Bosagna https://www.youtube.com/watch?v=_aAhcNjmvhc
This brief (5 minute) TedTalk breaks down the concept of epigenetics. It serves as a great lesson introduction.

Singh, Sm, B. Murphy, and R. Oreilly. "Involvement of Gene-diet/drug Interaction in DNA Methylation and Its Contribution to Complex Diseases: From Cancer to Schizophrenia." Clinical Genetics 64, no. 6 (2003): 451-60. doi:10.1046/j.1399-0004.2003.00190.x.
This is a scientific journal article that examines how diet and drugs actually cause DNA methylation and examines what problems may result from DNA methylation.

Guidry, Virginia, S. Rhodes and C. Woods. "Connecting Environmental Justice and Community Health Effects of Hog Production in North Carolina." North Carolina Medical Journal. September-October 2018 vol. 79 no. 5324-328
This primary source article is an easy read. In the aftermath of Hurricane Florence the flooding of several hog farms in eastern NC became a local health concern. The article details the exact concerns presented by hog farms.

Special to the New York Times. "CAROLINIANS ANGRY OVER PCB LANDFILL." The New York Times. August 11, 1982. Accessed November 17, 2018. https://www.nytimes.com/1982/08/11/us/carolinians-angry-over-pcb-landfill.html.
This 1982 article talks about the proposed PCB landfill in Warren COunty, NC and focuses on the opinions of the citizens.

Turnbull, Dairian. "Warren County Documentary." YouTube. June 04, 2014. Accessed November 17, 2018. https://www.youtube.com/watch?v=8YJJ2OQ3zSs.
In this 8 minute video citizens from Warren COunty , NC reflect back on the events surrounding the PCB landfill and how they ultimately lead to the birth of the environmental justice movement.

LivableFutureBlog. "Special Report Examines Effects of Hog Waste on Dublin County, N.C., Residents." YouTube. January 05, 2015. Accessed November 18, 2018. https://www.youtube.com/watch?v=ZB0uI8iHciE.
This twenty minute Youtube video examines the effects of hog waste in Dublin county NC

Bibliography

Avery, O. T. "Studies On The Chemical Nature Of The Substance Inducing Transformation Of Pneumococcal Types: Induction Of Transformation By A Desoxyribonucleic Acid Fraction Isolated From Pneumococcus Type Iii." *Journal of Experimental Medicine* 79, no. 2 (02, 1944): 137-58. doi:10.1084/jem.79.2.137.

Watson, J. D., and F. H. C. Crick. "Molecular Structure of Nucleic Acids: A Structure for Deoxyribose Nucleic Acid." *Nature* 171, no. 4356 (04 1953): 737-38. doi:10.1038/171737a0.

Travers, Andrew, and Georgi Muskhelishvili. "DNA Structure and Function." *FEBS Journal* 282, no. 12 (06 2015): 2279-295. doi:10.1111/febs.13307.

"Chemistry and Biology of Nucleosides and Nucleotides." 1978. doi:10.1016/b978-0-12-326140-3.x5001-3.

"Advancements in Genetic Engineering." OMICS International. https://www.omicsonline.org/scholarly/dna-replication-journals-articles-ppts-list.php.

"GENOME VARIATIONS." GNN - Genome News Network. http://www.genomenewsnetwork.org/resources/whats_a_genome/Chp4_1.shtml.

Dunn, P. M. "Gregor Mendel, OSA (1822-1884), Founder of Scientific Genetics." *Archives of Disease in Childhood - Fetal and Neonatal Edition* 88, no. 6 (11, 2003). doi:10.1136/fn.88.6.f537.

"Nature vs. Nurture." GoodTherapy.org - Find the Right Therapist. August 12, 2015. https://www.goodtherapy.org/blog/psychpedia/nature-versus-nurture.

"Brachydactyly." *SpringerReference*. doi:10.1007/springerreference_34518.

"What Is Epigenetics? - Genetics Home Reference - NIH." U.S. National Library of Medicine. Accessed November 17, 2018. https://ghr.nlm.nih.gov/primer/howgeneswork/epigenome.

Gonzaga-Jauregui, Claudia, James R. Lupski, and Richard A. Gibbs. "Human Genome Sequencing in Health and Disease." *Annual Review of Medicine* 63, no. 1 (02, 2012): 35-61. doi:10.1146/annurev-med-051010-162644

Nature News. https://www.nature.com/scitable/topicpage/dna-replication-and-causes-of-mutation-409.

Yang, Yisheng, and Lawrence Chan. "Monogenic Diabetes: What It Teaches Us on the Common Forms of Type 1 and Type 2 Diabetes." *Endocrine Reviews* 37, no. 3 (06 2016): 190-222. doi:10.1210/er.2015-1116.

Yazdi, Fereshteh T., Susanne M. Clee, and David Meyre. "Obesity Genetics in Mouse and

Human: Back and Forth, and Back Again." *PeerJ* 3 (03, 2015). doi:10.7717/peerj.856.

Rebbeck, Timothy R., and Susan M. Domchek. "Variation in Breast Cancer Risk in BRCA1 and BRCA2 Mutation Carriers." *Breast Cancer Research* 10, no. 4 (07, 2008). doi:10.1186/bcr2115.

Yasui, Akira, and Shirley J. Mccready. "Alternative Repair Pathways for UV-induced DNA Damage." *BioEssays*20, no. 4 (1998): 291-97. doi:10.1002/(sici)1521-1878(199804)20:43.0.co;2-t.

Patisaul, Heather. "Long-term Effects of Environmental Endocrine Disruptors on Reproductive Physiology and Behavior." *Frontiers in Behavioral Neuroscience* 3 (2009). doi:10.3389/neuro.08.010.2009.

Gerrard, Jonathan M. *Charles Broley: An Extraordinary Naturalist*. White Horse Plains Publishers, 1983.

Carson, Rachel, Lois Darling, and Louis Darling. *Silent Spring*. Houghton Mifflin, 1962.

Herbicides, Committee to Review the Health Effects in Vietnam Veterans of Exposure to. *Veterans and Agent Orange*. National Academies Press, 2004.

Yi, Sang-Wook, Heechoul Ohrr, Jae-Seok Hong, and Jee-Jeon Yi. "Agent Orange Exposure and Prevalence of Self-reported Diseases in Korean Vietnam Veterans." *Journal of Preventive Medicine & Public Health* 46, no. 5 (09, 2013): 213-25. doi:10.3961/jpmph.2013.46.5.213.

"Environmental Justice History." Department of Energy. Accessed November 18, 2018. https://www.energy.gov/lm/services/environmental-justice/environmental-justice-history.

“Summary of the Clean Air Act.” *EPA*, Environmental Protection Agency, 24 Aug. 2017, www.epa.gov/laws-regulations/summary-clean-air-act.

“NAAQS Table.” *EPA*, Environmental Protection Agency, 20 Dec. 2016, www.epa.gov/criteria-air-pollutants/naaqs-table.

“National Emission Standards for Hazardous Air Pollutants Compliance Monitoring.” *EPA*, Environmental Protection Agency, 29 Jan. 2018, www.epa.gov/compliance/national-emission-standards-hazardous-air-pollutants-compliance-monitoring.

“FACT SHEET: Overview of the Clean Power Plan.” *EPA*, Environmental Protection Agency, 9 May 2017, archive.epa.gov/epa/cleanpowerplan/fact-sheet-overview-clean-power-plan.html.