



GMOs: Costs, Benefits, and Controversies

Curriculum Unit 18.05.03, published September 2018

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Introduction

We have entered a time in human history in which we can potentially create a man made crop that retains whatever favorable traits we would like them to have. Imagine a super sweet strawberry the size of a baseball, or a basketball sized potato that can grow in the harshest terrain in developing countries that suffer from famine. Genetically Modified Organisms (GMOs) present this possibility for our societies. Although the examples given above haven't been created yet and may be a little farfetched, we already have created organisms that are as useful and serve a similar purpose as the examples that were just given. GMOs have allowed us to grow crops and obtain higher yields in ways and places that were previously incapable. GMOs have also allowed us to create crops with more favorable traits. These breakthroughs have already taken place. There is however, a considerable amount of push back and controversies surrounding GMOs. Some of the push back is valid, although much of it isn't based on sound arguments or facts. With all this said, if we can learn to master the process of genetically altering the genes of organisms, the possibilities seem endless.

I teach 6th grade science at Anna Yates Middle School, a public school that is part of the Emery Unified School district, located in Emeryville California. Emeryville is a relatively small city located in between Oakland and Berkeley. Because the city of Emeryville is small in size our student population is also small. Forty percent of our student body is composed of interdistrict transfer students from Oakland and Berkeley. Our middle school has roughly 175 students from various ethnic and socioeconomic backgrounds.

I teach in a self-contained classroom, meaning my class acts as a homeroom for my 6th grade students. I have 2 blocks of students throughout the school day. Each block consists of 25 students. I have each block for 2 and half hours and I teach math and science during each block. That gives me approximately 1hour and 15minutes to teach each subject. I do recognize that most math teachers have 45-50 minutes to teach each subject and that I am fortunate to have the additional time for instruction. Although I have more time with my students than the average middle school teacher, this curriculum is written in a way that also lends itself well to 45-50 minute blocks.

I teach a wide range of students with varying abilities. I have high performing students that enter my class confident, motivated and reading well above grade level as well as students that come to my class struggling academically, tuned out, and are generally feeling defeated as it pertains to their education. Of the 50

students I teach I have 3 English Language Learners, 8 Individualized Education Plan (IEP for struggling students) and 2 students on Behavioral Plans (behavior is severe and they are in jeopardy of being expelled).

I have thirteen desks in my room that seat 2 students each. Compared to the group table set up which typically has 3-4 students at a table, this arrangement allows students to work independently as they have ample space and less of a chance to be distracted by other students as they only have one other student at their table. It also works particularly well for partner work because their partner is already at the desk with them. If we do have an assignment that requires group work I simply instruct my students to push their desks together and work in groups of 4. These tables are arranged in rows of 6x10. I do have assigned seating in my class and like most teachers, I am very careful and purposeful about where I place students in my class. My general rule of thumb is to place students that are typically unfocused in the front, next to a students that are focused and students that have proven to have behavior challenges away from other students that have proven to have behavior challenges. I also make sure that I sit my English Language learners next to students that are bilingual if possible and I am sure to be clear that those students are there to support each other when needed.

I also have a class set of 25 chrome books in my class. This class set allows me to consistently integrate technology into my instruction and classwork. Our current science curriculum is Stemscopecs. This curriculum heavily relies on the use of computers in the class. This GMO unit will also require students to have some access to computers. Early in the unit students won't need computers; however, once students start their projects they will need access to a computers. With this said a clever teacher can teach this unit with even less access to computers, but it would mean more leg work in terms of gathering and printing information on the teachers part and less project options for students.

The philosophy at Anna Yates is that we are here to serve the whole child. This includes not only providing students with the best possible instruction but also ensuring that we are supporting families of our students as we understand that families have a direct impact on our students success and development. In doing this, we provide families with resources ranging from employment education to health services. As it pertains to instruction we believe it is imperative to meet students where they are by differentiated instruction to meet varying academic abilities as well as finding new and creative ways to engage students so that they have multiple ways to access information. This curriculum follows this philosophy in that I include multiples ways for students of varying abilities to access information and multiple methods for students to demonstrate learning.

Essential Question

In this unit students will need to answer the following questions: What are GMOs? What are the costs, benefits and controversies surrounding GMOs? Do I support GMOs? How can I impact this topic in a way that reinforces what I believe? In 6th grade we typically study genes as they relate to heredity, traits, mutations and the structure of DNA. Although it is possible to start this unit without having first taught these topics, it is recommended that teachers begin this unit after students have gained a basic understanding of these topics as this background will set the ground work for the content presented in this unit.

Aside from the fact that this unit is aligned with NGSS standards I believe this topic is incredibly important for students. First, students will gain an understanding of where their food comes from, how it is grown, and a basic understanding of the genetics of the food they consume. Being informed about what they put into their bodies can be transformative for students, as they may want to change their diet or help inform those around them. Secondly, through the lens of controversies surrounding GMOs, students will learn how to decipher

other controversies in our society by looking at both sides of an argument from an objective standpoint, doing their own research and coming to their own conclusion. This will be the process they follow in this unit and it will be helpful for them as they transfer this process to other issues through out their lives. Lastly, because students will have to complete a civil action for their final project they will learn that they have the power to impact their society and also learn the various tools that will allow them to do it. In addition, the projects and activities in this unit are designed to foster students ability to work together, problem solve, research, think critically, speak publicly, and cross reference as these transferable abilities are of the utmost importance as they matriculate through school and ultimately into the professional work force.

Instruction

This curriculum will provide various forms of instruction and assessment tools to engage students and check for understanding. As it pertains to instruction, students will be given various articles and texts to read along with videos in order to engage students at multiple levels. These videos will range from short clips to documentaries. Teachers will easily be able to upload or download these resources online. Students will be assigned individual research assignments to deepen their understanding as well as partner and group oriented assignments in an effort to give students the ability to learn from each other. Each of these assignments will include various levels of complexity, which will allow for differentiation, meeting students at their appropriate academic level. Teachers will also have the flexibility to implement various methods of formal and informal assessments throughout the unit. These assessment methods will include expository presentations, Power Point presentations, essays, team debate and a civil action project. The expository presentations, Power Point presentations, essays, team debate and a civil action project will be accompanied by teacher and student rubrics, and checklists. The idea is that students have multiple ways to demonstrate what they have learned.

I will use various strategies to provide my students with information about GMOs. Students will be given articles and excerpts from texts to read. In addition, we will be watching short news clips and documentaries that will outline the many arguments for and against GMOs and also describe how GMOs are created as well as discuss the different interest groups involved with this issue. If possible, it is recommended that teachers take a trip to a local organic farm so that students can hear from farmers, ask questions, and get additional information about GMOs. Students will be taking structured notes and answering various open-ended questions as they receive all of the information presented in this unit.

Content

What are GMOS?

The term Genetically Modified Organisms (GMOs) refers to a living organism that has undergone manipulation of its genes by humans for a specific purpose. Scientifically speaking, genetic modification is much more of a process than a final product. However, the term GMO has recently been embraced as a way of referring to a plant or animal that has had one or more of its genes manipulated or modified in order to benefit humans.

In order to better understand exactly what a GMO is, lets break up this term. Genetically, refers to the genes of a living organism. Every living organism on the planet has genes. The genes in an organism are made of DNA, which are the building blocks of life and determine the specific and unique traits an organism will have,

develop and pass down to its offspring. Modified, refers to making a partial or minor change to an organism, typically to improve upon it in a specific and purposeful way. Organisms, for all intents and purposes refer to any living unit of life. This science unit will focus primarily on plant GMOs. Specifically, as it pertains to crop GMOs that humans consume.

Although the term GMO has more recently come into public view within the context of a scientist in a lab tinkering with seeds, cells and DNA, humans have been creating GMOs for centuries. Going back as far as 9,000 years ago ancient farmers were selecting seeds from plants that had the most favorable traits, growing and crossbreeding those plants with seeds from other plants with similar desired traits and disregarding the seeds from plants with unfavorable traits.¹ This process is called domestication. This is the process by which a wild organism has been selected and evolved into a more favorable organism through artificial selection. Many of the fruits and vegetables we enjoy today come from plants that were domesticated thousands of years ago. Cereal crops were first domesticated around 9000 BCE in the middle Fertile Crescent in the Middle East.² Other domesticated produce we currently consume includes strawberries, lettuce, spinach, cabbage, carrots, etc.

Science writer Carl Zimmer discusses this process in his book *"She Has Her Mothers Laugh: The Powers, Perversions, and Potential of Heredity"*. In this text he describes the domestication of tomatoes by the indigenous farmers of Peru. Zimmer starts by describing how the original wild tomatoes of Peru were the size of blueberries. He then explains that there was a gene in these blueberry-sized tomatoes that was responsible for the size of the tomatoes and that this gene mutated and made bigger tomatoes. Farmers were able to continue to cultivate this gene over years of harvest until we now have the much bigger version of the tomato, which we currently find in our supermarkets. ³

Modern methods of creating GMOs essentially do the same thing at a much more efficient and faster pace. Modern scientists are now able to cut a favorable gene out of one plant and place it into another plant. Thereby, speeding up the domestication method of making GMOs by hundreds, even thousands of years.⁴

Controversies and Arguments Against GMOs

Harmful to human health

It is widely held in public thought that GMOs have an adverse effect on the human body as well as the animals that provide meat that humans consume. The most pertinent reason for this idea is that many GMO crops have a certain chemical herbicide imbedded in them in order to deter insects from ravaging crops before harvestings. Since 2015 "there has been a sharp increase in the amounts and numbers of chemical herbicides used in GM crops". This has been found to be true for GMOs worldwide.⁵ People believe that these herbicides are contributing to the rise of diseases we see in our society. Although there has been much research conducted with the goal of outlining the health risks of GMOs, there is little research that can conclusively assert that GMOs present direct health risks for humans. With this said, a groundbreaking ruling was handed down in San Francisco. In this case a groundskeeper came in direct contact with Monsanto Roundup weed killing herbicide and was subsequently diagnosed with cancer. The San Francisco jury in this case found that Monsanto's herbicide "was responsible for a former school groundskeeper's cancer" and awarded the plaintiff \$289 million dollars.⁶ Even though this particular case found that this particular herbicide, which is widely used in GMOs, was responsible for the groundskeeper cancer, there is little data that has found that GMOs are definitely linked to adverse health issues in people that consume them.

Psychological factors

There is also a psychological component regarding the arguments against GMOs. Jamieson et al. argues that people believe that “foods containing unnatural ingredients (GMOs) are produced using unnatural processes” and because of that they are unhealthy, unsafe and undesirable. These authors argue that this skepticism and fear of organisms that are perceived to be unnatural is hardwired into the cognition of humans.⁷ Examples of this fear can be seen in the many instances in which citizens of communities around the world have organized and protested against GMOs. In 2016 there were 3 separate citizen petitions requesting that the Food and Drug Administration (FDA) should prohibit the term “natural” on the labels of GMOs.⁸ This was caused by growing consumer concerns regarding food labels accurately reflecting both ingredients and process.

Patents

Other arguments against GMOs pertain to the fact that some companies are patenting GMOs. Although protecting ones intellectual property is not a new concept, many Americans have a particular problem with the patenting of GMOs. A *patent* is a set of exclusive rights granted by a sovereign state or intergovernmental organization to an inventor for a limited period of time in exchange for detailed public disclosure of an invention. Patent laws were designed to protect man made inventions. There hasn't been much controversy surrounding patents until companies began to patent GMOs. In 1980, a Supreme Court case ruled that bacteria had been genetically modified by the insertion of genes.⁹ The inserted genes transformed the bacteria from a product of nature to a commodity. This case opened a floodgate of patents sought for genetically modified organisms. The shift that occurred in 1980, allowing a patent on genes, started a monopoly over plants and crops. Allowing patents on living organisms causing a monopoly over certain crops. This monopoly is causing many farmers to lose their livelihood due to patent infringement laws. If a farmer is found to be using patented seeds without having paid for those seeds he can be sued. It can also be difficult for farmers that use organic seeds to compete with farmers that use patented GMO seeds because the latter tends to yield more and require less overhead, allowing those farmers to charge significantly less for their crops.

The ethical debate regarding GMOs is constant, with those opposed using various tools to combat what they see as gross misconduct by companies that are patenting crops. There is an obvious ethical issue here, in that, many don't believe humans should be able to patent a plant. The ramifications of this means that farmers have to consistently pay companies that own the rights to crops and are sued and face a lifetime of lawsuits when they do not adhere to the patent laws.¹⁰

Monsanto is an agricultural industry giant and has an infamous reputation of suing smaller farmers and effectively causing those farmers to go bankrupt and shut down their farms. One of the better-known cases was against Canadian farmer Percy Schmeiser. “Schmeiser discovered that his field had been contaminated with Monsanto's Roundup Ready canola seeds when the land segments surrounding utility poles were sprayed with Roundup. He then admittedly used the seeds from areas where he sprayed with Roundup to replant the following year's crops”.¹¹ This case went all the way to the Supreme Court of Canada, which ruled in favor of Monsanto. This is one of many cases in which agricultural companies are able to sue and win cases against small farmers.

Activism

Activists around the world are doing what they can to combat major GMO companies that are patenting crops.

Vandana Shivi is one of these activists. As it pertains to GMOs that have herbicides and chemicals like Round-up in them, Vandana believes that “the chemical process reorients agriculture toward toxicity and corporate control instead of working with ecological processes and taking the well-being and health of the entire agro ecosystem”. Thus, Vandana created Navdanya-saving local seed varieties. She has been able to collect seeds from around the world that she believes will produce better quality food with higher yields and return larger profits to farmers. Vandana also argues “instead of recognizing that farmers have been breeders over millennia, giving us the rich agro-biodiversity that is the basis for food security, breeding was reduced to breeding uniform industrial varieties that respond well to chemical inputs”.¹² Instead of small farms producing a handful of commodities. Correspondingly, the human diet shifted from having 8,500 plant species to about eight globally traded commodities available. The scientific paradigm was also transformed. Instead of encouraging a holistic approach the practice of agriculture was compartmentalized into fragmented disciplines based on reductionism.

Advantages of having GMOs

Financial Benefits

The use of GMOs in our society has increased exponentially over recent years. For example Glyphosate-tolerant soybean was notably the most cultivated transgenic plant in the world in 2006.¹³ In the USA 91% of soybean was transgenic in 2007.¹⁴ The reason for the proliferation of GMOs in our society is simple. There are many advantages to growing GMOs. One of those advantages comes from the perspective of the farmer. We can reference the example of HT soybean to better understand this. One of the principal advantages of HT soybean for farmers comes from the fact that weeding is simplified. In the past, farmers needed to use multiple herbicides and some weeds were still difficult to control. Transgenic simplifies this process because only a single product is required. In addition, the period when weed treatments can be applied is longer. Furthermore, the herbicides used previously showed instances of being persistent and would negatively affect other crops. This leads to a monetary advantage for farmers as well, because they don't have to purchase as many pesticides. Farmers using GMOs often see a greater profit margin as it pertains to money spent on pesticides¹⁵. In 2014 Klumper found that GMO crops reduced pesticide use by 36.93%, and pesticide costs by 39.15%.¹⁶ Furthermore, research conducted by Raney (2006) found several instances in which GMO crops showed distinct financial benefits for farmers. In this study Raney compared the net income of 2 small farmers that used GMO cotton to that of larger scale farmers that did not use GMO cotton. Results showed that the net income of the 2 small farmers using GMOs was twice as much of the net income of the larger scale farmers that did not use GMOs. Raney also noted an estimated 83% economic gain in Mexico, 80% benefit in India, and advantages (i.e., yield, pesticide, income) in KwaZulu Natal by using the same GM cotton variety.¹⁷

Yield Benefits

Another benefit GMOs present is the fact that they can increase yield. This is one of the main reasons farmers opt to grow GMOs instead of organic fruits and vegetables.

In 2009, Qaim found a study that found that Bt maize increases gross margins for farmers by 12% in the US, all the way up to 70% in Spain.¹⁸ Higher yields mean more profit as farmers have more crops to sell. Consumers can also benefit from the use of GMOs. Often times farmers are able to pass some of the savings on to the consumer.¹⁹ This allows the consumer to buy cheaper produce as increases in yield mean a decrease in consumer price. Barrows et al. estimates that use of GM corn resulted in a 13% decrease in prices, while use of GM cotton lowered prices 18% globally. For soybeans, these authors present a range of 265% global

price reduction.²⁰ In addition, not only will GMOs allow us to produce more food, they can also allow us to produce healthier food. GM is an example of this as “GM products have been manipulated to increase protein, starch and oil composition, and micronutrient content, thereby making these products more nutritious for consumers”.²¹

As we better understand how GMOs increase yield and lower production costs, it is important for us to analyze how the use of GMO crops can impact world hunger. Studies show that GMOs can be a critical component to positively impacting world hunger. Similar to corn, soybeans and wheat, rice is an incredibly important crop for many people around the world. It is a “Staple food for more than half the world’s population. More than 3.5 billion people rely on rice for more than 20% of their daily calorie in take”.²² The United Nations Food and Agriculture Organization (FAO) estimates that about 815 million people of the 7.6 billion people in the world are suffering from chronic malnourishment.²³ Increasing the yield of rice alone by 20 percent will help feed millions of people in impoverished countries. If we were to use GMOs to increase the yields of not only rice, but corn and wheat as well, by up to 20% and find a way to efficiently distribute these crops, we could theoretically support hundreds of millions more people and effectively eradicate world hunger.

We can refer to farmers in Africa to further understand how GMO’s can have a significant impact on crop yield and thus hunger, in impoverished areas. In Africa, “60% of all citizens are still farmers and they are not yet highly productive”.²⁴ This is a major issue for the country as Africa contributes to 6 of the world’s top ten hungriest countries. The proper implementation of GMOs in a continent like Africa will allow civilian farmers to produce higher yields, which in turn will drive down food costs and allow them to feed more people. The question of whether or not to use GMOs can be a difficult question depending on the part of the world you live in. However, if you live in a country that is suffering from severe food shortages you do not necessarily have the luxury of debate. Chances are, you need more food, and you need it now. In these instances the choice to use GMOs can become an easy choice.

Past and Future Implications for GMOs

As we think about the positive potential of GMOs we can also look at historical events regarding famine and see how GMOs could have been helpful. For example, the Irish Potato Famine was a period of mass starvation and disease in Ireland between 1845 and 1849.²⁵ The reason for this starvation is that the vast majority of the potatoes in Ireland, which was their staple crop, were stricken with potato blight, meaning a fungus-like parasite called an oomycete was growing on much of the potatoes making them inedible. As a result one million people died and a million more emigrated from Ireland. Now, it doesn’t take much thought to ponder how many lives could have been saved and how many families could have staved off emigration out of Ireland if the scientists during that time were able to insert their native potato with a gene that would kill the parasite that causes potato blight. If farmers during the Irish Potato Famine had access to genetically modified potatoes that would be immune to potato blight there simply would not have been an Irish Potato Famine. Now extrapolate this example to all the other famines that have happened throughout the world over the course of human history and even consider the potential future famines that could happen particularly because of global warming. It is not difficult to see the vast and amazing potential GMOs can have on our food supply world wide, particularly in places that have the potential to have famine or are prone to droughts.

Environmental Benefits

There are also environmental benefits related to the use of GMOs. The restricted use of chemical fertilizers and pesticides is typically much better for the environment. When fewer of these agents are sprayed on crops

the surrounding environment takes on fewer of these agents as well. However, using fewer of these pesticide agents is also linked to a lower yield and higher land use. Thus, farmers use GMOs that inherently contain herbicides to circumvent this problem. Glyphosate is the most common herbicide used in GMOs. It is embedded into the GMO crop so that traditional herbicide use is significantly decreased. The low toxicity of glyphosate leads to less herbicide treatments which in turn leads to the environment being exposed to less toxic herbicide.²⁶ Similarly, just as there can be fewer herbicides introduced into the environment as a result of farmers growing GMOs, there can be less herbicide introduced into the human diet as well.

Content Objectives

Students will demonstrate an understanding of the domestication of crops by ancient civilizations. Students will learn the positive and negative outcomes of GMO research, production, and consumption. Students will decide if they support GMOs or not based on what they have learned. Students will create a civil action plan that supports their beliefs.

Non-Content Objectives

Students will be able to take an objective look at an issue and carefully research multiple sides of an argument before they decide which side they agree with. Students will be able to speak publicly and present information they have found. Students will collaborate and create a finished product with a group of their peers.

The content and objectives in this unit are aligned with several NGSS standards.

LS3.A: Inheritance of Traits -Genes are located in the chromosomes of cells, with each chromosome pair containing two variants of each of many distinct genes. Each distinct gene chiefly controls the production of specific proteins, which in turn affects the traits of the individual. Changes (mutations) to genes can result in changes to proteins, which can affect the structures and functions of the organism and thereby change traits.

LS31: Develop and use a model to describe why structural changes to genes (mutations) located on chromosomes may affect proteins and may result in harmful, beneficial, or neutral effects to the structure and function of the organism.

RST.68.1: Cite specific textual evidence to support analysis of science and technical texts.

This unit should take roughly 4-5 weeks to complete. However, feel free to extend or shorten the unit as you see fit. The first 2 days of the unit should be devoted to giving students a solid understanding of what GMOs are. This is essentially the introductions to GMOs and it is important that students can demonstrate understanding of this content before you move on to the pros, cons and controversies surrounding GMOs and the projects that will follow. Once you are confident that your students understand the content presented thus far, you will begin teaching them about the benefits of GMOs. Next, you will teach them about the costs associated with GMOs. Then, students will begin working on their individual projects. They will have several projects to choose from. They will have several days to complete each of these projects. After this they will have a class debate. Students will be placed in teams of 2 and will be debating other teams in their class. Students will have a week to prep for the debate. Lastly, students will complete a final group civil action project. Students will be given 1 week to complete this project. This project will conclude the unit. For each project students will have the opportunity to choose which project they would like to complete from a list of several options. Giving students choice will increase engagement as they feel more of a sense of ownership

over how they demonstrate what they have learned.

Assessments

Students will be given various forms of formal and informal assessments throughout this unit. The formal assessments will consist of the final projects in the unit. The informal assessments will be teachers' observations of student participation, work ethic, and group work. In addition teachers will be using rubrics to assess students completion of various projects and presentations. The assessments in this unit will be structured in a way that allows the teacher to record the many ways students demonstrate their understanding of content and learning goals.

Projects/Assignments

Teachers and students will have many assignments and projects to choose from as they use this unit. There will be traditional worksheets and note taking assignments such as making KWL Charts. However, this unit will be written in a way that stresses group and individual projects in order to practice learned content, demonstrate learning, and meet teaching objectives.

Student projects will include:

-A **research paper** in which students chose and write about a topic pertaining to GMOs.

-A **slide show presentation** that will connect to their research paper.

-A **debate**. Students will be placed in pairs in order to have a team debate against other teams in the class. Students will take a stance of being either for or against the consumption, research, and manipulation of GMOs.

-**Civil Action Assignment**. Students will decide if they are for or against the consumption, research, and manipulation of GMOs and then pick a civil action assignment in order to get involved in this issue. Students will have the option of writing a letter to congress and businesses that sell GMOs, creating a YouTube video that expresses their views or give a presentation to two other classes in the school. Each one of these options will have a rubric in which students can plan and measure their level of completion.

Classroom Lessons/ Projects

No matter a students diet, we can be confident that each of our students has consumed a GMO at some point in their life. As a result of current regulations in the United States we can also be confident that our students don't know if or when they are eating GMOs because companies that produce and sell GMOs are not required to label their products. The projects and lessons in this unit are designed in a way that allows students to gain an in depth understanding of the costs, benefits, and controversies associated with GMOs. Upon completing this unit students will not only have gained a deeper understanding of GMOs, but will also have taken a stance on one side of the GMO debate and design a method for impacting this debate in a way that reflects their stance.

This is a research-based unit. At no point in the unit will teachers directly give students information about GMOs. Students will be gathering information via science and news articles, and videos. Teachers will support the learning by giving research based assignments and facilitating discussions, and allowing students to teach each other about what they have learned. Students will be gathering and organizing information in a way that allows them to feel empowered and informed enough to decide which side of the controversy they land on.

Lesson 1: Hook

Rationale: Before we begin, it is important to generate a level of excitement for the new unit. If students are bought in early, they are more likely to remain interested in the content and activities throughout the unit. Thus, the purpose of this assignment is to develop an initial level of engagement for students.

Objectives:

1. Students will understand what a controversy is.
2. Students will understand that malnourishment is a major problem throughout the world.
3. Students will understand that GMOs have the potential to have a significant impact on world hunger.

Background:

I like to start each unit with an interesting hook that allows students to see the big picture and practical implications of the unit topic. In doing this I try to get them to think about the topic outside the classroom and begin loosely brainstorming ideas related to the topic. At the end of the hook lesson I hone in on those ideas and connect them directly to the unit topic. I also leave somewhat of a cliffhanger before we actually jump into the content during the next lesson. I have found that this strategy builds a certain level of suspense and engagement.

Procedure:

1. Begin by asking students if they know what a controversy is. Give them 1 min. to write down their definition in their science notebooks and 1 min. to discuss their definition with a partner.
2. Call a couple students to share out. List accurate answers on the board. If students are unable to accurately describe a controversy instruct students to write this definition in their science notebooks: Controversy- A prolonged public dispute or debate concerning a matter of
3. Give students an example of a controversy. One example you might want to use is the controversy involving NFL players kneeling during the national anthem. Explain that this is a controversy because there are opposing views on the matter. One side believes that players are protesting racial injustice, and the other side believes that players are disrespecting the American flag. Feel free to elaborate.
4. Ask students to write down 2 other controversies they can think of. Give them 1 min. to brainstorm and write it down and then give them 1 min. to share.
5. Call on a few students to share. Confirm whether the examples given by students are controversies or not and why.
6. Show students a video that depicts the issues involving world hunger. I have included several videos in the teacher resources section.
7. After watching the video ask students "what would you say if I told you we could grow enough food in poor parts of the world to end world hunger but some people are against it?" Let students share their thoughts.
8. Explain to students that we could potentially do that with GMOs. During this unit you all will learn why

GMOs are so controversial.

Lesson 2: KWL Chart (Know, Want to know, Learned)

Rationale: It is also important to understand student's prior knowledge base regarding genetically modified organisms. Thus, the purpose of this assignment is to provide teachers with a snapshot of student's prior understanding of GMOs and allow students to do a self check-in regarding their own familiarity with GMOs prior to and after the lesson. This lesson will give students a solid understanding of what a GMO is.

Objectives:

1. Students will write down everything they know about GMOs.
2. Students will write everything they want to know about GMOs.
3. Students will learn what GMOs are and write everything they have learned about GMOs.

Background:

KWL Charts are a great lesson to start each unit with. They provide teachers and students an opportunity to mark and measure what they know and what they will have learned throughout the unit. KWL Charts also give students a chance to constantly check in about what they want to know about the topic throughout the unit.

Procedure:

1. Ask students to write down what they know about GMOs under the K, on the KWL chart. Give students 5-10 minutes to finish.
2. Ask students to share what they wrote. Create a poster/chart of the information students already know about GMOs.
3. Ask students what they want to know under the W, on the KWL chart. Give students 5-10 minutes to finish. Create a poster/chart of the information students want to know about GMOs.
4. Ask students to share what they wrote. Create a poster/chart of the information students want to know about GMOs.
5. Provide students with the definition of GMOs and ask them to write it in their science notebooks.
6. Show them one of the provided video clips on GMOs. Ask them to take 5-10 notes pertaining to what a GMO is.
7. Come back to the chart pertaining to what students want to know about GMOs and ask them to look at their notes to see if any of the questions students had were answered by the video.
8. Provide them with one of the provided articles and ask them to take 5 notes on the article pertaining to what a GMO is.
9. Come back to the chart pertaining to what students want to know about GMOs and ask students to look at their notes to see if any of the questions students had were answered by the article. If so, instruct students to explain in their notebooks.
10. Instruct students to complete the Learned section of their KWL Chart.

Assessment: Teacher will read journal and KWL entries and assess them informally for their thoughtfulness and reflection on the ideas discussed. Teachers also have the option to give feed back and use student written notes to prompt class discussions.

Lesson 3: GMO Benefits

Rationale: As students begin to understand the benefits and costs associated with GMOs it is important for them to learn about both sides of the controversy. This lesson will give students the opportunity to research the benefits of GMOs.

Objectives:

1. Students will read 2 articles and identify 5-10 benefits associated with GMOs.
2. Students will share at least 3 benefits with a partner.
3. Students will write down at least 2 questions they have about each article.

Background: Throughout the unit students will be constantly collecting and analyzing information pertaining to the costs and benefits of GMOs. After the first few lessons students will begin writing a research paper on the controversies surrounding GMOs. Although students will be expected to gather additional information regarding GMOs this lesson ensures that students have a solid base of facts pertaining to the benefits of GMOs to begin their research paper.

Procedure:

1. Give students one of the articles and instruct them to write 5-10 notes on the benefits of GMOs. Give students 20-30 minutes to complete. If they finish early give them the second article.
2. Students will share 2-3 notes with a partner and add those notes to their own. Give students 5-10 min. to finish.
3. Ask students to share their notes and start a poster/chart of 5 benefits to using GMOs. Teacher should also use this as an opportunity to discuss the various arguments presented.

Assessment: Teacher will read journal entries and assess them informally for their thoughtfulness and reflection on the ideas researched and discussed.

Lesson 4: GMO Costs

Rationale: In the previous lesson students identified the benefits associated with GMOs. This lesson will give students the opportunity to research the costs of GMOs.

Objectives:

1. Students will read 2 articles and identify 5-10 costs associated with GMOs.
2. Students will share at least 3 costs with a partner.
3. Students will write down at least 2 questions they have about each article.

Background: Throughout the unit students will be constantly collecting and analyzing information pertaining to the costs and benefits of GMOs. After the first few lessons students will begin writing a research paper on the controversies surrounding GMOs. Although students will be expected to gather additional information regarding GMOs this lesson ensures that students have a solid base of facts pertaining to the costs of GMOs to begin their research paper.

Procedure:

1. Give students one of the articles and instruct them to write 5-10 notes on the costs of GMOs. Give students 20-30 minutes to complete. Once they are finished give them the second article.
2. Students will share 2-3 notes with a partner and add those notes to their own. Give students 5-10 min. to finish.
3. Ask students to share their notes and start a poster/chart of 5 benefits to using GMOs. Teacher should also use this as an opportunity to discuss the various arguments presented.

Assessment: Teacher will read journal entries and assess them informally for their thoughtfulness and reflection on the ideas researched and discussed.

Project 1: Research Paper

Rationale: At this point in the unit students have collected 10-20 notes pertaining to the benefits and costs associated with GMOs. They will now organize those notes and write a research paper that will allow them to describe the controversies surrounding GMOs by outlining the arguments on both sides of the debate.

Objectives:

1. Students will organize their notes on GMOs.
2. Students will write at least 4 paragraphs.

Background/Procedure: This project should take 4-6 days to complete. At the beginning of each block, teachers will show students either a video on GMOs or give them an article to read before they start doing their own research. The videos and articles can be found in the teacher resource section. The idea is that teachers are providing some structure and scaffolding to students' research process. Even if students are struggling to find information, they can at least rely on the resources provided by the teacher. There will be very little instruction given during the duration of this assignment aside from giving students instructions and setting up expectations. Although students should currently have enough information to get started, the teacher should allow them to have 20-30 minutes on their computers to continue to research the costs and benefits of GMOs. Be sure to give them time to write as well. This balance of writing and research time or combination of both will be decided by the discretion of the teacher. Students are expected to write at least 4 paragraphs in this research paper, preferably 6 and use the checklist as a guide. Feel free to adjust the assignment so that it fits your expectations and teaching style. Students should start by writing a rough draft in pencil. Once the teacher has checked the rough draft against the checklist and for spelling/grammatical errors students will then type their final draft. This paper should be complete with an introduction, 2 body paragraphs, conclusion and bibliography.

Assessment: Teacher will check and grade student's final papers against the provided checklist. Teachers should adjust the rubric according to their standards and expectations.

Project 2: Slide Presentation

Rationale: Students will work with a partner to create a slide show to that reflects their research papers. This project should take 2-3 days to complete. Once complete the pairs will present their projects to the class.

Objectives:

1. Create a slide show presentation.
2. Present the slide show.

Background/Procedure:

Students will create their slide shows on Google Slides. If the class does not have experience with Google slides, it will be important to spend 20-30 minutes showing students how to create new slides, pick backgrounds, type and upload illustrations from Google images. I teach my new classes how to use Google slides at the beginning of each school year. I typically walk them through each step by first creating mock slides on our class projector and allowing them to watch and then allowing them to use their computers as we walk through each step together. Showing students how to use Google slides will be an invaluable tool as you can use Google slides for future projects. Once students understand how to use Google slides give them the checklist of everything their projects need to include. The checklist will include 10 slides. Within these 10 slides students need to introduce GMOs and the controversies surrounding them (costs benefits). Students need to include at least 8 illustrations and 8 backgrounds. There also needs to be at least 2 sentences on each slide. Finally the project needs to have a conclusion.

Assessment:

Teachers will check and grade student's final projects against the provided checklist. Teachers should adjust the rubric according to their standards and expectations.

Project 3: Debate

Rationale: Students will be placed in pairs in order to have a team debate against other teams in the class. Students will take a stance of being either for or against the consumption, research, and manipulation of GMOs.

Objective:

1. Students will collect and organize all of their notes regarding the benefits and costs associated with GMOs.
2. Students will develop an opening statement and closing argument for both sides of the debate.
3. Students will outline their top 6 arguments for each side of the debate.
4. Students will create a potential counter argument for each of their arguments.
5. Students will present their arguments and be able to rebuttal arguments presented during the debate.

Background/Procedure: Debating is an effective method for demonstrating what a student has learned throughout a unit. Students have an opportunity to practice researching, organizing data, creating arguments, critical thinking, and public speaking. This debate should not require much research as students have been collecting data throughout the unit. However, be sure to promote the use of further research as students prep for their debate. The structure for the debate will be outlined in the handouts given. Nonetheless, teachers should feel free to alter the structure or any aspect of the debate as they see fit. Students should not know whether they will be arguing for the use of GMOs or against them until the day of the debate. Thus, students should complete the prep form both for and against the use of GMOs. This will ensure that students are prepared for both sides of the discussion, maximizing students understanding of the topic. Teachers should decide how to determine which pair will be arguing either side of the debate. I simply allow students to draw sides out of a cup 5 min. before their debate begins.

Students should be given 2-3 days of prep time. During this time student pairs need to write an opening statement, closing argument, and 6 arguments along with 6 potential counter arguments in order to be ready

for the debates. Expectations for the opening statement and closing arguments will be included in the debate prep worksheets, however it may be useful for the teacher to take some time to explicitly teach how to write an opening statement and closing argument. The debate structure will follow the structure of the outlines given. It may be useful to show a video of students debating at the beginning of the unit so that students are familiar with what a debate looks like. The duration of each debate should be 5-10 minutes. While students are debating the rest of the class should be using the provided checklist to score the quality of each pair of debater so that students are constantly aware of expectations for the debate. This checklist should also be given to the class students at the beginning of the debate prep.

Assessment: Teachers will use the provided checklist to grade each debate.

Project 4: Civil Action Assignment.

Rationale: After learning all about the costs benefits and controversies associated with GMOs, students will decide if they are for or against the consumption, research, and manipulation of GMOs and then pick a civil action assignment in order to get involved in this issue. Students will have the option of writing a letter to congress or businesses that sells GMOs, creating a YouTube video that expresses their views or give a presentation to two other classes in the school.

Objectives:

1. Students will decide if they are for or against the consumption, research, and manipulation of GMOs.
2. Students will choose and execute a civil action by writing a letter, creating a YouTube video or giving a presentation to two other classes within the school that expresses their views on the topic.

Background/Procedure:

Teachers have the choice of allowing students to complete this assignment independently, in pairs, or in groups depending on which project they choose. Students have the option of writing a letter to congress or a business that sells GMOs, creating a YouTube video that expresses their views or giving a presentation to two other classes in the school that explains their views about GMOs. Giving students choice as they choose their final project is important as it teaches them that there are many ways to be active in their communities and it will also give them more of a sense of power and ownership of their project. Students should be given 3-4 days to complete these projects. Although I have outlined and given structure to the other assignments and projects in this unit I will allow teachers to decide how to implement and structure these 3 projects as each of these projects can be structured and assessed in many different ways. It is also important for teachers to have ownership and flexibility in the units they use. With that said, teachers should feel free to add or omit civil action projects choices for this last project. For example, if a teacher would like to add a project in which students organize a rally, or if teachers would like to omit the YouTube video it should be done, as teachers understand what will work best for their particular class and their particular teaching style. This final project should be fun and empowering for students.

Assessment: Teachers will decide the assessment methods for these projects.

Teacher Resources

Videos on food shortages/hunger

This is Something You Need To See! Food Shortage and Climate Change-<https://youtu.be/ExH6kSwoFBw>

BBC Documentary The future of the Global Food Supply at Risk- <https://youtu.be/3lgAe2bdoAc>

CRISIS Food Shortage in the USA! Rationing will Happen! Get Ready!-<https://youtu.be/9wCDSSInns8>

Our World Is Hungry - Facts About World Hunger & Poverty-<https://youtu.be/bRR8dhOZavs>

Videos on GMOs

Eyes of Nye - GMO foods- https://youtu.be/8z_CqyB1dQo

Why are GMOs bad?

<https://youtu.be/sH4bi60alZU>

Neil DeGrasse Tyson gets to the bottom of GMOs

<https://youtu.be/aMDhUsxom0U>

Are GMOs Good or Bad? Genetic Engineering & Our Food

<https://youtu.be/7TmcXyp8xu4>

10 Most BIZARRE Genetically Modified Plants EVER- <https://youtu.be/aKohkmt6GRI>

Why GMOs are Good for the World- <https://youtu.be/bnNy7aLEcos>

Why are GMOs Bad? - <https://youtu.be/sH4bi60alZU>

How to Identify G.M.O Produce at the Grocery Store- <https://youtu.be/ZAAejSEnqmc>

Are Any Foods Natural Anymore? GMOs Explained- <https://youtu.be/JWttYSTqePI>

GMO Articles/News/Website for Students

<http://www.kidsrighttoknow.com/gmos/>

<https://www.newela.com>

<https://www.timeforkids.com/>

<http://www.eschooltoday.com/gmo/genetically-modified-foods.html>

<https://www.nytimes.com/topic/subject/genetically-modified-food>

GMOs: Facts About Genetically Modified Food-<https://www.livescience.com/40895-gmo-facts.html>

Genetically Modified Salmon: Food or 'Frankenfish'?-<http://teachingkidsnews.com/2014/09/24/6-genetically-modified-salmon-food-frankenfish/>

Genetically Modified Organisms-<http://encyclopedia.kids.net.au/page/gm/GMO>

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Research Paper Checklist

- I have an introduction that introduces the topic, explains why it's important and briefly explains why GMOs are controversial.
- I have a conclusion that summarizes my main arguments.
- I have at least 4 arguments that explain the benefits of GMOs.
- I have at 4 arguments that explain the costs of GMOs
- I indented when I started a new paragraph.
- I have included my name, date and title.
- I have cited my facts and included a bibliography.
- My introduction gets the readers attention.
- I double-checked my work for spelling and punctuation errors.

Slide Show Checklist

- I have 10 or more slides.
- Each slide has at least 2 or more sentences.
- Each slide has a background.
- Each slide has an illustration that reflects the information presented on the slide.

Debate Rubric

| 4 | 3 | 2 | 1 | 0 |
|---|--|--|--|---|
| 1. Students have an introduction that explains the topic, why it's important and declares their stance. 2. Students have presented 6 arguments that support their stance 3. Students were able to rebuttal with at least 2 counter arguments. 4. Students summarize the topic, 3 of their best arguments and reiterate their stance. | Students have 3 of the four criteria outlined. | Students have 2 of the four criteria outlined. | Students have 1 of the four criteria outlined. | Students do not have any of the four criteria outlined. |

Debate Outline- Pro GMOs

Introduction.

Students will explain the topic and why its important. Students will briefly explain why the topic is controversial and mention one of the main counter arguments against their position. Lastly, students will state their stance on the discussion.

1st Argument for the use of GMOs

Potential counter argument

Rebuttal (address the counter argument)

2nd Argument for the use of GMOs

Potential counter argument

Rebuttal (address the counter argument)

3rd Argument for the use of GMOs

Potential counter argument

Rebuttal (address the counter argument)

Closing Arguments

Students summarize the topic, 3 of their best arguments, 1 of the counter arguments and reiterate their stance.

Debate outline Against GMOs

Introduction.

Students will explain the topic and why its important. Students will briefly explain why the topic is controversial and mention one of the main counter arguments against their position. Lastly, students will state their stance on the discussion.

1ST Argument against the use of GMOs

Potential counter argument

Rebuttal (address the counter argument)

2nd Argument against the use of GMOs

Potential counter argument

Rebuttal (address the counter argument)

3rd Argument against the use of GMOs

Potential counter argument

Rebuttal (address the counter argument)

Closing Arguments

Students summarize the topic, 3 of their best arguments, 1 of the counter arguments and reiterate their stance.

Debate Structure

Part 1

Team 1- Opening Statement

Team 1- 3 main arguments

Team 2- 1- 2 counter arguments

Team 1- Rebuttals

Team 1-Closing Statement

Part 2

Team 2- Opening Statement

Team 2- 3 main arguments

Team 1- 1- 2 counter arguments

Team 2- Rebuttals

Team 2-Closing Statement

End of debate

KWL Chart

K What I know **W** What I wonder **L** What I learned

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