FUTURELAB+

BIOMED

Behind the Scenes of Scientific Breakthroughs

Bioengineering of Plants

Developed in partnership with:

Discovery Education and Ignited

In this Lesson Plan:

Print the **Teacher Section** →

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This document is separated into two sections, For Teachers [T] *and* Student Resources [S]*, which can be printed independently.*

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Cover Image
This is a conceptual illustration of genetic engineering.

BIOMED / BEHIND THE SCENES OF SCIENTIFIC BREAKTHROUGHS

Bioengineering of Plants

DRIVING QUESTION

How are genetically modified plants made and used?

OVERVIEW

Genetically Modified Organisms, or GMOs, are a topic rife with controversy and widely misunderstood by consumers. Change can bring about confusion and uncertainty. GMOs are often misunderstood because they are relatively new. This lesson will introduce students to genetically modified plants and how they may be used to boost human health and potentially increase human lifespan. Students will work to present both the facts and the existing controversy around the use of genetically modified plants.

The class will begin by exploring the differences between GMO products and traditional cross-breeding. They will then investigate GMO health testing. They will analyze data on the usage of different GMO crops in the United States and present on different potential health advantages. The lesson concludes with a whole class debate on the topic of Golden Rice.

ACTIVITY DURATION

Five class sessions
(45 minutes each)

ESSENTIAL QUESTIONS

What impact may genetically modified crops have in global communities?

How have methods to genetically modify crops evolved?

Why might someone be opposed to using genetically modified plants?

OBJECTIVES

Students will be able to:

Investigate different means of modifying plants.

Analyze data on GMO usage trends in the United States.

Explore a variety of ways GMO plants can improve health.

Debate various statements regarding Golden Rice.

BACKGROUND INFORMATION

Savvy food marketers have jumped on the phrase “non-GMO” as a signifier of health foods. Customers assume that a food labeled as “non-GMO” is better for them. However, that is not necessarily true. Some crops are being modified to have even more nutrients and benefits. Genetically engineered crops have the potential to combat starvation and provide economic stability to communities in need. Genetic engineering could also help eradicate terrible diseases. Can you imagine a world without malaria? This could become a reality by genetically modifying mosquitoes. Bioethicists are engaged in depth conversations about genetic engineering. What if tinkering with DNA has unknown consequences we cannot predict? What if genetic engineering becomes an advantage that only rich, wealthy nations have access to? What are the social, ethical, and cultural impacts of GMOs? Students will explore these necessary topics through conversations on the genetically modified crop Golden Rice.

Materials

- **GMO Plan Rubric**
- **GMO Webquest**
- **GMO Webquest Rubric**
- **GMO Safety Article Response Capture Sheet**
- **GMO Safety Article Response Rubric**
- **How Do GMOs Improve Health? Poster Rubric**
- **GMO Trading Card Rubric**
- **Golden Rice Anticipation Guide**
- **Golden Rice Response Prompts Capture Sheet**
- **Golden Rice Response Prompts Rubric**
- **Statement Reflection**
- **Debate Rubric**
- **Sticky Notes**
- **Trading Card Templates (printed)**
- **Design Journal**

Pedagogical Framing

Instructional materials are designed to meet national education and industry standards to focus on in-demand skills needed across the full product development life cycle—from molecule to medicine—which will also expose students and educators to the breadth of education and career pathways across biotechnology.

Through this collection, educators are equipped with strategies to engage students from diverse racial, ethnic, and cultural groups, providing them with quality, equitable, and liberating educational experiences that validate and affirms student identity.

Units are designed to be problem-based and focus on workforce skill development to empower students with the knowledge and tools to be the change in reducing health disparities in communities.

SOCIAL-EMOTIONAL LEARNING

Students will hone their social awareness and relationship skills through repeated group work. This topic may reveal strong emotions and opinions that may require self-management and mindfulness skills when participating in group work. When discussing these topics with peers, students will need to manage their emotions and display empathy and understanding of others' points of view. This week's lesson will conclude with a debate that will require students to demonstrate numerous socio-emotional skills, such as control of emotions, understanding of others' points of view, self-management, and mindfulness, as well as a variety of skills related to maintaining positive social relationships.

CULTURALLY AND LINGUISTICALLY RESPONSIVE INSTRUCTION

Throughout the lesson students examine the use of GMO plants from the perspective of food and nutrient scarce areas, which affect various segments of the population, including BIPOC who represent cultures, backgrounds, and languages of historically marginalized groups. Considerations will need to be taken of the potential benefits of more nutrient dense crops and their impacts on traditional foods and diets. The differences between US regulation and perception vs European regulation and perception of GMOs will be highlighted. In their final project, students will be debating the merits and shortcomings of GMOs, which may be influenced by personal experience as well as cultural beliefs.

COMPUTATIONAL THINKING PRACTICES

In this lesson, students take on the role of plant biologist in order to examine threats to crops. They use the computational thinking strategy of decomposing problems by creating a plan for protecting their selected crops using either conventional breeding methods or genetically engineering. They analyze data by comparing GMO regulation in the United States and Europe, and then explore a variety of ways GMO plants can improve health.

CONNECTIONS TO THE PRODUCT LIFE CYCLE

This lesson focuses on the **discover**, **develop**, and **commercialize** phases of the product life cycle. Students will be learning the techniques scientists use to modify plants in the lab and information on developing technologies in various levels of testing. Students will explore regulation policy, both domestically and abroad, in regards to these products, the different forms of safety testing they have undergone over the years, as well as the local and global debates centered on these products, which range from human health and economic benefit to health concerns and impact on ethnic and cultural traditions.

Have you ever wondered…

What does it mean when food is labeled "non-GMO"?

There is no federal program or guidelines on GMO labeling in food. Some third-party groups or food producers have begun to label foods as "non-GMO" but do not necessarily have the same standards for applying this label. While for some groups this means that the product is 100% GMO free, whereas others will allow some traces of GMO ingredients in the product.

Why would we want to genetically modify foods?

Genetically modified foods may provide several advantages for farmers including insect resistance and reduction in the need for herbicides. By having these characteristics, farmers can potentially produce a higher yield of crops from their efforts while reducing reliance on insecticides that may kill pollinators. Modifying foods may also allow for increased nutritional yield in our produce, increasing the health of those that consume these foods.

MAKE CONNECTIONS!

How does this connect to the larger unit storyline?

Genetically modified plants have the potential to improve the health of many, especially those in areas that suffer from food scarcity or whose diets lack specific nutrients. When we look at improving health, the food we eat is one of the first things to be considered. If we want to expand the human lifespan and perhaps more importantly, improve the quality of life during those years, we need to explore the options available to us through our diet. Better diet and improved nutrition are two important considerations that could potentially be more easily managed through the cultivation and distribution of GMO crops.

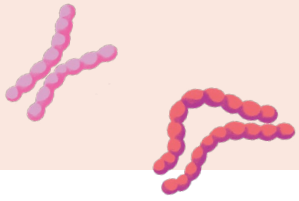
How does this connect to careers?

Plant biologists are the scientists working to imagine, create, and test genetically modified plants. Plant biologists can work in fields such as genetics, or they may work in conservation or studying growing techniques. They are hired to work in academic positions, in patent offices, by organizations such as the USDA, and by conservation groups.

Bioethicists study the ethical controversies that come about from advances in biology and medicine. They advise patients, scientific researchers, public policy makers, and/or doctors about a vast range of ethical issues associated with bioengineering plants.

How does this connect to our world?

Genetically modified plants are a hot topic in many households. People have very strong and polarizing views about consumption and availability of these products. There are disagreements about the presence of labels and an inconsistent response across nations. Despite the debate, their usage in the United States continues to grow. To be responsible consumers, students should learn what makes a food a "GMO", what are the health implications, and how have they been studied.



Day 1

Procedure

LEARNING OUTCOMES

Students will be able to:

Investigate different means of modifying plants.

Plan a plant modification to protect from a chosen threat.

INDUSTRY AND CAREER CONNECTION

Students will learn about the role of plant scientists/ biologists, as well as education requirements, salary, and why this job is so important.

Whole Group (5 minutes)

1 Ask students, if they could grow a plant to do anything or have any characteristic, what type of plant would they grow? Would it be a plant that smelled like cheeseburgers, produced antibiotics, or was big enough to be used as shelter?

2 Encourage students to share their ideas for a plant with their elbow partners. Use an equitable calling strategy, such as *Pick a Stick,* to call on pairs of students to share the idea for a plant they like best.

Individual Work (10 minutes)

1 Establish a purpose for reading by sharing this quote from the article: "Before now, I didn't sleep well when I planted corn in my field. I was always afraid that I would wake up one day to find my corn field destroyed by the corn borer. This is because the corn borer in the Philippines does not respect any season, it is always there in the corn field." (Edwin Paraluman, a farmer from the Philippines). Encourage students to read the article to discover how biotechnology helped Paraluman with his farming.

2 Have students independently read about Bt corn, which has been designed to protect crops in areas plagued by the corn borer that has been known to decimate crops—*GMO Corn is Transforming Farmer's Lives in the Philippines*.

3 Use an equitable calling strategy, such as *Pick a Stick,* to call on students to share what they discovered.

Whole Group (10 minutes)

1 As a class, respond to the reading by using the *Brainstorm* protocol to consider other threats to crops farmers may face. Select a few students with access to devices to research the topic, including pests that affect specific crops. Students may find a variety of factors, including frost, drought, pests, or poor soil. Record student answers on the board.

2 Project the description of *Botanists and Plant Scientists* and briefly review the information presented.

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Day 1

Continued

Procedure

Small Group (20 minutes)

1	In groups of three to four, have students assume the role of a plant biologist. Groups should select one specific crop and one specific threat from the previous *Brainstorm* session. If they choose pests, it should be a specific pest, such as the corn borer, boll weevils (cotton), Hessian fly (wheat), etc.
2	Have students review the provided questions and answers in *Understanding New Plant Varieties*, specifically the Science Q & A section, as well as the infographic *A Quick Look at Genetically Modified Organisms*, which compares conventional breeding to genetic engineering.
3	Ask groups to create a plan for protecting their selected crops from their chosen threats using either conventional breeding methods or genetic engineering. Have students create short *Paper Slide* presentations detailing their plan. Provide them with the *GMO Plant Rubric*. As student groups work, circulate to make sure they can describe the difference between genetic engineering and selective breeding.

Teacher Note > *Grade based on the GMO Plan Rubric.*

Extension

Those students who wish to continue to explore can create a second plan using the alternate modification choice.

COMPUTATIONAL THINKING IN ACTION

Students decompose problems by developing a plan that addresses the chosen threat and crop, and is logical and shows understanding of crop modification techniques. They use the strategy of abstraction by pulling out key details and sharing them in a brief slide presentation.

Day 2

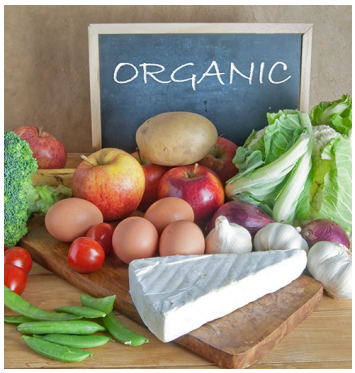
Procedure

LEARNING OUTCOMES

Students will be able to:

Compare and contrast GMO regulation in the United States and Europe.

Analyze data on GMO usage trends in the United States.



Whole Class (10 minutes)

1 In response to one, two, or all of the statements below, have students *Vote with Their Feet* on a continuum from "not at all" to "very much." Once students are lined up, fold the continuum in half so that students are paired up. Encourage students to share with each other why they lined up where they did.

a. Do you agree that GMOs are safe to consume?

b. Do you agree that GMOs should be regulated?

c. Do you agree that GMOs should be labeled?

2 Explain to students that they will consult some resources to discover different perspectives on these questions.

Small Group (25 minutes)

1 Have students get into groups of three to four and use the following resources to carry out each task. Provide students with the *GMO Webquest Capture Sheet* and the *GMO Webquest Rubric*.

a. Task one: Read *Same Science, Different Policies: Regulating Genetically Modified Foods in the U.S. and Europe*. While reading, students should answer the following questions:

- Describe TWO ways in which the United States and Europe differ in their approaches to GM foods.
- Describe how these approaches lead to different outcomes in the United States and in Europe.

b. Task two: Access the *USDA* page on GMO usage in the United States and click on the link labeled "Genetically engineered varieties of corn, upland cotton, and soybeans, by State and for the United States, 2000–20," which will pull up data on GMO varieties by state and year. Select a state, crop (which can be selected by clicking on the excel sheet tabs at the bottom of the spreadsheet), and then two varieties (varieties may include variations, such as insect-resistant, herbicide resistant, stacked genes, all GE varieties, etc. After examining the data, students should create a display of the information on their selected state's usage of the crop varieties by making either a comparative bar graph or line graph that shows prevalence of their varieties across 20 years and writing a short reflection on what the data indicates.

Teacher Note > *Walk through an example with any struggling student groups.*

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Day 2

Continued

Procedure

INDUSTRY AND CAREER CONNECTION

Students watch an interview with a plant biologist as he discusses the topic of GMO safety, including how plant biologists assure safety and what kinds of future projects may arise.

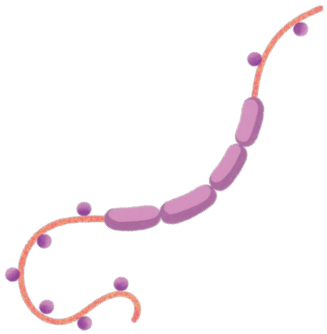
c. Task three: Watch the following interview with a plant biologist, *Do GMOs Harm Health?* Encourage students to watch the entire interview, but tell them to watch at least until the 2:34 mark. After viewing the interview, students should state one claim the plant biologist made and one question they would ask.

Teacher Note > *Grade students based on the GMO Webquest Rubric.*

Individual Work (10 minutes)

1 Ask students to read the article: *Will GMOs Hurt My Body? The Public's Concerns and How Scientists Have Addressed Them*.

2 Provide students with the *GMO Safety Article Response Capture Sheet* and the *GMO Safety Article Response Rubric*. Have students complete the *GMO Safety Article Response Capture Sheet* using one of the three prompts provided and post their responses on an online discussion board such as *Padlet* or *Now Comment*. Ask students to then respond to at least three other posts to promote discussion.



Teacher Note > *This assignment is unlikely to be completed in class and students should finish their work at home. Assess student work using the GMO Safety Article Response Rubric.*

Day 3

LEARNING OUTCOMES

Students will be able to:

Explore a variety of ways GMO plants can improve health.

Create their own GMO plant that will improve health.

Procedure

Whole Class (5 minutes)

Present the following statements to students. Tell them two are true and one is a lie. Use an equitable calling strategy, such as *Roll 'Em,* to ask students which statement they think is the lie and why.

1. GMOs help solve plastic pollution problems.
2. Grasses neutralize toxic pollutants from bombs.
3. 40–50% of supermarket foods have ingredients from GMOs.

Teacher Note > *3 is the lie. 60–70% is more accurate.*
(Source: GMOs: Distinguishing Fact from Fiction)

Small Group (25 minutes)

1 Divide students into six groups. Have each group select or be assigned a different article from those below:

- *Grasses Neutralize Toxic Pollution from Bombs*
- *Impossible Burgers Deemed Safe*
- *Making Alternative Fuels Cheaper*
- *GMOs Help Solve Plastic Pollution Problem*
- *GMO Cotton Farming and the Soaring Need for Masks*
- *Reducing Pesticide Use and Greenhouse Gas Emissions*

2 Have groups read the article and complete a poster to be hung around the room. Encourage students to make sure their posters are informative and visually appealing. Share the *How Do GMOs Improve Health? Poster Rubric* with students and cover expectations before they begin working.

3 Once posters are complete, ask students to complete a *Gallery Walk*, leaving sticky note comments on three other projects. Remind students to leave only kind and constructive comments for their peers.

Teacher Note > *If time runs out, feel free to have students take a photograph of their poster and submit it to an online forum the whole class can view. Allow students to view the posters digitally after class and submit comments.*

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Day 3

Continued

Procedure

Small Group (15 minutes)

1	Distribute to each group a printed copy of the *Trading Card Template* and the *GMO Trading Card Rubric*. In groups of two to three students, have them work together to imagine their own unique GMO plants that would, in some way, improve human health. Have students think about what current plant they would start with, and then what kinds of DNA modifications would improve their new GMO plant. For example, you might insert a gene that allows the new plant to produce important human antibodies.
2	Instruct students to use the provided template to make their own GMO plant trading cards.

Teacher Note > *There are three blank trading card templates on the page. Depending on the group, you could assign one card or all three cards. Grade students based on the GMO Trading Card Rubric.*

INDUSTRY AND CAREER CONNECTION

Students will be displaying an openness to learning and assuming the role of a plant biologist in designing a GMO plant with a directed purpose.

Day 4

LEARNING OUTCOMES

Students will be able to:

Identify and decipher complex terms on topics such as Golden Rice.

Compose a journal entry in response to the Golden Rice debate.

Procedure

Whole Group (10 minutes)

Teacher Note > *Have students complete the Golden Rice Anticipation Guide before they watch the video.*

1 Project this video on Golden Rice, *Glenn Stone and GMOs* (4:30), to the whole class.

Small Group (20 minutes)

1 In groups of two to three students, have them read *Modified Organisms: The Golden Rice Debate*. While reading, students should mark the text by circling key words, people's names, and numbers and underlining statements they find important.

Teacher Note > *English language learners and/or struggling students may have difficulty with some of the terms in the article. Provide definitions for complex terms, such as* undermine, humanitarian, micronutrient, bioconversion, *and* imminent.

Individual Work (15 minutes)

1 Have students independently provide responses to a series of prompts that relate to the reading using the *Golden Rice Response Prompts Capture Sheet*. After writing their responses, students should be encouraged to share their thoughts and respond respectfully to their peers, either by pairing with other students and reading their responses or through the teacher selecting students to read theirs aloud to the class.

Teacher Note > *Assess student work using the Golden Rice Response Prompts Rubric. Encourage students to revisit their Golden Rice Anticipation Guide and compare it to what they now know. After writing their responses, students should be encouraged to share their thoughts and respond respectfully to their peers, either by pairing with other students and reading their responses or through the teacher selecting students to read theirs aloud to the class. They should return to their Design Journal and respond to the reflective questions for Lesson 6.*

Day 5

Procedure

LEARNING OUTCOMES

Students will be able to:

Debate various statements regarding Golden Rice.

Teacher Note > *Today, students will be debating the merits and pitfalls of Golden Rice using a technique called Philosophical Chairs. If you are unfamiliar with this method, please review A Framework For Whole Class Discussion prior to the start of class. Chairs will need to be arranged in advance with two lines or semicircles facing one another and a chair in the center. It is beneficial to have a roster printed in advance for the moderator to use to record participation.*

Whole Group (15 minutes)

1. Explain to the class that today they will be engaging in a debate about Golden Rice using a format called *Philosophical Chairs*. Explain the following steps verbally and provide a visual on the board for reference:
   - **a.** The teacher will read a statement about Golden Rice.
   - **b.** Students will silently write their thoughts on the statement for three minutes.
   - **c.** Students will choose whether they agree, disagree, or are undecided. They will then sit in chairs on either the agreement side, disagreement side, or stand off to the side if undecided. If at any point a student changes his or her mind, that student may change seats without having to provide an explanation.
   - **d.** The conversation is directed by a student facilitator who will call on students, work to keep students on topic, and ask follow-up questions.
   - **e.** Discussion continues for 8 to 10 minutes, and then students write another reflection on the statement under their initial thoughts.
2. The teacher will project rules for the debate such as those *here* or a list of their own making. The class will review the rules and they will remain visible for the remainder of the debate.

Teacher Note > *Assess debates using the Debate Rubric.*

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Day 5

Continued

Procedure

CULTURALLY AND LINGUISTICALLY DIVERSE STRATEGY

This activity provides for personal voice because choice of topic has been allowed. Emphasis of educational content over creative design is important for modeling standard academic work, but allowing for some personal choice in design can validate and affirm their cultural ideals. This allows the whole assignment to become a bridge between the academic and the cultural.

Whole Group (30 minutes)

1 Distribute a few *Statement Reflection* papers and the *Debate Rubric* to each student and select their student facilitator—this person may remain in this role for the entire period of the debate or you may choose to change this role with every new topic. If the debate stagnates, ask follow-up questions or move on to a different statement. You may choose from any of the following statements or create your own:

- State, "Supporters of the project believe that the improvement of public health in developing countries trumps the risks associated with golden rice." Do you agree or disagree with this statement and why?
- It is possible that Golden Rice may be approved for usage in developing nations, but not here in the United States. Is it ethical to supply a GMO to a struggling nation that we would not yet consider safe enough to consume in the United States?
- Other programs are currently in existence that provide vitamin and nutritional assistance to these areas through supplements. Should Golden Rice continue to receive funding when other programs already exist?
- Respond to this statement, "Another source of opposition to the project stems from questions regarding the motives of the *Golden Rice Project* and its ties to several large biotech industries. Is it a ploy to enhance public support for GMOs, which could take funding away from cheaper, more realistic solutions? Or are they out to make a profit?"

National Standards

Next Generation Science Standards

Science and Engineering Practices

Constructing an explanation

Compare and evaluate competing arguments or design solutions in light of currently accepted explanations, new evidence, limitations (e.g., trade-offs), constraints, and ethical issues. Evaluate the claims, evidence, and/or reasoning behind currently accepted explanations or solutions to determine the merits of arguments.

Obtaining, evaluating, and communicating information

Gather, read, and evaluate scientific and/or technical information from multiple authoritative sources, assessing the evidence and usefulness of each source.

Crosscutting Concepts

Scale, Proportion, and Quantity

Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth).

Cause and Effect

Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

Career and Technical Education (CTE)

A1.4

Research and identify public misunderstandings related to biotechnology and discern the source of these misunderstandings.

A5.1

Use the Internet and World Wide Web to collect and share scientific information.

A5.2

Use a variety of methods, including literature searches in libraries, computer databases, and online for gathering background information, making observations, and collecting and organizing data.

A6.4

Create data tables and graphs using Excel for the purpose of collecting and analyzing data.

4.3

Use information and communication technologies to synthesize, summarize, compare, and contrast information from multiple sources.

GMO Webquest

ANSWER KEY **Do not share with students**

Task One

Directions
Read Same Science, Different Policies: Regulating Genetically Modified Foods in the U.S. and Europe.

Group's ideas

1. Describe TWO ways in which the United States and Europe differ in their approaches to GM foods.

The United States focuses more on final product while Europe focuses more on the process.

Europe is far stricter than the United States.

The United States does not require labeling and Europe labels foods containing more than 0.9% GM material.

2. Describe how these approaches lead to different outcomes in the United States and in Europe.

The United States grows more GM foods than Europe grows.

GM crops are approved sooner in the United States than in Europe.

Task Two

Directions
Access the USDA page on GMO usage in the United States.

Group's ideas

3. Create a display of the information on the selected state's usage of the crop varieties by making either a comparative bar graph or line graph that shows prevalence of their varieties across 20 years.

Use Webquest rubric to evaluate.

4. Write a short reflection on what the data indicates.

Use Webquest rubric to evaluate.

Task Three

Directions
Watch the following interview with a plant biologist, Do GMOs Harm Health?

Group's ideas

5. State one claim the plant biologist made.

GMOs that are currently available on the market have no health problems that are any different from conventional foods.

GMOs are the most intensively studied new foods introduced over the last 20 years.

GMOs are essentially the same as the foods that have been grown for years.

We can ask specific questions about the new proteins these plants produce.

We can never say that something is absolutely safe.

Attitudes toward food and regulatory agencies differ in different parts of the world.

We have not done long-term feeding studies on GMOs or on any other food.

6. Record one question you would ask the biologist if you could.

How are these proteins tested?

How are GMOs regulated in different countries?

How long will it take to know the long term effects of GMOs?

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GMO Plant Rubric

	Score	3	2	1
	Crop Specified	Group identified a specific crop to modify.	Group mentioned a crop.	No particular crop specified.
	Threat Specified	Threat is specified and appropriate to the chosen species.	Threat is specified but not appropriate to the proposed species.	No threat selected.
	Plan	Plan for modification addresses the chosen threat and crop, and is also logical and shows understanding of crop modification techniques.	Group has a plan, but is lacking in detail or nonsensical.	Plan is unclear.
	Presentation	Presentation expressed the modification plan clearly, is easy to navigate, and was attractive to look at.	Presentation created, but was missing information or was difficult to read.	Presentation did not meet criteria.
	Final Score			

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GMO Webquest Capture Sheet

Task One

Directions
Read Same Science, Different Policies: Regulating Genetically Modified Foods in the U.S. and Europe.

Group's ideas

1. Describe TWO ways in which the United States and Europe differ in their approaches to GM foods.

2. Describe how these approaches lead to different outcomes in the United States and in Europe.

Task Two

Directions
Access the USDA page on GMO usage in the United States.

- *Click on the link labeled "Genetically engineered varieties of corn, upland cotton, and soybeans, by State and for the United States, 2000–20."*
- *Select a state, crop (which can be selected by clicking on the excel sheet tabs at the bottom of the spreadsheet), and then two varieties (varieties may include variations, such as insect-resistant, herbicide resistant, stacked genes, all GE varieties, etc.*

Group's ideas

3. Create a display of the information on the selected state's usage of the crop varieties by making either a comparative bar graph or line graph that shows prevalence of their varieties across 20 years.
4. Write a short reflection on what the data indicates.

Task Three

Directions
Watch the following interview with a plant biologist, Do GMOs Harm Health?

Group's ideas

5. State one claim the plant biologist made.

6. Record one question you would ask the biologist if you could.

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GMO Webquest Rubric

	Score	3	2	1
	Required Elements	Students selected a specific crop from a given state and compared two varieties over the course of 20 years.	Many components of the project met, but some missing.	Missing most required elements.
	Graph	Graph created accurately, includes title, axis labels, bars/lines labeled, and is an appropriate scale for data.	Graph created but missing titles, labels, or difficult to interpret for various reasons.	No graph created.
	Analysis	Thorough analysis of created graph and provided data examining trends in the selected state/varieties.	Analysis attempted, but data misinterpreted or incomplete.	No summary provided.
	Final Score			

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GMO Safety Article Response Capture Sheet

Directions

Respond to one of the following prompts after reading the article: Will GMOs Hurt My Body? The Public's Concerns and How Scientists Have Addressed Them.

After the Institute for Responsible Technology released their study's findings, many other labs began attempting to replicate their work. In science, why do scientists repeat each other's work and why is work being reproducible important?

At the beginning of the fifth paragraph the article states, "Experiments like these on humans would be completely unethical." Why would these studies be unethical in humans?

What were the findings from the section "Can GMOs Change Our Genes?"

Do you feel these findings are enough to ensure food safety? If you could devise your own study, what aspects of GMO safety would you like to investigate and why?

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GMO Safety Article Response Rubric

	Score	3	2	1
	Article Response	Response addresses the prompt, includes numerous supporting details, facts, or opinions.	Response attempted but very sparse, does not address prompt and/or does not include any detail.	Response not attempted or attempted but provided information unrelated to the prompt.
	Final Score			

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How Do GMOs Improve Health? Poster Rubric

	Score	3	2	1
	Information	Poster relays most important parts of the reading to the audience.	Contains some information from reading, but is limited.	Includes little or no information from the reading.
	Appearance	Poster is eye-catching and attractive to look at, includes images, color, and design that support the information on the poster.	Some attempts at including color, images, or design features.	Lacks any color or design elements.
	Response	Commented on at least three other posters, leaving compliments, comments, or constructive criticism.	Left one to two constructive comments for peers.	Did not respond to any other posters or left unkind remarks.
	Final Score			

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GMO Trading Card Rubric

	Score	3	2	1
	Overall Appearance	Contains all necessary parts of a trading card including title and symbol, colorful and attractive to look at.	Missing small features, such as a name or symbol, little to no use of color.	Card missing key components, mostly incomplete.
	Image	Picture matches description and is detailed and colorful.	Attempt at picture, lacks detail and/or color or is unrelated to description.	No image of an imagined plant.
	Human Health	Clear and detailed explanation for how this plant would improve human health.	There is some connection to improving human health but lacks detail.	Description has no connection to improving human health.
	Final Score			

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Golden Rice Anticipation Guide

Directions
In each of the numbered boxes below, read the statements and decide whether you agree or disagree with its contents. In the boxes to the right, include information that either supports or corrects the statement.

		Support	Correction
1 The creation of GMOs is a threat to small scale farmers.	☐ Agree ☐ Disagree		
2 Traditional cultural foods should not be altered by the addition of GMOs.	☐ Agree ☐ Disagree		
3 Adding additional nutrients to foods through genetic modification could save lives in food-scarce regions.	☐ Agree ☐ Disagree		
4 GMOs should not be planted for fear of cross-contamination with native plants.	☐ Agree ☐ Disagree		
5 The potential health benefits of GMOs warrant further investigation and investment of resources.	☐ Agree ☐ Disagree		

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Golden Rice Response Prompts Capture Sheet

Directions
Respond to the questions after reading The Golden Rice Debate.

1. What do you think are the most compelling arguments *for* the use of Golden Rice?

2. What do you think are the most compelling arguments *against* the use of Golden Rice?

3. Are you in support or against the propagation of this GMO?

4. What types of new information might make you change your mind?

5. Would you feed Golden Rice to your own family if it were available at your grocery store? Why or why not?

6. How do you think rice can relate to culture?

7. What further questions do you have or might someone have about Golden Rice before making a decision?

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Golden Rice Response Prompts Rubric

Score	4	3	2	1
Journal Response	Responses to prompts are thorough, demonstrate an understanding of the complexities of the debate, and use facts and supporting details from the text to enhance their writing.	Responses to prompts demonstrate some understanding of the Golden Rice debate, but lack supporting facts and details from the text.	Responses to prompts are attempted, but do not display understanding of the reading and are brief.	Responses are mostly incomplete.
Final Score				

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Statement Reflection

Directions
Use this page to take notes as your class discusses the merits and pitfalls of Golden Rice.

Summary of Statement

I choose to sit with:

- ☐ Agree
- ☐ Undecided
- ☐ Disagree

Final Response

Initial Response

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Debate Rubric

	Score	3	2	1
	Participation	Participated readily in debate and enhanced conversations.	Volunteered responses one to two times.	Declined to participate in debate.
	Adherence to Structure	Mostly adhered to structure, did not speak over others, summarized the previous point while speaking, allowed others to speak before speaking again.	Some attempt at following structure, had to be reminded multiple times.	Did not follow rules of debate.
	Knowledge of Topic	Responses demonstrate a thorough understanding of the debate topic and pulled from other areas of learning and experience.	Responses demonstrate some understanding of the Golden Rice debate.	Responses demonstrate knowledge of the Golden Rice debate.
	Courtesy	Student demonstrated respect and courtesy toward others during debate, acknowledged and respected others' points of view and experiences.	Student's responses were mostly respectful, maybe minimized other students experiences or spoke over someone briefly.	Student was not courteous to peers, had rude responses, and interrupted.
	Written Responses	Wrote thoughtful and detailed primary and final responses to all prompts.	Wrote some responses, incomplete or very brief.	Did not create any written responses to prompts.
	Final Score			

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References

Byrne, P., Pendell, D., and G. Graff. *Labeling of Genetically Modified Foods—9.371–Extension*. October, 2014.

How GMO Crops Impact Our World | FDA. U.S. Food & Drug Administration. September, 28 2020.