Syngenta Summer Fellowship Educator's Guide

A biotechnology and agri-science STEM education program.

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Overview/Welcome

This series of lesson plans was authored by North Carolina teachers after their experience in the Syngenta Summer Fellowship program. The Fellowship is a 10-day experience that immerses STEM teachers into the world of agricultural biotechnology. The program is an interactive experience that explores the process of developing a biotech product from discovery to commercialization, including tours of labs, field visits and meeting with lobbyists to understand agriculture policy. In addition to becoming more effective science and agriculture communicators, participants apply their experiences in the collaborative development of school lesson plans, which are classroom tested and made available to teachers. For more information about the program, contact program coordinator Tanya Markham (tanya.markham@syngenta.com) or program lead Lisa Zannoni (lisa.zannoni@syngenta.com).

Recognition of Teacher-Authors

How Do We Sustainably Feed the World?

Megan Bennett, Southern School of Energy and Sustainability, Durham, N.C.

Cameron Gupton, Greene Early College High School, Snow Hill, N.C.

Madison Wagner, James Kenan High School, Warsaw, N.C.

"GMOs" and Credibility

Claire McLaughlin, Brunswick Early College High School, Bolivia, N.C.

Population Change

Terry Howerton, Atkins Academic & Technology High School, Winston Salem, N.C.

Bruce Boller, Bertie Early College High School, Windsor, N.C.

To Market

Terry Howerton, Atkins Academic & Technology High School, Winston Salem, N.C.

Bruce Boller, Bertie Early College High School, Windsor, N.C.

Corn Production Integrated Math

Connie Smith, Northeast Regional School for Biotechnology and Agriscience, Plymouth, N.C.

Plasmid Problem Solving

Heather McPherson, West Columbus High School, Cerro Gordo, N.C.

Mariel Sellers, East Columbus High School, Waccamaw, N.C.

Geometry in Agriscience

Christi Rogerson, Northeast Regional School for Biotechnology and Agriscience, Plymouth, N.C.

Agricultural Legislation

Will Prettyman, Northeast Regional School for Biotechnology and Agriscience, Plymouth, N.C.

How Can we Sustainably Feed the World?

Grade Level: HS (9–12)

National Ag Literacy Outcomes Addressed

Food, Health and Lifestyle

- Recognize that agriculture provides our most basic necessities: food, fiber, energy and shelter (T3.K-2.b)
- Science, Technology, Engineering and Math

Content Standards

History:

- NCSS 7: Production, Distribution and Consumption
- NCSS 8: Science, Technology and Society

Science:

- 1-LS1: From Molecules to Organisms: Structures and Processes
- 1-LS3: Heredity: Inheritance and Variation of Traits

English Language Arts:

- Speaking and Listening: CCSS.ELA-LITERACY.CCRA.SL.1

Keywords

- Transgenic Organism
- Recombinant DNA Technology
- Genetically Modified Organisms (“GMOs”)

Purpose

The purpose of this lesson is to introduce students to the opportunities and challenges with transgenic organisms.

At the conclusion of this lesson, students will be able to:

- summarize how transgenic organisms are engineered to benefit society
- understand how innovation allows individuals to pursue an improved quality of life
- use research and evidence to back claims and stimulate thoughtful discussion
- understand and evaluate the ethical issues surrounding the use of DNA technology

Time

- three one-hour class periods, or comparable time frame

Materials

Day 1:

- Access to: “What Is Innovation?” (Video) https://www.youtube.com/watch?v=IiyMkOfycOg
- Tear sheet “chart” paper and/or whiteboards (one per group)
- Markers (one per student)
- Notebook (one per student)
- Access to: “A Brief History of American Agriculture” (Slide Deck) https://drive.google.com/file/d/0Bwzn5nSDLEEnQWVLNnRaTlROU1k/view
- Print copy of The Morrill Act: 153 Years of Innovations for American Agriculture (Webpage) http://blogs.usda.gov/2015/07/02/the-morrill-act-153-years-of-innovations-for-american-agriculture/ (one per student/group)
- Access to: “Biotechnology and Syngenta” (Slide Deck) https://drive.google.com/file/d/0Bwzn5nSDLEEnLW83TkNvLVJMRDg/view
- Access to: “What Is Biotechnology” (Video) https://www.youtube.com/watch?v=SnkHmwTKksQ
- Access to: “Syngenta Brand” (Video) https://www.youtube.com/watch?v=fEgf6Y-Pry0
- Large index card (one per student)

Day 2:

- Notebook (one per student)
- Tear sheet "chart" paper and/or whiteboards (one per group)
- Markers (one per student)
- Access to: "Can You Tell If Any of These Animals Are Transgenic?" (Slide Deck) http://www.biotechinstitute.org/download/files/YourWorld/yw-51-trangenic-animals.pdf

Day 3:

- Notebook (one per student)
- Paper and writing utensil (one per student)
- Access to: "Some Food for Thought" (Video) https://www.youtube.com/watch?v=7A4oAyKOGHg
- Access to: "What Is Genetically Modified Food – Instant Egghead" (Video) https://www.youtube.com/watch?v=JMPE5wlB3Zk
- Access to: "Eyes of Nye – GM Foods - HTS2100" (Video) https://www.youtube.com/watch?v=8z_CqyB1dQo
- Access to: Virtual Printing Press (Webpage) http://www.readwritethink.org/files/resources/interactives/Printing_Press
- Access to: "What's the Deal with Genetically Modified Food?" (Video) https://www.youtube.com/watch?v=0WSCs78Gl9M

Background – Agricultural Connections

The International Food Information Council Foundation defines biotechnology as using "what is known about plant science and genetics to improve the food we eat and how it is produced."[i] Through the use of biotechnology, scientists are able to focus on solving food issues and confronting challenges in agriculture, such as drought, pests and limited land.

Interest Approach – Engagement

1. Before class begins, divide students into groups of four. Have large chart paper and various colored markers at each group's table. On each chart paper write "Seen Dots," "Unseen Dots" and "Necessary?"
2. To begin the lesson, have students watch the video "What Is Innovation?" Divide students into the pre-made groups of four. Direct students to the large piece of chart paper and markers at their group's table, and explain that "Seen Dots" are everyday items that we all see and use (i.e., bicycle), "Unseen Dots" are things these items may be used for to further society or advance the product itself (i.e., adding a motor, carriage and four wheels creates a car not just a bicycle) and "Necessary?" determines whether or not innovation is created by using things already there (i.e., could the car only have been created if the bike already existed? Was there a need for the car? etc.).
3. Instruct the students that the topic to address is agriculture. Allow students to write on their group chart paper at the same time, resembling graffiti, for three to five minutes as they address the categories: Seen Dots, Unseen Dots and Necessary? Stop students after the allotted time and post the papers on the wall. Ask students to make a comparison of the charts.
4. Discuss student answers as a class.

Procedures

Day 1:

1. Transition into a mini-lesson on the history of U.S. agriculture using "A Brief History of Agriculture." Discuss the following questions throughout or after the mini-lesson:
   a. How did the steel plow and reaper impact early agriculture?
   b. How do the plow and the reaper compare and contrast?
   c. How are these inventions examples of innovation?
   d. Do you agree or disagree that today's agriculture has advanced well beyond this? Why or why not?

2. Have students watch "History of American Agriculture." Discuss the following questions after the video:
    a. Why was the plow important to the West?
    b. How does the steel plow compare with the farming tools of today?
    c. How did McCormick's reaper affect productivity?
    d. Are inventions such as these enough to feed the world today?
3. Independent Practice – Source Analysis: Have students independently (or as partners) read The Morrill Act: 153 Years of Innovation.
    a. Students may underline, circle, highlight and/or code information they connect with, new information they learned, information they find helpful to understand a topic, etc.
4. After students have analyzed the article, have them transition to small groups and share their analysis with their group members.
    a. To ensure student participation, require each student to share his/her personal analysis for at least 45 seconds. Have those who are not sharing stay engaged by taking notes, highlighting ideas or questioning the information other students are sharing.
5. The groups will choose one student from each group to share his/her analysis with the entire class.
6. After groups have shared, pose the question: "How are we trying to innovate agriculture for the future?" Discuss student answers and have them refer to the text for support.
7. Using the slideshow "Biotechnology and Syngenta," transition into a mini-lesson on agriculture, biotechnology and Syngenta.
8. Have students watch "What Is Biotechnology?"Have students watch Syngenta's brand video.
9. Discuss the following questions throughout or after the mini-lesson:
    a. What is Syngenta's purpose?
    b. Why is biotechnology significant?
    c. How is Syngenta using Seen and Unseen Dots to innovate?
    d. Can you predict how Syngenta and biotechnology will influence the future of agriculture?
    e. How would you decide, or what criteria might you use, to determine if Syngenta has fulfilled its goals?
10. Give each student a large index card and ensure each student has a marker or writing instrument. Have each student come up with a summary of the lesson. Use the essential questions to create these summaries:
    a. How does innovation create change (support answer with historical instances/ examples)?
    b. How has society progressed in agriculture over the past 150 years (support answers with examples from history, Syngenta and/ or biotechnology)?
11. Gather students back into groups of four and have them share their summaries/answers with each other. Have each group pick the best summary/answer and share out loud with the class.
    a. Give extra credit or another reward for best summary/answer, if desired.

Day 2:

1. To start the lesson, the teacher will post the following scenario and accompanying questions on the board and engage student conversation:
    a. In the movie "The Hunger Games" the Capitol (a term used to refer to what we would call the government) produced genetically enhanced birds called Jabberjays to spy on rebels. Unexpectedly, these birds bred with mockingbirds, creating a new hybrid bird called the Mockingjay. The Capitol did not intend for this to happen, and the bird became a symbol of rebellion. What questions might we raise about genetic engineering from this example?
2. Transition the class to the lesson with guiding questions such as the following:
    a. Could a scenario like this, where a genetically engineered organism hybridizes with a wild animal or plant, happen in the real world? Why or why not?

3. As a class, students will brainstorm a working definition of recombinant DNA technology.
    a. Definition: “Breeding technique in which a copy of a piece of DNA containing one or a few genes is transferred between organisms, or ‘recombined’ within another organism.”[1]
4. Students will write their brainstorm notes in their notebook.
5. Work with students to formulate examples of recombinant DNA technology in agriculture to further understand the concept.
    a. Examples include:
        i. Herbicide Resistant: Many herbicides work to prevent specific cellular activity in weeds, thereby killing the plant. A herbicide-resistant plant uses genes from another organism to resist the effects of the herbicide.
        ii. Pest Resistant: Plants that are pest resistant have “borrowed” genes from other organisms that make the plant not attractive to the pest.
        iii. Vitamin Insertion: Still not available in the market, Golden Rice is a genetically modified rice that contains the beta carotene gene, the source of Vitamin A. Vitamin A is essential for many body functions, including vision.
6. Place students into groups of three and give them the article “Can You Tell If Any of These Animals Are Transgenic? Students will have 20 minutes to read the publication and collaborate on whiteboards/chart paper. The students must include the following:
    a. Graphic representation of their thoughts on the publication
    b. Words/phrases/sentences
    c. Five Interesting facts
    d. Three questions
7. Students will present their whiteboards/chart paper to the class.
    a. The teacher will ask relevant questions to broaden as well as enrich the students’ thinking.
    b. To ensure learning and participation, students will need to have their individual notebooks and take notes.
8. To assess student learning, ask the following questions:
    a. What are transgenic organisms?
    b. Summarize how transgenic organisms are used within society.
    c. How is Syngenta related to DNA technology?

Day 3:

1. To introduce the lesson, post the following situation on the board and engage students in the following conversation: “The Sunflower Festival is next weekend, and you have decided to enter your famous seeds into the Sunflower Seed competition. Create, engineer and describe your winning sunflower seeds.”
2. Give students time to complete the opening activity and then have the class choose a winner.
3. To transition the lesson, review the following with students:
    a. What is DNA technology?
    b. What is a genetically modified organism?
    c. What does transgenic mean?
        i. How does it happen?
4. Share the definition of genetically modified organism (“GMO”).
    a. Definition: “The production of heritable improvements in plants or animals for specific uses, via either genetic engineering or other more traditional methods. Some countries other than the United States use this term to refer specifically to genetic engineering.”[2]
    b. Teacher note: The U.S. Food and Drug Administration notes that the term “GMO” can be misleading and recommends the use of more scientifically accurate terms such as bioengineered, genetically engineered or foods produced using biotechnology.
5. Initiate a short Q&A discussion on:
    a. Are “GMOs” safe?
    b. Are “GMOs” right?
    c. Are “GMOs” ethical? (What does ethical mean?)
6. Important note: Thoughts and discussion are based on students’ prior knowledge and

previous days' learning. Engage the class by saying, "Notice we all have different opinions and experiences just like society. Today, we are going to explore the ethical issues surrounding DNA technology with a strong focus on foods produced using biotechnology."

7. Show two or three short videos that explain both the pros and cons to "GMOs". Students are to watch and take notes throughout the videos.
    a. "Some Food for Thought"
    b. "Genetically Modified Organism ("GMO") - Myths and Truths"
    c. "Eyes of Nye - GM foods - HTS2100 Edition"
8. After watching the videos, students will work in small groups to create a T-chart detailing the benefits and controversies of genetically modified organisms (animals, seeds, etc.).
9. After completing the chart, students will participate in class discussion with the following focus questions:
    a. In the United States, we assume our food is safe. Is it? Why? Explain.
    b. What role does the government play?
    c. Is a "GMO" corn seed right? Why or why not?
    d. By 2050, the population is expected to grow to 9 billion. How are we going to feed everyone?
    e. The amount of farmland in the world is not changing/will not change. How are we going to feed everyone without increasing land?
    f. The amount of usable fresh water on the Earth is not changing. How do we continue to grow crops without excess water? What about droughts?
    g. How do we meet the world's changing needs? Are "GMOs" the answer?
    h. How do we feed the world without further damaging the planet?
    i. What ethical issues does Syngenta face?
10. To close the lesson, students will write an editorial article for a newspaper on one of these themes:
    a. Discussing the advantages of "GMOs" and why you agree with using them
    b. Discussing the disadvantages of "GMOs" and why you disagree with their useClose with a summary of genetically modified organisms and closing questions.
11. Close with a summary of genetically modified organisms and closing questions.
    a. Genetically modified crop seeds have only been available since the mid-1990s. To make such seeds, companies like Syngenta manipulate the gene sequence in a plant's DNA so that it has special traits, such as the ability to tolerate a specific weed killer while the plants around it die or to repel pests like the rootworm. Companies can then patent these genetically modified seeds, which gives them the legal right to control the use of any seed that contains their patented gene sequence. This situation has changed agricultural practices and spurred controversy.
        i. What issues could Syngenta face with their "GMO" seeds?
        ii. Why are theses considered ethical issues?

Additional Video Options:

- Discovery News: “What’s the Deal with Genetically Modified Food?” https://www.youtube.com/watch?v=0WSCs78Gl9M
- “GMO” Answers: “How Are “” Created?” https://youtu.be/2G-yUuiqIZ0

Did You Know? (Ag Facts)

1. Did you know? The word biotechnology was first used in 1919! A Hungarian engineer by the name of Karl Ereky used it to describe “all lines of work involved in creating products from raw materials with the aid of living organisms.”[4]
2. Did you know? The world population is expected to reach 9 billion people by 2050. That’s a lot of humans to feed!

Enriching Activities

1. To extend the lesson, have students visit the United State Census Bureau U.S. and World Population Clock website at http://www.census.gov/popclock/. Using the data provided, respond to the following prompts and questions:
    a. Looking at U.S. population growth by region, describe your region of the country and factors that you think contribute to the rate of growth.
    b. Mark the top 10 most populous countries on the map. Thinking about current events specific to agriculture — including trade, land use, pollution and so on — write down an opportunity and a challenge for each of these countries (specific to agriculture).

Sources/Credits

[1] International Food Information Council (N.D.) Glossary of food and agricultural biotechnology terms. Retrieved from http://www.foodinsight.org/sites/default/files/Ch7_BiotchGd_Fd-AgGlossary.pdf.

[2] International Food Information Council (N.D.) Glossary of food and agricultural biotechnology terms. Retrieved from http://www.foodinsight.org/sites/default/files/Ch7_BiotchGd_Fd-AgGlossary.pdf.

[3] International Food Information Council (2013). Questions and answers about food biotechnology. Retrieved from http://www.foodinsight.org/Questions_and_Answers_About_Food_Biotechnology.

[4] International Food Information Council (2013). Questions and answers about food biotechnology. Retrieved from http://www.foodinsight.org/Questions_and_Answers_About_Food_Biotechnology.

“GMOs” and Credibility

Grade Level: HS (9–12)

National Ag Literacy Outcomes Addressed

Food, Health and Lifestyle

- Recognize that agriculture provides our most basic necessities: food, fiber, energy and shelter (T3.K-2.b)
- Science, Technology, Engineering and Math

Content Standards

History:

- **NCSS 8:** Science, Technology and Society

Science:

- **2-LS4:** Biological Evolution: Unity and Diversity

English Language Arts

- Reading: CCSS.ELA-LITERACY.CCRA.R.6
- Reading: CCSS.ELA-LITERACY.CCRA.R.8
- Reading: CCSS.ELA-LITERACY.CCRA.R.10

Keywords

- Genetically modified organism (“GMO”)
- Research

Purpose

The purpose of this lesson is to assess how a reader can evaluate the validity of a text. Students will read articles about “GMOs” and work in groups to identify the specific aspects of the texts that support or refute their validity.

At the conclusion of this lesson, students will be able to:

- Develop the ability to assess the validity of claims made in an article
- Become more confident with research with verified documents
- Discuss findings in a logical, research-based way

Time

- One hour

Materials

- Handout: Evaluating Text (one per student)
- Access to internet and/or pre-printed articles (see suggested list at end of lesson)
- Access to Addressing Misconceptions: Credibility Checklist found at http://www.agfoundation.org/addressing-misconceptions/story_content/external_files/CredibilityChecklist.pdf (PDF)

Background – Agricultural Connections

Research is crucial in any industry, and it’s no different for agriculture. As new technologies are discovered, research is essential to make sure techniques and end products are safer than ever. The U.S. Food and Drug Administration (FDA) researches and regulates all aspects of food, including food from genetically engineered plants. Its overall mission is to “promote and protect public health.”[1]

Interest Approach – Engagement

1. Using a scrap piece of paper, have students respond to the opening prompt:
   a. Your research for experiments and projects is similar to large-scale research done by major agencies like the FDA. List some good research practices.
2. Give students a few minutes to list out good research practices. Have students pair up and compare lists, noting and discussing any differences.
3. Focus the class and start a class list of good research practices on the board.
   a. Examples: comparing multiple sources, using updated or recent files, using credible sources, checking for a source list within the article or information, looking in peer-reviewed journals, etc.

4. Remind students that good research is based on solid science.

Procedures

1. Review the characteristics of good science experiments: large sample size, repeatability, a hypothesis that can be disproved, causation and not correlation, good control groups, measurable data, etc.
2. Ask students, "Why is it important for readers to think critically while reading text?"Discuss.
3. Pass out the "Evaluating Text" handout and explain it. Instruct students to work in pairs.
4. Each pair will read one or two articles from the list provided (some are longer than others). Ideally more than one group should read each article.
5. Students will read their article individually and fill out the handout in complete sentences. For each sentence written, students should fill out EITHER the column about validity OR the column about questionability.
    a. Students will then compare their answers with their partner.
6. Have all of the groups who read the same article come to the front of the room. One student will summarize the article for the rest of the class. Each group will share an example that promotes or refutes the text's validity.
7. Develop a list as a class of characteristics of a valid text and characteristics of a questionable text.

Suggested Articles:

- "Fewer Pesticides Farming with "GMOs" http://www.pbs.org/wgbh/nova/next/nature/fewer-pesticides-farming-with-gmos/
- "Genetically Modified Organisms Inject DNA into Intestinal Bacteria" http://www.naturalnews.com/032800_GMOs_intestinal_bacteria.html#ixzz4L7Q8Wo4t
- "Assessing the Survival of Transgenic Plant DNA in the Human Gastrointestinal Tract" http://www.nature.com/nbt/journal/v22/n2/full/nbt934.html
- "Case Studies: A Hard Look at GM Crops" http://www.nature.com/news/case-studies-a-hard-look-at-gm-crops-1.12907
- "Transgenics: A New Breed" http://www.nature.com/news/transgenics-a-new-breed-1.12887
- "Percy Schmeiser" http://www.monsanto.com/newsviews/pages/percy-schmeiser.aspx

Did You Know? (Ag Facts)

1. Did you know? "GMOs" undergo testing by three different government agencies: The Food and Drug Administration (FDA), the United States Department of Agriculture: Animal and Plant Health Inspection Service (USDA-APHIS) and the Environmental Protection Agency (EPA).[2]
2. Did you know? Evaluating sources can be overwhelming, but it's an important and crucial step in research. Learning to evaluate effectively is a key skill. Don't just accept everything you find![3]

Enriching Activities

1. Have students work individually or in pairs.
2. Students will choose one article from the lesson above to start. Using the Addressing Misconceptions: Credibility Checklist, students will assess the credibility of the article. If time allows, students may complete multiple assessments.

Sources/Credits

[1] United States Food and Drug Administration. Retrieved from: http://www.fda.gov/Food/FoodScienceResearch/default.htm

[2] "What Effect Do "GMOs" Have on Human Health?" Best Food Facts. Retrieved from: https://www.bestfoodfacts.org/gmo-human-health/

[3] "Evaluating Sources: Overview." Perdue Online Writing Lab. Retrieved from: https://owl.english.purdue.edu/owl/resource/553/01/

Evaluating Text

Citation of Article:

Quote from Text	How does this statement contribute to the validity of the text?	How does this statement detract from the validity of the text?

Population Challenge

Grade Level: HS (9–12)

National Ag Literacy Outcomes Addressed

Agriculture and the Environment

- Describe how farmers use land to grow crops and support livestock (T1.K-2.a)

Food, Health and Lifestyle

- Recognize that agriculture provides our most basic necessities: food, fiber, energy and shelter (T3.K-2.b)

Content Standards

Science Area:

- **1-LS1:** From Molecules to Organisms: Structures and Processes
- **1-LS3:** Heredity: Inheritance and Variation of Traits

English Language Arts:

- Reading: CCSS.ELA-LITERACY.CCRA.R.1
- Reading: CCSS.ELA-LITERACY.CCRA.R.8
- Speaking and Listening: CCSS.ELA-LITERACY.CCRA.SL.2
- Speaking and Listening: CCSS.ELA-LITERACY.CCRA.SL.4

Mathematics:

- CCSS.MATH.PRACTICE.MP2

Keywords

- Herbicide
- Pesticide
- Seed traits
- Drought-tolerant

Purpose

The purpose of this lesson is to address the driving question, "How can we grow food to feed a growing world population?"

At the conclusion of this lesson, students will be able to:

- Assess traits available in crops and their contribution to the global food supply
- Understand that seeds can be classified by different traits

Time

- One hour

Materials

- Computers with internet access
- Access to: Page 5 of the United Nations report "World Population to 2300" http://www.un.org/en/development/desa/population/publications/pdf/trends/WorldPop2300final.pdf (one copy per group)
- Materials to create posters
- Whiteboards or chart paper (one per group)
- Paper and writing utensil (one per student)

Background – Agricultural Connections

"Over the past 50 years, global gross agricultural output has more than tripled in volume, and productivity growth in agriculture has enabled food to become more abundant and cheaper."[1] This rapid growth in agriculture is has many factors, but it is partly in response to the burgeoning world population. With the world population slated to reach 9 billion by 2050, there is a need for research and collaboration with regard to the available food supply.

Interest Approach – Engagement

1. Give students the graph on page 5 of the United Nations report "World Population to 2300." Have students determine when the world's population will reach 8 billion and when it will reach 9 billion.
2. Have students calculate how many days it would take to count to a million if you could count one number every second. (11.6 days)
    a. Have students repeat this process to determine how long it would take to count to one billion in years. (31.7 years)

Procedures

1. Inform students there are currently 7 billion people on Earth. If there are 8 billion people on Earth in 2030, what effects will that have on the population and on the planet?
    a. Have students brainstorm in groups on their whiteboards or chart paper.
    b. Have each group share and explain one thing on their board/paper. The other groups must put a check beside that item if they have it recorded on their board. Continue until everything has been shared.
    c. Give students time to copy the important points. Make sure that students include something about consumption of resources, waste production, habitat destruction, burning and possible depletion of fossil fuels, running out of food and water and deforestation.
2. Tell students that we are going to focus on the question: How can we grow more food to feed a growing world population?
3. Give students time to brainstorm around this question in small groups on their whiteboards or chart paper.
4. Focus the class and tell students that they will be researching one of the following topics: pests, weeds, water, fertilizer/yield or nutrition. Have students write their top three choices in order on a piece of paper.
    a. Assign students to groups based on their choices.
5. Student Procedure:
    a. Give students five minutes to discuss what they know about their topic and make a preliminary research plan.
    b. Give students 15 minutes to do overview research using the internet.
    c. Give students 10 minutes to capture their discoveries on a whiteboard or notepaper.
6. Establish project parameters: Develop parameters* for the research project as a class. *Clarify that each group should research only one crop within their topic. Within their topic, they should research any options for organic, conventional or genetically engineered seeds. Students will research how the technology works for their specific crop within their topic and the regulations.
    a. Pesticide Tolerance (trait): corn, soybean, rice
    b. Herbicide Tolerance (trait): corn, soybeans, canola, potato
    c. Drought Tolerance (trait): corn
    d. Enhanced Nutrition (trait): rice
    e. Fertilizer/Increased Yield (trait): corn, soybeans
7. Remind students that scientists use posters and trifolds to communicate information. We will do the same. We will be presenting to each other and to the community. Our presentations must be understandable by people who do not have science backgrounds.
8. Depending on the scope of the project and time available, have students conduct research in class or as homework. Consult with each group as needed.
9. Have students present their poster or trifold to their classmates and receive feedback.
    a. Give groups the opportunity to incorporate the feedback into their presentations.
10. Give students the opportunity to present to an audience outside their class.
11. Use the following rubric to evaluate student work:

    ____ Does the driving question encompass the project in its entirety?

    ____ Does the project cover multiple subject areas?

____ Does the teacher create balanced/ effective groups of students?

____ Is the problem being addressed relevant or real world to students?

____ Is student voice and choice maximized when possible?

____ Are 21st century skills utilized?

____ Does the project drive student inquiry or innovation?

____ Is there an effective draft and revision process?

____ Do students present their final products to someone other than their teacher or peers?

____ Does the final presentation provide for a suitable post-assessment of what students have learned?

____ Do students have an opportunity to reflect on the project at the end, both as a group and individual?

Did You Know? (Ag Facts)

1. Did you know? More than half of the global population is urban. This brings "enormous changes to landscapes and lifestyles."[2]
2. Did you know? There are only eight genetically modified crops available in the United States. They are corn (field and sweet), soybeans, cotton, canola, alfalfa, sugar beets, papaya (Hawaiian) and squash. Three more crops are approved but not yet on the market.[3]

Enriching Activities

1. Using the United Nations report "World Population to 2300," have students read the report or excerpts from it and write a personal response, including (but not limited to) challenges and opportunities, consequences of growth patterns, population density, changing age structures, etc.

Sources/Credits

[1] Fuglie, Keith and Wang, Sun Ling. "New Evidence Points to Robust But Uneven Productivity Growth in Global Agriculture." United States Department of Agriculture Economic Research Service. Retrieved from: http://www.ers.usda.gov/amber-waves/2012-september/global-agriculture.aspx#.V-ucevkrJhE

[2] Edwards, Steven. "10 Things You Didn't Know about the World's Population." United Nations Population Fund. Retrieved from: http://www.unfpa.org/news/10-things-you-didn%E2%80%99t-know-about-world%E2%80%99s-population

[3] "What Foods Are Genetically Modified?" Best Food Facts. Retrieved from: https://www.bestfoodfacts.org/what-foods-are-gmo/

To Market

Grade Level: HS (9–12)

National Ag Literacy Outcomes Addressed

Plants and Animals for Food, Fiber and Energy

- Explain how farmers work with the lifecycle of plants and animals (planting/breeding) to harvest a crop (T2.K-2.a)

Food, Health and Lifestyle

- Recognize that agriculture provides our most basic necessities: food, fiber, energy and shelter (T3.K-2.b)

Content Standards

Science:

- **1-LS1:** From Molecules to Organisms: Structures and Processes
- **1-LS3:** Heredity: Inheritance and Variation of Traits

Speaking and Listening:

- CCSS.ELA-LITERACY.CCRA.SL.1
- CCSS.ELA-LITERACY.CCRA.SL.3
- CCSS.ELA-LITERACY.CCRA.SL.4

Keywords

- Genetically modified organism (“GMO”)
- Stacked traits
- DNA

Purpose

The purpose of this lesson is to help students become familiar with what a “GMO” is and how companies market their products.

At the conclusion of this lesson, students will be able to:

- Define a genetically modified organism
- Understand marketing techniques

Time

- Multi-day lesson opportunities

Materials

- “GMO” Investigator™ Kit lab from BioRad http://www.bio-rad.com/en-us/product/gmo-investigator-kit
- Lesson handout (one per student or group)

Background – Agricultural Connections

You are inundated with marketing tactics all day long. From commercials on the radio to the ads in your sidebar, companies are constantly vying for our attention. Marketing is taken very seriously, since converting — or winning over a customer — equals profit to the company. In agriculture, companies also use marketing to promote their products.

Interest Approach – Engagement

1. Give students one minute to write down all of the times they have encountered marketing today. Students will write down as many items as they can once the timer begins. At the conclusion, have students call out their examples popcorn style.
2. Focus the class and ask students to name effective marketing techniques and non-effective marketing techniques. List on the board. Tell the students that today they are going to learn more about marketing in agriculture.

Procedures

This project is designed to be multilayered. With additional time (3, 45-miute sessions), the project can include a lab.

Day 1:

1. Assign the project to student small groups (four to five students/group):
   a. As a marketing consultant, you have been hired by the company Syngenta to promote their line of genetically engineered crops. It is your job to help inform the public of their products, including how they are created,

and to address the misconceptions people have about genetically engineered foods. You are to produce a presentation that can be viewed from the company website.

2. Have students brainstorm what they know and need to know. Debrief as a class and discuss. Facilitate student research.
   a. To learn more about genetically engineered products and agriculture in the United States, the students can use the lesson handout as a starting point. They can also use any print sources from credible sources.
3. Before beginning the research and project, facilitate a class discussion on presentation format choices (PowerPoint, Prezi, website, etc.). Share with students where they can share/view web resources that they discover while doing research. You may wish to post comments and use for formative assessment to check student/group progress.
4. For a final assessment, students will present formal presentations to an authentic audience. (This may include fellow teachers, other classes, parents, school board members, administrators, local farmers, politicians, agriculture cooperative extension agents, 4H/FFA representatives, etc.)

Days 2, 3, and 4:

1. Have students complete the "GMO" Investigator™ Kit lab from BioRad (http://www.bio-rad.com/en-us/product/gmo-investigator-kit.

Did You Know? (Ag Facts)

1. Did you know? Marketing isn't just for the big companies! All companies and businesses use marketing, from the small family-owned stores to the large corporations.
2. Did you know? Most agricultural products are perishable — just think about your own food! It is important for agricultural products to be marketed with that in mind. [1]

Enriching Activities

1. Students may research and report to their group on one of the following jobs and then add this to the groups' presentation:
   a. Trait Developer: Comes up with novel traits that can be engineered into crop plants.
   b. Vector Constructor: Designs the recombinant DNA that will be integrated into the crop plants.
   c. Transformation Scientist: Uses a gene gun or Agrobacteria tumefaciens to insert the vector into the plants.
   d. Plant Analyst: Assesses the transformed/transgenic plants to understand integration and expression of the trait gene(s).
   e. Product Safety: Assesses the safety of the products before they can be marketed.

Sources/Credits

[1] "Agricultural Marketing." Retrieved from: http://www.marketing-schools.org/types-of-marketing/agricultural-marketing.html

Suggested Websites

Companies

- Syngenta: http://www.syngenta-us.com/home.aspx
- Monsanto: http://www.monsanto.com/Pages/default.aspx
- BASF: http://www.agro.basf.com/agr/AP-Internet/en/
- DuPont Pioneer: http://www.dupont.com/industries/agriculture.html

Genetically Modified Foods/Biotechnology

- "GMO" Answers: http://www.gmoanswers.com
- Biotech Institute "Your World: Genetically Modified Crops" http://www.biotechinstitute.org/download/files/YourWorld/yw-101-food-crop.pdf

Crop Development

- "New Method for Associating Genetic Variation with Crop Traits" http://www.sciencedaily.com/releases/2012/07/120722135125.htm
- "New Non-GM Technology Platform for Genetic Improvement of Sunflower Oilseed Crop" http://www.sciencedaily.com/releases/2013/05/130513123223.htm

Government and Other Organizations

- U.S. Department of Agriculture – Natural Resources Conservation Service: http://www.nrcs.usda.gov
- U.S. Food and Drug Administration: http://www.fda.gov
- United States Department of Agriculture: http://www.usda.gov
- Biotechnology Innovation Organization: http://www.bio.org
- Environmental Protection Agency: http://www.epa.gov/

Populations

- Science Daily "New Projection Shows Global Good Demand Doubling by 2050" http://www.sciencedaily.com/releases/2011/11/111121194043.htm

Corn Production Integrated Math

Grade Level: HS (9–12)

National Ag Literacy Outcomes Addressed

Agriculture and the Environment

- Describe how farmers use land to grow crops and support livestock (T1.K-2.a)

Plants and Animals for Food, Fiber and Energy

- Explain how farmers work with the lifecycle of plants and animals (planting/breeding) to harvest a crop (T2.K-2.a)

Content Standards

History:

- **NCSS 9:** Global Connections

Science:

- **2-LS4:** Biological Evolution: Unity and Diversity

English Language Arts:

- Writing: CCSS.ELA-LITERACY.CCRA.W.9

Mathematics:

- CCSS.MATH.PRACTICE.MP8

Keywords

- Sustainability
- Yield
- Bushel

Purpose

The purpose of this lesson is to investigate the rising global population and the resources available within the economy, food supply and water supply to address this topic.

At the conclusion of this lesson, students will be able to:

- Assess how population growth affects the economy, food supply and water supply
- Verbalize how math can describe the effects of rising population growth
- Compare, analyze and use data in calculations related to current and historical corn production in the United States
- Analyze plant traits that affect production and compare these traits in an objective manner

Time

- One hour

Materials

- Access to the internet and computer (one per group)
- Writing utensil and paper (one per student)
- Lesson handout: U.S. Corn Acres (one per student)
- Access to: http://www.quotecorn.com
- Large paper or poster board
- Various art supplies (scissors, glue, rulers, paint, tape, markers, etc.)
- Best fit line tools (Examples include paper graph and ruler, calculator, excel, CPMP tools, etc.)
- Optional Access to: USDA Economic Research Service corn data, available at http://www.ers.usda.gov/topics/crops/corn/background.aspx

Background – Agricultural Connections

Corn is one of the main crops grown to feed livestock, making up 95% of total grain produced for feed. Sorghum, barley and oats are also grains used for feed. There are more than 90 million acres of land planted in corn in the United States. In addition to being used for livestock feed, humans consume corn in a variety of ways. Some varieties of corn can be eaten fresh, while others are processed into products like starch, sweeteners, corn oil and fuel ethanol. In the past 30 years, the number of feed grain farms has decreased; however, the number of acres in production per farm has increased.[1]

Interest Approach – Engagement

1. As students come into class, have the population clock from www.census.gov/popclock available for the class to see. Using data from the population clock, students will need to predict the population of the world at a designated time (Example: at the end of the class period, in 10 minutes, etc.). Have students write down their answer so they remember. Remind students that a growing population means more to feed and, ultimately, more food to produce.
    a. Note: Don't forget to check the population clock and compare students' answers at the designated time!

Procedures

1. Ask students the following question. Record answers on the board.
    a. How does the population growth affect the economy, food supply and water supply?
2. Students will write a short paragraph on how they think population affects the economy, food supply and water supply.
3. Distribute the "U.S. Corn Acres" lesson handout to students, showing acres of corn planted vs. acres harvested. Have students use graph paper to graph the acres planted vs. acres harvested. Direct students to draw a line of best fit for the graphed data.
4. Have the students analyze the graph, and then, using the data in the chart, create two linear equations to represent planting and yield of corn in United States. Students will compare and contrast the two graphs. They will look at rate of change and possible intersections. Students will need to answer the following questions:
    a. Can the amount of acres realistically continue to grow? Why or why not?
5. Students can find the best fit line via paper graph and ruler, calculator, excel, CPMP tools, now-next (recursive).
6. Using the data available, instruct students to determine a function for U.S. Corn Yield in bushels/acre as a function of time.
    a. What prediction can be made about the amount of bushels/acre in the future? Is it possible? Why or why not?
7. Using the functions from Step #3 and Step #4, determine a function that gives the number of bushels as a function of time.
8. Have students determine the number of bushels for the year 2030.
9. Inform students that farmers have to deal with conditions such as droughts and pest infestations that lower the yield of their crops. If the yield is compromised, then the farmer's income is as well.
10. Students will research the average cost of spraying pesticides on an acre of land planted in conventional (non-organic) corn. Determine a function for cost of spraying pesticide as a function of acres planted. Start with a now next (recursive) equation and then put in function notation.
    a. Research the average cost of conventional corn by the acre and then determine a function for the cost of corn as a function of acres planted. Start with a now next equation then put in function notation. Note: Not sure where to start? Check out "2015 Crop Production Budgets" at http://cornandsoybeandigest.com/blog/average-cost-production-423-corn-1096-soybeans.
11. Using results from the previous steps, students will create a function that gives the total cost of planting conventional corn as a function of acres planted.
12. If the U.S. yield of corn in 2012 was 155 bushels/acre, and a farmer earns on the average $7.63/bu., does the farmer make or lose money per acre?
    a. Go to http://www.quotecorn.com to see current corn prices. Recalculate based on the current corn price.
13. Students will write a summary on how their functions and conclusions compare and contrast with the other groups' results.
14. Redirect students to the population clock and the paragraph they wrote at the beginning of the class period. With their new knowledge of the inputs for just one crop, corn, have them add to or edit their paragraph based on the following question:

a. How did the knowledge shared in this lesson affect your thoughts about the global economy and feeding a growing population?

Did You Know? (Ag Facts)

1. Did you know? Farmers work closely with companies and local education specialists to bring the best corn seed to their field! Farmers choose the traits in their seed based on their field needs.
2. Did you know? On average, it takes 13 years and $130 million dollars to bring a “GMO” product to market — or in other words — available in your local grocery store. That’s a lot of time and money![2]

Enriching Activities

1. Optional: You may wish to visit the USDA Economic Research Service site to evaluate corn acreage and yield (bushels harvested per acre).
2. Have students look at the data from this unit and determine how well it fits a linear regression and if it should be quadratic or exponential instead.
3. Using the data from the handout, have students present the data in an alternate way.

Sources/Credits

[1] Capehart, T. (2016, July 14). USDA ERS - Corn: Background. Retrieved October 11, 2016, from http://www.ers.usda.gov/topics/crops/corn/background.aspx.

[2] “10 Things You Should Know about “GMO’s.” Retrieved from: https://gmoanswers.com/studies/beyond-labels-10-things-you-should-know-about-gmos.

United States Corn Acres: Planted vs. Harvested

Year	Acres Planted (millions)	Acres Harvested (millions)
1993	73	63
1994	89	73
1995	72	65
1996	79	73
1997	79	73
1998	80	73
1999	77	71
2000	79	73
2001	76	69
2002	79	69
2003	79	71
2004	81	74
2005	81	75
2006	78	71
2007	94	86
2008	86	79
2009	86	80
2010	88	81
2011	92	84
2012	97	88
2013	97	89
2014	95	89
2015	88	81
2016	94	86

United States Corn Acres: Bushels per Acre

Year	Bushels/Acre
1982	101
1994	121
2003	139
2012	155

Source:
"U.S. Corn Acres." National Agricultural Statistics Service, United States Department of Agriculture.
Retrieved from: www.nass.usda.gov/Charts_and_Maps/graphics/cornac.pdf.

Plasmid Problem Solving

Grade Level: HS (9–12)

National Ag Literacy Outcomes Addressed

Agriculture and the Environment

- Describe how farmers use land to grow crops and support livestock (T1.K-2.a)

Plants and Animals for Food, Fiber and Energy

- Explain how farmers work with the lifecycle of plants and animals (planting/breeding) to harvest a crop (T2.K-2.a)

Food, Health and Lifestyle

- Recognize that agriculture provides our most basic necessities: food, fiber, energy and shelter (T3.K-2.b)

Content Standards

History:

- **NCSS 8:** Science, Technology and Society
- **NCSS 9:** Global Connections

Science:

- **1-LS1:** From Molecules to Organisms: Structures and Processes
- **1-LS3:** Heredity: Inheritance and Variation of Traits

English Language Arts:

- Reading: CCSS.ELA-LITERACY.CCRA.R.10
- Speaking and Listening: CCSS.ELA-LITERACY.CCRA.SL.1

Keywords

- Genetically modified organism (“GMO”)
- Biotechnology
- Transgenic organisms
- Restriction enzyme
- Plasmid

Purpose

The purpose of this lesson is to introduce students to transgenic organisms and the general use of biotechnology.

At the conclusion of this lesson, students will be able to:

- Define how transgenic organisms are created
- Analyze DNA segments using restriction enzymes
- Research the applications of biotechnology for society

Time

- Two class periods

Materials

Day 1:

- Lesson support handouts:
  a. Plasmid DNA sheet (one per group)
  b. Scenario Cards (one card per group)
  c. DNA Strip for Rootworm Resistance (Bt) (one per group)
- Paper or notebook and writing utensil (one per student)
- Scissors (one per group)
- Clear tape (one section of tape per group)
- Three different colored pencils (one set per group)

Day 2:

- Paper or notebook and writing utensil (one per student)

Background – Agricultural Connections

A scientist, by definition, is “a person who is trained in a science and whose job involves doing specific research or solving scientific problems.”[1] As the world population increases, scientists are a crucial piece of the puzzle to help avoid a global food crisis.

Interest Approach – Engagement

1. Give students the lesson support handouts, and instruct them to take a few minutes at the beginning of the lesson to complete the questions on the handout.
2. Once finished, focus the class and discuss.

Procedures

Day 1:

1. Relay the following challenge to the students: Your job as a new owner of a farm is to evaluate your needs as a corn grower and come up with solutions to any foreseeable problems.
    a. Give each group one of the two scenarios from the “Scenario Cards” handout.
2. Provide the following instructions to students:
    a. Now you are all scientists! Your job as a scientist is to use biotechnology to help solve the growers’ problems. You will create a plasmid that contains the desired trait to correct the problem of the grower.
3. Ask students:
    a. What must first happen to the plasmid to begin this process? (cut open the plasmid)
    b. How can a plasmid be cut? (Restriction enzyme)
    c. How many times would I need to cut the plasmid? (ONE site only)
    d. How should the cell DNA be processed? (cut on either side of the plant gene)
    e. Should the same enzyme be used to cut your cell DNA? (yes)
    f. What happens if you use a different enzyme? (cut sites will be different and the DNA and plasmid will not “stick” to each other)
    g. How many times should the DNA be cut? (at TWO sites)
    h. Where should the cuts occur? (one above and one below the gene)
4. Have students record a flowchart for this process in their notebook.
5. You may wish to assemble DNA plasmids prior to class or have students assemble at the start of this activity.
    a. To assemble plasmids, copy the “Plasmid DNA” sheet for each group.
    b. Cut out the strips and tape them consecutively into one, continuous strip (first strip 1, then strip 2, etc.).
    c. Then, tape the end of strip 6 to the beginning of strip 1 to make a ring. Check to be sure that none of the bases were covered up in the process of taping.
6. Hold up a DNA Plasmid and a paper DNA Strip containing desired gene for rootworm resistance (in this case, Bt). Ask students how we could cut the desired gene out of the DNA Strip. Since it is difficult to see what is happening in the plasmid during transformation, we will do a paper simulation.
7. Break students into pairs and give them scissors, clear tape, three different colored pencils, one DNA Plasmid, one DNA Strip and three restriction enzyme cards.
8. Have students create a transformed bacterial plasmid that includes the desired gene. In their notebooks, students should write a paragraph explaining the process used to create the transformed plasmid, including which enzyme they used and why.
9. Ask students:
    a. Now that we have a plasmid with the desired gene, what can we do with it? (Get the bacteria to “take it up,” so it can make our corn better suited for the farm)
    b. Since we can’t see the gene, plasmid or even the bacteria, how will we know if it transformed? (Test for the presence of trait)

Day 2:

1. Students will work in groups to research one medical, agricultural and/or environmental use of biotechnology similar to what was demonstrated in the previous lab activity.
    a. Medical examples:
        i. Pharmacogenomics is the study of testing the safety and impact of certain drugs based on the genetic information of the patient.[2]
        ii. Gene therapy is used to integrate a beneficial gene into a patient in order to help cure a disease.[3]
        iii. Insulin is made for diabetic patients using recombinant DNA technology. Scientists build the human insulin gene using bacterial plasmids.[4]
    b. Agricultural examples:
        i. Corn, cotton and potatoes have been genetically engineered to produce their own Bt (Bacillus thuringiensis). Bt is a naturally occurring bacterium that is found in the soil. The Bt in the plant allows the plant to be resistant to certain devastating pests.[5]
        ii. Some crops have also been genetically engineered to resist herbicides. This allows a farmer to spray herbicides without killing the plant. Glyphosate-resistant (GR) crops are a common type of herbicide-resistant crop.[6]
    a. Environmental:
        i. Bioremediation is the process of using naturally occurring microorganisms — such as bacteria, fungi and yeast — to clean up polluted waterways, such as a body of water after an oil spill.[7]
2. Students will use a “speed-dating” protocol to share research findings with classmates.
3. Arrange student desks in an inner/outer circle formation, with students’ desks facing each other. After students are seated, tell them that they will have one minute to share and/or explain the most important information about their research.
4. After the minute, tell the students to switch “experts” and allow the other student to share.
5. After that minute, tell students that they have 30 seconds each to ask clarifying questions about the subject matter.
6. Once finished, direct the students in the inner circle to remain seated and the students in the outer circle to shift counter-clockwise one seat; the process repeats until the students are with their original partners.

Did You Know? (Ag Facts)

1. Did you know? Humans have been manipulating the genes of various crops with selective plant breeding for thousands of years![8]
2. Did you know? If you took apart all of the DNA in your body and linked it together, it would stretch to the sun and back 600 times! [9]

Enriching Activities

3. To extend the lesson, students can work in groups to market their newly created genetically engineered product.
    a. Create a trade name
    b. Create an advertisement to entice growers to buy
    c. Choose a target audience
    d. Create a presentation about your product for a group of “buyers”

Sources/Credits

[1] "Scientist." Merriam-Webster. Retrieved from: http://www.merriam-webster.com/dictionary/scientist.

[2] Pharmacogenomics. (n.d.). Retrieved October 11, 2016, from https://www.boundless.com/biology/definition/pharmacogenomics/.

[3] Biotechnology in Medicine - Boundless Open Textbook. (n.d.). Retrieved October 11, 2016, from https://www.boundless.com/biology/textbooks/boundless-biology-textbook/biotechnology-and-genomics-17/biotechnology-119/biotechnology-in-medicine-480-11702/.

[4] "How Did They Make Insulin from Recombinant DNA?" (n.d.). Retrieved October 11, 2016, from https://www.nlm.nih.gov/exhibition/fromdnatobeer/exhibition-interactive/recombinant-DNA/recombinant-dna-technology-alternative.html.

[5] "By Planting Insectresistant Cotton, Researchers Hope." (n.d.). Insect-resistant Crops Through Genetic Engineering. Retrieved October 11, 2016, from http://www.aces.uiuc.edu/vista/html_pubs/biotech/insect.htm.

[6] Green, J. M., & Owen, M. D. K. (2011). "Herbicide-Resistant Crops: Utilities and Limitations for Herbicide-Resistant Weed Management." Journal of Agricultural and Food Chemistry, 59 (11), 5819–5829. http://doi.org/10.1021/jf101286h.

[7] "What Is Bioremediation?" (n.d.). Retrieved October 11, 2016, from http://www.hawaii.edu/abrp/biordef.html.

[8] "Core Truths." Popular Science. Retrieved from: http://www.popsci.com/article/science/core-truths-10-common-gmo-claims-debunked.

[9] "10 Weird but True Facts about DNA." Retrieved from: http://blogs.ancestry.com/cm/2014/09/16/10-weird-but-true-facts-about-dna/.

Scenario Cards

Scenario 1:
You have inherited a 500-acre farm from your great uncle Ralph. You are new to farming, but you have plenty of equipment and staff to run a very large farming operation. You have consulted with your local extension agent, and you agree that you should plant corn in the upcoming growing season.

When you are chatting with a neighbor from down the road, you find out that a neighboring corn farm lost 40% of its crop due to a rootworm infestation last year, and you become concerned.

1. Research the kind of damage rootworms cause in corn plants.
2. Research ways to get rid of rootworms.
3. What would you decide to do?

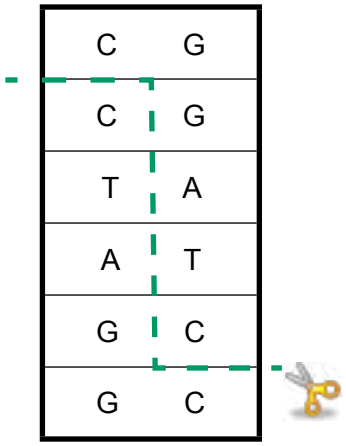
Scenario 2:
You have inherited a 500-acre farm from your great uncle Wallace. You are new to farming, but you have plenty of equipment and staff to run a very large farming operation. You have consulted with your local extension agent, and you agree that you should plant corn in the upcoming growing season.

You can't help but notice that during the off-season, your fields have become completely overrun by weeds. In some areas, you can't even see the soil. It will take a lot of work to get the fields in shape for planting, but you are worried that the weeds will return once the corn starts growing.

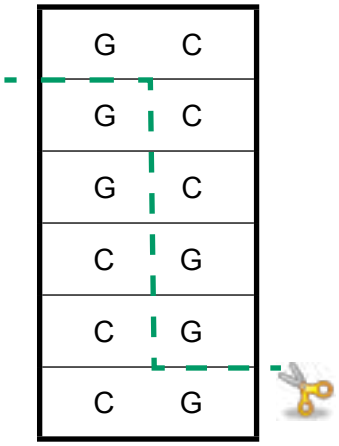
1. Research the kind of damage weeds can cause in corn fields.
2. Research ways to get rid of the weeds if they do return while your corn is growing.
3. What would you decide to do?

Restriction Enzymes

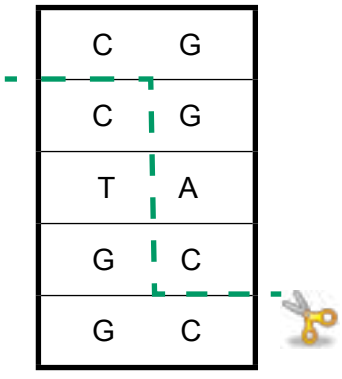
Bam HI



Xma I



Ava II



DNA Strip for Rootworm Resistance

A T	T A
T A	G C
T A	G C
C G	C G
T A	A T
C G	T A
G C	T A
G C	C G
T A	T A
G C	C G
G C	G C
G C	A T
C G	G C
C G	G C
C G	G C
A T	C G
G C	C G
G C	C G
T A	T A
C G	C G
T A	T A
Attach next strip here	

This section of DNA came from a bacterial cell of the species *Bacillus thuringiensis*.

The shaded portion ( ) is a gene that codes for the production of a protein that is toxic to corn rootworm larvae.

Plasmid DNA

G C	A T	T A	C G	T A	T A
C G	G C	A T	G C	G C	A T
C G	A T	G C	A T	G C	A T
C G	A T	G C	G C	T A	G C
A T	A T	C G	T A	G C	C G
G C	A T	C G	T A	G C	C G
A T	T A	C G	A T	G C	G C
G C	G C	C G	A T	G C	T A
T A	T A	C G	C G	G C	A T
T A	G C	T A	C G	C G	G C
T A	T A	T A	T A	A T	G C
C G	G C	T A	A T	A T	T A
T A	T A	T A	G C	G C	T A
T A	C G	T A	G C	G C	C G
A T	C G	A T	A T	T A	G C
A T	A T	G C	G C	T A	A T
G C	G C	G C	G C	A T	A T
G C	T A	G C	G C	T A	C G
T A	A T	A T	C G	A T	T A
C G	G C	C G	C G	C G	C G
T A	G C	T A	C G	T A	C G
tape – 1 – here	tape – 2 – here	tape – 3 – here	tape – 4 – here	tape – 5 – here	tape – 6 – here

Geometry in Agriscience

Grade Level: HS (9–12)

National Ag Literacy Outcomes Addressed

Agriculture and the Environment

- Describe how farmers use land to grow crops and support livestock (T1.K-2.a)
- Describe the importance of soil and water in raising crops and livestock (T1.K-2.b)
- Identify natural resources (T1.K-2.c)

Plants and Animals for Food, Fiber and Energy

- Identify the importance of natural resources (e.g., sun, soil, water, minerals) in farming (T2.K-2.e)

Content Standards

Economics:

- Economics Standard 2: Decision Making

Science:

- K-2-ETS1: Engineering Design

Mathematics:

- CCSS.MATH.PRACTICE.MP2
- CCSS.MATH.PRACTICE.MP5

Keywords

- Agriscience
- Genetically modified organism (“GMO”)

Purpose

The purpose of this lesson is to introduce students to math concepts, specifically geometry, used in everyday agriscience.

At the conclusion of this lesson, students will be able to:

- Compare/contrast conventional crop breeding versus genetically modified crop breeding
- Understand how and why farmers use test plots in their fields
- Compute the perimeter and area of geometric shapes
- Use geometric methods to design test plots to meet the land acreage restraints and opportunities

Time

- One hour

Materials

- Chart paper or whiteboard (one per student)
- Markers
- Paper and writing utensil (one per student)
- Access to: “Your Food, Farm to Table” video, available at https://www.youtube.com/watch?v=K1XbEpNZ5yk
- Access to: “Designing Research and Demonstration Tests for Farmers’ Fields” http://extension.uga.edu/publications/detail.cfm?number=B1177 , or print one article per student
- Optional: Access to computer design software such as AutoCad, Google SketchUp, etc.

Background – Agricultural Connections

Genetically modified foods have only been available since the 1990s, however, people have been selecting plants based on the traits they possess for more than 10,000 years. In the 1700s, farmers began crossbreeding plants. Researchers have been working since the 1940s to introduce genetic variation into plant genes.[1] Farmers choose their crop seed for their land based on region, environment, weather patterns and soil needs. Many factors go into seed selection, and part of that choice is whether to use conventional or transgenic seed.

Interest Approach – Engagement

Students will watch "Your Food, Farm to Table" to introduce them to crop production. A table group discussion will follow to compare and contrast conventional versus genetically modified crop breeding. Students will list their ideas on chart paper and discuss as a class.

Procedures

1. Students will research corn-breeding methods, including both traditional and genetically engineered methods, to gain a better understanding of the two concepts. As part of their research, students will understand how field plots, or test plots, are used for in agriculture.
    a. Use the article "Designing Research and Demonstration Tests for Farmers' Fields" to better understand the purpose of test plots for crops.
2. In their research, specifically the article above, the students will look at the math used to mark off entire fields and field test plots.
3. Break the class into small groups, and present the scenario below.
    a. A farmer (the student) will use a part of his land to test five new varieties of corn from Syngenta. These test plots will be within the farmer's normal corn field. Choose a field size between 100 and 1,000 acres. Create a 2D or 3D model of the test plots in a field by using acreage, perimeter, area and row dimensions. A layout of the models should be done on graph paper and on the computer with design software (if available).
    b. Include the perimeter and area computations used for each model. Have students explain why they chose to use these dimensions to create their model.
4. A layout of each model should be drawn by hand **and** by computer 3D software if available (e.g., CPMP Tools, Google Sketchup, AutoCad, etc.).
5. Each group will present their project to the class.
    a. A rubric will be used to grade the model project that includes creativity, ability to follow directions, neatness, deadlines met and math accuracy. See the sample rubric below.

Items to be scored	maximum points	Team 1	Team 2	Team 3	Team 4
Project Is Related to Sustainability	100				
Voice	50				
Stage Presence	50				
Power of Expression	50				
Response to Questions*	100				
General Effect	50				
Every Team Member Participated	100				
Design Present	50				
Presentation Done Uniquely	100				
TOTAL POINTS (Net)	650				
Team Total Points					
COMMENTS					

Did You Know? (Ag Facts)

1. Did you know? Farmers often use GPS technology to map out their fields as part of their precision farming tools! Check out the article "Precision Farming Tools: Global Positioning System (GPS)" to read more![2]
2. Did you know? Planting test plots allows farmers and seed companies to compare the different hybrids with each other. There should always be a "standard treatment," or a hybrid the farmer is already familiar with in the equation so that they have something to compare to.[3]

Enriching Activities

1. To follow up or extend the activity, students may write a one-page essay comparing/contrasting traditional and transgenic methods of breeding corn and why a farmer may or may not use certain seeds and seed technologies.
2. If available, contact a local corn or soybean farmer in your area who has test plots. Arrange a field trip or for the farmer to come visit the class.

Sources/Credits

[1] "10 Things You Should Know about "GMO's." Retrieved from: https://gmoanswers.com/studies/beyond-labels-10-things-you-should-know-about-gmos.

[2] "Precision Farming Tools: Global Positioning System (GPS)." Virginia Cooperative Extension. Retrieved from: http://pubs.ext.vt.edu/442/442-503/442-503.html.

[3] "Designing Research and Demonstration Tests for Farmer' Fields." University of Georgia Extension Service. Retrieved from: http://extension.uga.edu/publications/detail.cfm?number=B1177#Experimental.

Agricultural Legislation

Grade Level: HS (9–12)

National Ag Literacy Outcomes Addressed

Culture, Society, Economy and Geography

- Explain why farming is important to communities (T5.K-2.b)

Content Standards

Economics:

- Economics Standard 16: Role of Government and Market Failure
- Economics Standard 17: Government Failure

History:

- **NCSS 6:** Power, Authority and Governance
- **NCSS 10:** Civic Ideals and Practices

English Language Arts:

- Speaking and Listening: CCSS.ELA-LITERACY.CCRA.SL.4
- Language: CCSS.ELA-LITERACY.CCRA.L.6

Keywords

- Legislative process
- Democracy
- Lobbyist

Purpose

The purpose of this lesson is to teach or review the U.S. legislative process, with emphasis on current events, including food and farm related items.

At the conclusion of this lesson, students will be able to:

- Describe the U.S. Legislative process
- Understand how a citizen can affect the legislative process
- Understand lobbying groups and how they interact with government
- Interact with current events and their related bills or legislative actions

Time

- One hour

Materials

- Paper and writing utensil (one per student)
- Access to: “Schoolhouse Rock: America – I’m Just a Bill” https://www.youtube.com/watch?v=FFroMQlKiag.
- Access to the internet or newspapers for research on current events

Background – Agricultural Connections

Each individual has a voice and each group of individuals that represent an occupation or interest often has representation in government. Agriculture is no different! Many agriculture organizations have dedicated staff working with the U.S. government as a part of the legislative process.

Interest Approach – Engagement

1. To begin, show students the classic Schoolhouse Rock Video “I’m Just a Bill”: https://www.youtube.com/watch?v=FFroMQlKiag.

Procedures

1. To start the lesson, decide on a current or fictitious bill to present to the class. Have the basics of this bill written in a place for the entire class to see. Include the following information:
    a. Bill number
    b. Purpose
    c. Introduced by
    d. Content of the bill
2. Students will be given access to the internet or newspapers to research bills that are related to current events. Bills could include stances on: genetically engineered crops, Education, Health Care, Energy/Natural Resources, Immigration, Individuals Rights, Taxes, etc. (See handout for organization websites.)Separate students into four different groups: U.S. Senators, U.S. Representatives, Lobbyists and Legislative Staff Researchers.
    a. Lobbyists and researchers will conduct their own research and use information provided by the teacher to develop:
        i. Their position on the bill
        ii. A plan of action to try to influence/ inform lawmakers on the proposed bill
    b. Senators and representatives will meet and review together the process of a bill moving through the legislative branch of government.
3. Have students stand up, with Lobbyists and Legislative Staff Researchers in one line facing a line of U.S. Senators and U.S. Representatives. The activity will work like speed dating.
4. Lobbyists and Legislative Staff Researchers will have 45 seconds to give their position on the bill and any supporting factors. At the end of 45 seconds, the lawmakers will be able to ask one question, and the lobbyists and legislative staff will have 15 seconds to respond.
5. Have the lawmakers move one space to the right, creating a new set of partners. Repeat the activity as time allows.
6. As time allows, have the students choose a different role. Repeat as necessary.
7. Students will write an essay on their position on the bill, where the bill is in the legislative process and any other relevant information.
8. Optional: You may wish to have students present their papers in a presentation format.

Did You Know? (Ag Facts)

1. Did you know? The United States Department of Agriculture was started by Abraham Lincoln in 1862.[1]
2. Did you know? At the beginning of World War I, more than 50% of the U.S. population farmed. Today, only 2% of the nation claims farming as an occupation. [i]

Enriching Activities

1. To extend the activity, have students research specific organizations related to agriculture that have lobbyists in Washington, D.C. Choose two or three from the list. Compare and contrast their current priority issues.

Sources/Credits

[1] "Agriculture and the Government." America's Heartland. Retrieved from: http://www.americasheartland.org/education/teachers/011_ah_farm_facts_lesson.pdf.

Website Resources

Genetically Modified Foods/Biotechnology

- U.S. Food and Drug Administration: http://www.fda.gov
- United States Department of Agriculture: http://www.usda.gov
- "GMO" Answers: http://www.gmoanswers.com

Education

- U.S. Department of Education: http://www.ed.gov
- National Educators Association: http://www.nea.org

Health Care

- U.S. Centers for Medicare & Medicaid Services: http://www.healthcare.gov
- U.S. Department of Health and Human Services: http://www.hhs.gov

Energy/Natural Resources

- U.S. Department of Energy: http://www.energy.gov
- U.S. Department of Agriculture – Natural Resources Conservation Service: http://www.nrcs.usda.gov
- U.S. Natural Resources Defense Council: http://www.nrdc.org

Immigration

- U.S. Citizenship and Immigration Services: http://www.uscis.gov
- U.S. Immigration and Customs Enforcement: http://www.ice.gov
- Federation for American Immigration Reform: http://www.fairus.org

Vocabulary

Unless otherwise referenced, all definitions are directly sourced from "Food Biotechnology: A Communicator's Guide to Improving Understanding," developed by the International Food Information Council.[1]

Agriscience
The application of science to agriculture.[2]

Bacillus thuringiensis (Bt)
A common soil microorganism in bio insecticides used by farmers, including organic farmers and home gardeners, to control insects with minimal environmental impact.

Biotechnology
The application of biological science to enhance attributes of plants, animals and other organisms, or to improve methods for producing foods. Includes techniques such as fermentation, enzyme purification and plant and animal breeding (particularly recombinant DNA technology).

Breeding (traditional or selective)
Making deliberate crosses or matings of plants or animals so the offspring will have particular desired characteristics derived from one or both of the parents. Practices used in traditional plant breeding may include aspects of biotechnology such as tissue culture, mutational breeding and marker-assisted breeding.

Bushel
A measurement of dried goods based on weight. For current U.S. commercial bushel sizes, visit https://www.unc.edu/~rowlett/units/scales/bushels.html.

Deoxyribonucleic Acid (DNA)
Carries the genetic information for most living systems. The DNA molecule consists of four base proteins (adenine, cytosine, guanine and thymine) and a sugar phosphate backbone, arranged in two connected strands to form its characteristic double-helix. The genome (all of the genetic information in a living organism), rather than single DNA molecules, determines the organism's characteristics.

Drought-tolerant
A drought-tolerant/resistant plant uses a survival mechanism, such as defoliating or going dormant, to survive abnormally dry conditions, but it needs moisture to resume its normal lifestyle. [3]

Gene
The fundamental unit of heredity. A gene contains the "blueprints" for building proteins in a specific pattern that determines the characteristics of a plant, animal or other organism, and how those traits will be passed from one generation to the next. It is typically a specific segment of a Chromosome.

Genetic Engineering
The selective, deliberate alteration of an organism's genes using modern molecular biology, particularly recombinant DNA techniques. Other terms used include gene splicing, gene manipulation, recombinant DNA (rDNA) technology or transgenic technology.

Genetic Modification/Genetically Modified Organisms ("GMOs")
The production of heritable improvements in plants or animals for specific uses, via either genetic engineering or other more traditional methods. Some countries other than the United States use this term to refer specifically to genetic engineering.

Herbicide
Class of crop protection and specialty chemicals used to control weeds on farms and in forests, as well as in non-agricultural applications such as golf courses, public properties and home lawns.

Herbicide-tolerant Crops
Crops that have been developed to survive (tolerate) exposure to particular herbicides by the incorporation of certain gene(s), either through genetic engineering or traditional breeding methods. The herbicide can therefore be applied to the field for weed control without damaging the crop.

Insecticide
A class of crop protection and specialty chemicals used to control insects on farms and forests, as well as non-agricultural applications such as residential lawn care, golf courses and public properties.

Insecticide Resistance
The development or selection of heritable traits (genes) in an insect population that allows them to survive exposure to an insecticide that would otherwise debilitate or kill them. The presence of such resistant insects makes the insecticide less useful for managing pest populations.

Legislative Process
The sequence of steps required for laws to move through the system, from ideas to formally adopted legislation.[4]

Lobbyist
A person who takes part in an organized attempt to influence legislators.[5]

Organic Agriculture
Agricultural production without the use of synthetic pesticides or fertilizers. The USDA Organic Standards provides a list of pesticides (fungicides, insecticides and herbicides) and other additives approved for production of organic crops, and currently does not allow the use of genetically engineered seeds.

Pesticide
A broad class of crop protection products, including four major types: insecticides used to control insects; herbicides used to control weeds; rodenticides used to control rodents; and fungicides used to control mold, mildew and fungi. Both farmers and consumers use pesticides in the home or yard to control termites and roaches, clean mold from shower curtains, stave off crab grass on the lawn, kill fleas and ticks on pets, disinfect swimming pools, etc.

Plasmid
A genetic structure in a cell that can replicate independently of the chromosomes, typically a small circular DNA strand in the cytoplasm of a bacterium or protozoan. Plasmids are much used in the laboratory manipulation of genes.[6]

Recombinant DNA technology (rDNA)
Breeding technique in which a copy of a piece of DNA containing one or a few genes is transferred between organisms, or "recombined" within another organism.

Research
Careful study that is done to find and report new knowledge about something.[7]

Restriction Enzyme
An enzyme produced chiefly by certain bacteria that has the property of cleaving DNA molecules at or near a specific sequence of bases.[8]

Seed Traits
A genetically determined characteristic[9] that is present in the seed of a crop.

Stacked Traits
The biotechnology process by which more than one gene can be transferred, resulting in a plant with two or more transgenic traits. Usually a result of the crossing of two transgenic plants with different transgenes.

Sustainability
Avoidance of the depletion of natural resources in order to maintain an ecological balance.[10]

Transgenic Organism
A plant, animal or other organism with different traits from the parent organism, resulting from the use of recombinant DNA techniques to insert genetic material from another organism.

Yield
An amount produced of an agricultural or industrial product.[11]

Sources/Credits

[1] By IFIC Foundation (2013). "Food Biotechnology: A Communicator's Guide to Improving Understanding." Retrieved October 11, 2016, from http://www.foodinsight.org/education/food-biotechnology-communicators-guide-improving-understanding.

[2] "Agriscience." (2016) Oxforddictionaries.com

[3] Westphoria by Sunset. (2015). "Xeric, Water-wise, Drought-tolerant – What Does It all Mean?" Retrieved from http://westphoria.sunset.com/.

[4] Chegg.com. (n.d.). Retrieved October 11, 2016, from http://www.chegg.com/homework-help/definitions/legislative-process-53.

[5] "Lobbyist." (2016) Oxforddictionaries.com.

[6] "Plasmid." (2016) Oxforddictionaries.com.

[7] "Research." (2016) Merriam-Webster.com. Merriam-Webster.

[8] "Restriction Enzyme." (2016) Oxforddictionaries.com.

[9] "Trait." (2016) Oxforddictionaries.com.

[10] "Sustainability." (2016) Oxforddictionaries.com.

[11] "Yield." (2016) Oxforddictionaries.com.

For more information about the Syngenta Fellowship program,

contact program coordinator Tanya Markham (tanya.markham@syngenta.com) or

program lead Lisa Zannoni (lisa.zannoni@syngenta.com).

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