

# BRINGING BIOTECHNOLOGY TO LIFE

An Educational Resource for Grades 7-10



AMERICAN FARM BUREAU  
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## Welcome

“Bringing Biotechnology to Life” is a resource for science educators and others interested in learning more about biotechnology and its role in food production. This unit of instruction addresses national learning standards for 7th – 10th grade, yet the interest level may be much broader. Seven sequential lessons guide the learner through the process of understanding DNA, selective breeding over time, agricultural biotechnology today, including foods produced through biotechnology (often referred to by consumers as genetically modified organisms (“GMOs”)). Students are also presented with tools to evaluate the reliability of information they see and hear. The unit culminates with a relevant research paper and presentation to people beyond the students’ classmates and teacher. This unit follows the principles of Project Based Learning by engaging students with a driving question, encouraging voice and choice, incorporating critique and revision, and including a public audience for the final project.

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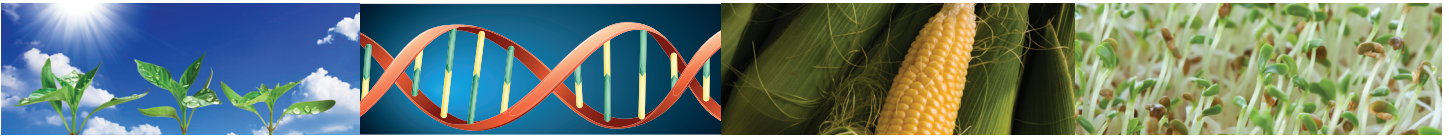
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## LESSON 1

### DRIVING QUESTION: WHAT IS DNA?

**Length:** 1 hour

**Objectives:** Students will be able to:

- identify the primary components in a DNA structure.
- describe the role of DNA in trait inheritance.

#### Standards:

*Next Generation Science Standards Addressed*

Disciplinary Core Ideas	Practices	Cross-Cutting Concepts
LS1.B Growth and Development of Organisms  LS3.A Inheritance of Traits  LS3.B Variation of Traits	Asking Questions	Structure and Function: Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the relationships among its parts, therefore complex natural structures/ systems can be analyzed to determine how they function.

#### Materials:

- Copies of Lesson 1 Student Handout: “Delicious DNA” (1 per group of 2-3 students)
- Paper towels (1 per group of 2-3 students)
- \*Licorice vines (2 per group of 2-3 students)

- Toothpicks (20 per group of 2-3 students)
- \*Gummy candy in four colors (20 per group of 2-3 students)
- Optional: Student science textbook for additional information on DNA (1 per group of 2-3 students)

*\* You may wish to substitute fruit and/or vegetables for the candy options in the DNA model. The materials list suggests using licorice vines for the sugar phosphate backbone, gummy candies such as gummy bears, jellybeans or colored marshmallows for the bases, and toothpicks to connect components.*

#### Suggested Video:

*The Double Helix by BioInteractive*

<http://www.hhmi.org/biointeractive/double-helix> (16:53)

*\*Note: Due to the length of this video, you may wish to show only a portion of the history of DNA research.*

**Key Concepts:** Before we can jump into a discussion about biotechnology, we must know how genetic information is passed from generation to generation. In eukaryotic organisms, DNA is contained within the nucleus of the cell. Genes on the double helix DNA structure contain genetic information, which will provide a blueprint for the characteristics/traits of the offspring. During meiosis, this information is passed from parent to offspring.

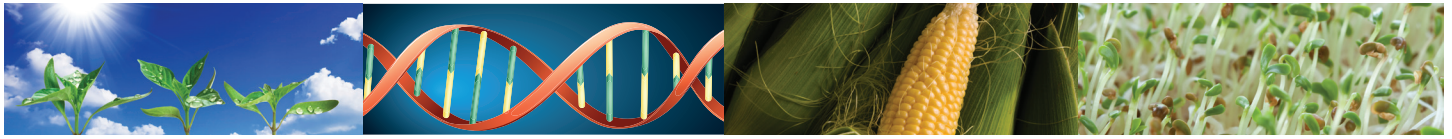
**Setup:** Set out lab supplies and prepare copies of the student handout.

#### Outline:

1. Draw three boxes on a whiteboard. Above the first box, draw a large pair of eyes. Above the second box, draw a movie slate board clapper. Above the third box, draw a question mark.

2. Ask students to think about what they already know about DNA. Help them “unpack” this knowledge by sorting concepts into three categories: what DNA looks

*(continued)*



## LESSON 1: (CONTINUED)

### DRIVING QUESTION: WHAT IS DNA?

like (eyes), what it does (clapper), and why we should care/significance of it (question mark). Solicit responses and capture information in each box.

- Invite students to ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring. Encourage students to think of “What?”, “Why?”, “How?”, and “Where?” questions. Capture questions on the white board or poster paper for review throughout the unit.
3. Preview the activity by sharing with students that they’ll have a chance to build their own DNA structure and eat it too!
  4. Distribute student handout, “Delicious DNA.” Pre-read the handout with the students. In this activity, students will create a DNA structure using a variety of food items and toothpicks. Students must be able to clearly describe the components of the DNA structure and create a logical legend using the candies provided.
    - Note: Students may elect to use food items for different components of the structure. Part of the learning process is giving students the opportunity to make logical connections and create their own road map of understanding.
  5. Break students into collaborative working groups of two to three.
  6. Clarify expectations: By the end of the class period,

students should have assembled a 3-D DNA model and completed the student handout.

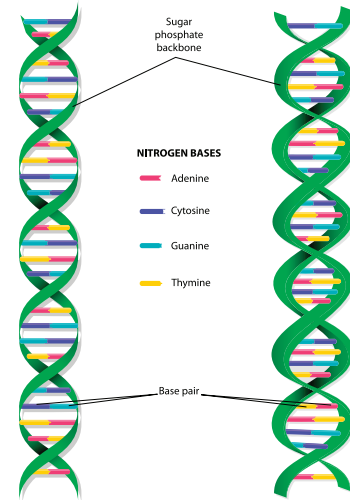
7. Distribute lab supplies and one paper towel to each group. Monitor student progress and address questions.
8. After all students have completed the activity, prompt students to clean work areas.
9. Refer back to the boxes of information drawn on the whiteboard at the beginning of class. Ask students to re-evaluate this information, taking into consideration the knowledge they now have. Ask students what statements they would modify or add to the list. Share additional information as needed.
  - *Just like our DNA, DNA in plants and animals contain what we refer to as the genetics of that organism. Each strand of DNA consists of four bases: adenine (A), cytosine (C), thymine (T), and guanine (G). It does not matter if the DNA is from an animal, insect, or a human, we all share the same four bases. In different organisms, the bases are just arranged to code for different proteins.<sup>1</sup>*
  - *Gene is the root word of “genetics.” Understanding genetics is the basis for understanding food production.*
10. As a take-home challenge, ask students to think of a fruit or vegetable that can be found in different varieties (e.g., apples), and consider the role genetics plays in the traits we observe about that food item.

# Lesson 1 Student Handout: Delicious DNA

Names: \_\_\_\_\_ Date: \_\_\_\_\_ Class Period: \_\_\_\_\_

**Directions:** Using the supplies provided, create a 3-D model of DNA. Your model must include the components in the table below. Complete the legend by listing the materials you used for each component.

Legend	
DNA Component	Item We Used
Sugar Phosphate Backbone	
Adenine	
Thymine	
Guanine	
Cytosine	



After you have built your 3-D model, answer the following questions.

1. What is DNA?

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2. Where is DNA found?

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3. Why is DNA important?

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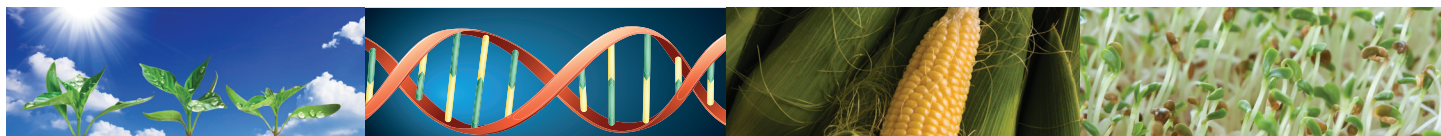
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### Evaluation Rubric:

Grading Rubric – For Teacher		
Model includes all required components.	Model is assembled correctly and follows legend.	Questions are thoroughly completed on lab sheet.
Score _____/ _____	Score _____/ _____	Score _____/ _____



## LESSON 2

### DRIVING QUESTION: HOW CAN WE EXAMINE DNA?

**Length:** 1 hour

**Objectives:** Students will be able to:

- extract DNA from common fruits/ vegetables.

#### Standards:

*Next Generation Science Standards Addressed*

Disciplinary Core Ideas	Practices	Cross-Cutting Concepts
<p>LS1.B Growth and Development of Organisms</p> <p>LS3.A Inheritance of Traits</p> <p>LS3.B Variation of Traits</p>	<p>Planning and Carrying Out Investigations</p>	<p>Structure and Function: Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the relationships among its parts, therefore complex natural structures/ systems can be analyzed to determine how they function.</p>

#### Materials:

- Copies of Lesson 2 Student Handout: “Discovering DNA” (1 per student)
- Pint/ quart sized sealable plastic bag (i.e., Ziploc) (1 per student)
- Previously frozen strawberries (1 per student)
- DNA extraction buffer (10 ML) pre-mixed for class: 50mL dish soap, 15g NaCl (2 tsp plain salt), 900 mL water
- Paper towels (1 per student)
- Ice cold 90% ethanol or isopropyl alcohol
- Test tube or plastic champagne flute (1 per student)
- Funnel (optional)
- Plastic coffee stir straw (1 per student)
- Optional: tomato, banana, avocado, cucumber, or other produce to replicate lab

#### Suggested Video:

##### *Genetic Engineering*

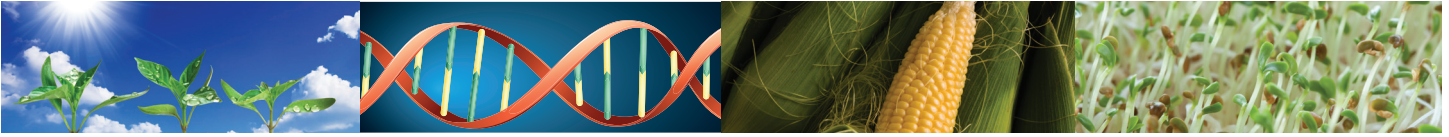
[https://www.youtube.com/watch?v=nfC689EIUVk\(7:20\)](https://www.youtube.com/watch?v=nfC689EIUVk(7:20))

**Key Concepts:** The process for discovering biotechnology begins with a strong foundation of understanding about DNA. In this lab, students will have a hands-on experience extracting DNA.

##### **Setup:**

- Chill the alcohol in a freezer or ice bath for at least one half hour to make it as cold as possible.
- Freeze produce and then allow thawing prior to class. Freezing helps break down the plant material.
- Optional: You may wish to melt the end of a coffee stir straw with a flame to form a hook/knob for ease in catching the DNA.

*(continued)*



## LESSON 2: (CONTINUED)

### DRIVING QUESTION: HOW CAN WE EXAMINE DNA?

#### Outline:

1. Distribute student handout “Discovering DNA” and have students preview the lab procedure.<sup>11</sup> Answer questions before beginning lab.

- Place one thawed strawberry in the plastic bag and squeeze until all lumps are turned into a uniform puree.
- Add 10 mL of buffer solution. Zip the bag closed.
- By squeezing the bag, mix the strawberry with the buffer solution completely.
- Fold the paper towel into a half circle, then a quarter circle, opening it to form a cone.
- Fill the test tube or champagne flute (approximately two inches) with ice-cold alcohol. Place the filter paper cone into the test tube/flute so that half of the cone is on the inside and half is on the outside of the test tube/flute.
- Fill the paper towel cone with the strawberry solution.
- As the strawberry mixture filters through the cone and comes in contact with the cold alcohol, the DNA will form ribbons and then coagulate at the top of the alcohol.
- Use the straw to scoop and retrieve the DNA.

2. Have the students compare their DNA sample with those of other classmates. Discuss their observations.

Ask the students: *Did everyone's DNA look the same? Why did some people have more DNA? Why is isolating DNA an important process? What do you think scientists can learn from studying DNA?* Listen for students to recall that DNA contains genetic information. By studying DNA, scientists are able to identify the genes (genetic markers), which code for specific traits.

3. In the event that one or more students did not have any DNA, explore why not. Listen for students to evaluate if they followed the procedure correctly.
4. If desired, repeat the process with additional samples.
5. When observations have been made, have the students pour contents of the test tubes back into a plastic cup and dispose of the materials as directed.
6. Optional Extension Opportunities:
  - Have students weigh the strawberry prior to testing, and the DNA after separating. Create a class graph evaluating the relationship between weight and amount of DNA collected.
  - Increase the variables (e.g., hot vs. cold alcohol, 70% vs. 90% alcohol, type of soap used in buffer, different types of fruit/vegetables, frozen vs. unfrozen samples, etc.) and compare results.

# Lesson 2 Student Handout: Discovering DNA

Names: \_\_\_\_\_ Date: \_\_\_\_\_ Class Period: \_\_\_\_\_

**Lab Procedure:**

1. Place one thawed strawberry in the plastic bag and squeeze until all lumps are turned into a uniform puree.
2. Add 10 mL of buffer solution. Zip the bag closed.
3. By squeezing the bag, mix the contents with the buffer solution completely.
4. Fold the paper towel into a half circle, then a quarter circle opening it to form a cone.
5. Fill the test tube or champagne flute with (approximately two inches) ice-cold alcohol. Place the filter paper cone into the test tube/flute so that half of the cone is on the inside and half is on the outside of the test tube/flute.
6. Fill the paper towel cone with the strawberry solution.
7. As the strawberry mixture filters through the cone and comes in contact with the alcohol, the DNA will form ribbons and then appear supernatant (floating) at the top of the alcohol.
8. Use the straw to scoop and retrieve the DNA.
9. Compare your DNA with that of other classmates and complete questions below.
10. Repeat with other produce samples as directed by your teacher.
11. Clean up your lab area.

	<b>Describe your DNA. What does it look like? How much is present?</b>
Sample 1: Strawberry	
Sample 2:	
Sample 3:	

1. Compare your solution to your classmates' solutions. Does everyone's DNA look the same? Speculate why or why not.

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2. Why is isolating DNA an important process?

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3. What do you think scientists can learn from studying DNA?

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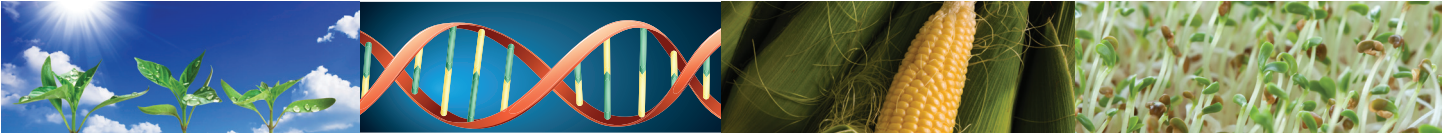


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**Evaluation Rubric:**

<b>Grading Rubric – For Teacher</b>		
Student successfully completed lab according to written procedure.	Lab responses indicate a working knowledge of the role of DNA in science.	Sections are thoroughly completed on handout.
Score _____/ _____	Score _____/ _____	Score _____/ _____





## LESSON 3

### DRIVING QUESTION: WHAT IS SELECTIVE BREEDING?

**Length:** 1 hour

**Objectives:** Students will be able to:

- define selective breeding.
- describe how selective breeding changes a population over time.

#### Standards:

*Next Generation Science Standards Addressed*

Disciplinary Core Ideas	Practices	Cross-Cutting Concepts
LS3.A Inheritance of Traits  LS3.B Variation of Traits	Developing and Using Models	Cause and Effect: Cause and effect relationships may be used to predict phenomena in natural systems.

*Common Core English Language Arts Standards Addressed*

- Reading Standards for Literature 6-12: Craft and Structure, 4
- Writing Standards 6-12: Production and Distribution, 4

#### Materials:

- Scissors (1 per group of 2 students)
- Copies of Lesson 3 Student Handout: "Superhero!" (1 per group of 2 students)
- Lesson 3 Resource: "Wild Mustard Plant" (1 copy per student, or display using projector)
- Internet access and projector or printed images from "How Your Food Would Look if not Genetically Modified Over Millennia" <http://www.geneticliteracyproject.org/2015/02/02/how-your-food-would-look-if-not-genetically-modified-over-millennia-2/>.

#### Suggested Video:

*Backcross Breeding*

<http://passel.unl.edu/pages/animation.php?a=BXbreed.swf&b=990818773> (self-paced)

*Marker Assisted Selection* <http://passel.unl.edu/pages/animation.php?a=MASBreeding.swf&b=1130281891> (self-paced)

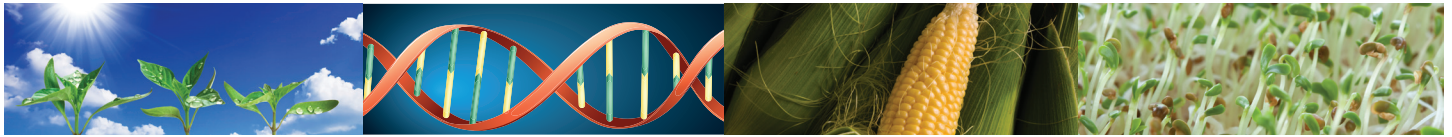
**Key Concepts:** Selective breeding is not a new phenomenon. Humans have been trying to systematically improve their food supply for at least 10,000 years through food biotechnology. As people began selecting and breeding plants and animals for desired traits, they improved these plants and animals for agricultural purposes.<sup>iii</sup> Food biotechnology uses what is known about science and genetics to improve food and how it is produced. Moravian monk Gregor Mendel pioneered the study of inheritance and selective breeding. He discovered the interaction of dominant and recessive traits and patterns of inheritance with simple pea plants. Today there are many food products we enjoy that humans have genetically modified over time through selective breeding. Nobel Laureate Norman Borlaug started the Green Revolution with successful selective breeding of wheat in Mexico, and as a result is said to have "saved more lives than any person who has ever lived."<sup>iv</sup>

**Setup:** Write the following quote about Norman Borlaug on the white board or display with a projector: "[He] saved more lives than any person who has ever lived."

#### Outline:

1. Direct students' attention to the quote about Dr. Borlaug. Ask students to speculate what a person with this descriptor may have done. Share with students that this quote is about Dr. Norman Borlaug, a man who received the Nobel Peace Prize for his work breeding wheat plants which helped nourish billions of people around the world.

*(continued)*



## LESSON 3: (CONTINUED)

### DRIVING QUESTION: WHAT IS SELECTIVE BREEDING?

2. Ask students to recall key information from the previous lesson.

- *In the last lesson, we explored the structure of DNA. Today we'll take a closer look at an amazing process that has enabled scientists like Dr. Borlaug to save countless lives in a growing world. But first, we'll start with a superhero challenge!*

3. Inform students that they will create a powerful colony of superheroes. Distribute student handout "Superhero!" Have students work in pairs to complete the handout.

4. After students have completed the student handout, talk through each scenario. For each scenario, ask students which offspring they selected and why. Listen for selections based on genetic traits that are beneficial in the given situation.

5. Ask students to identify the effect of their selection on the population of superheroes. Have students reflect on the action (selecting for specific traits) that caused this effect.

6. Reinforce that genes, which are encoded in the DNA located in our chromosomes/cell nuclei, control genetic traits. The process of selecting offspring based on their traits is called "selective breeding." This is a process that has been used for thousands of years to breed the right plants and animals for a specific situation.

7. Ask students to describe the ways we use plants and animals. Listen for answers such as food, fuel, shelter, medicines, transportation, etc.

8. Explain to students that humans have been using plants and animals for their benefit for thousands of years.

- For example, humans harvested the best seed of wild grasses, saved it, and planted it the next spring. Soon humans crossed one grass with another (or perhaps several) and created wheat on one continent and corn on another. Neither wheat nor corn, as we know them today,

ever existed as a wild grain. This marked the beginning of manipulating genes to create new products that humans desired.

- Domestication of animals soon followed through genetic modifications made by humans. For example, animal scientists and anthropologists believe that humans domesticated the dog from wolves 12,000 to 14,000 years ago.<sup>v</sup>

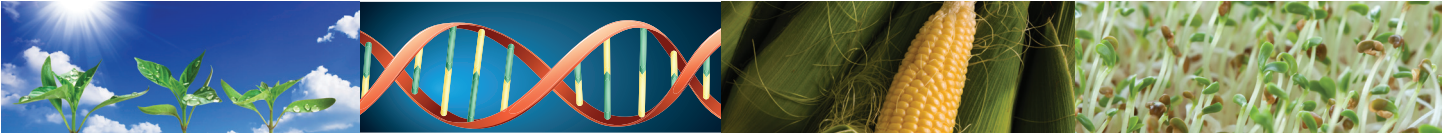
9. Connect superhero activity to selective breeding decisions in real-life. Just like the students selected superheroes for specific scenarios, people have selected plants and animals for specific scenarios over time.

- *What might have been the most important trait selected for in animals?* (Listen for: amount of meat produced, amount of milk produced, quality of wool, amount of fat, size, using feed efficiently, flavor of meat, tenderness of meat, rapid growth, ability to reproduce easily, good mothering behaviors (takes good care of offspring), ease of giving birth, for draft animals like oxen or workhorses – strength, sound feet and legs, good disposition, willingness to work, etc.)
- *What might have been the most important trait selected for in plants?* (Listen for: yield, flavor, texture, ability to dry, growing season/conditions needed, etc.)

10. Share the Lesson 3 Resource: "Wild Mustard Plant" illustrating the variety of crops we enjoy today which were developed through selectively breeding the wild mustard plant (*Brassica oleracea*). Ask students to evaluate the images and hypothesize the trait which breeders selected for to achieve each plant.

- Kohlrabi – selected for stem
- Kale – selected for enlargement of leaves
- Broccoli – selected for suppression of flower development
- Brussels sprouts – selected for lateral leaf buds
- Cabbage – selected for terminal leaf bud
- Cauliflower – selected for sterility of flowers<sup>vi</sup>

(continued)



## LESSON 3: (CONTINUED)

### DRIVING QUESTION: WHAT IS SELECTIVE BREEDING?

11. Display pictures of watermelon, corn, banana, eggplant, carrot, and cabbage/kale from “How Your Food Would Look if not Genetically Modified Over Millennia” at <http://www.geneticliteracyproject.org/2015/02/02/how-your-food-would-look-if-not-genetically-modified-over-millennia->

12. Ask students to share observations and summarize selective breeding in their own words. Listen for students to clarify that animals or plants are selected because of a desired trait and bred to continually improve that trait over generations. Direct students' attention back to the quote about Dr. Borlaug. Inform students that Dr. Borlaug used this technology to breed specific varieties of wheat that could grow well in different areas, providing food for people who would otherwise be hungry.

13. As a take home challenge, have students review the article and series of poems “Mendel's Peas” at [http://www.thehumangenome.co.uk/THE\\_HUMAN\\_GENOME/Mendels\\_Peas.html](http://www.thehumangenome.co.uk/THE_HUMAN_GENOME/Mendels_Peas.html). Have students draft their own poem about selective breeding of a food item and bring it to the next class period.

**Enrichment Opportunity:** Have students research global agricultural challenges, such as breeding better corn in drought prone areas like Africa, and report back on how selective breeding could be applied to help people.

**For More Information, Check Out:**

- “The Man Who Fed the World” by Leon Hesser. Book and educator guide available at [www.agfoundation.org](http://www.agfoundation.org).
- Wiczorek, A., & Wright, M. (2012). History of agricultural biotechnology: How crop development has evolved.<sup>vii</sup>

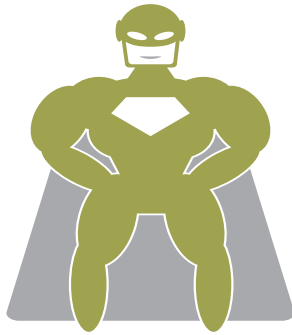
# Lesson 3 Student Handout: Superhero!

Names: \_\_\_\_\_ Date: \_\_\_\_\_ Class Period: \_\_\_\_\_

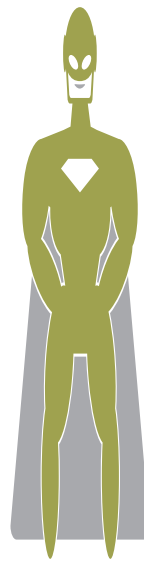
**Directions:** You have a chance to save the world by creating an amazing superhero. Follow the steps to build your superhero family.

**Setup:** Cut out the four genetic trait cards included with this activity. Place the two height cards in a pile, and the two strength cards in a separate pile. Fold all cards so that you cannot see the trait inside.

**Step 1:** Meet your superheroes! We're crossing two superheroes to start your family.



Short and Strong



Tall and Weak

**Step 2:** Build your superhero family! You have a chance to build 10 superheroes by crossing the parents we just met. For each child (1-10), draw one height card and one strength card. Record the outcome in the table below. Height: T (tall) S (short), Strength: S (strong), W (weak). After each drawing, put the cards back before you draw again.

	1	2	3	4	5	6	7	8	9	10
<b>Height</b>										
<b>Strength</b>										

*(continued)*

# Lesson 3 Student Handout: Superhero! (Continued)

**Step 3:** Pick the right superhero for the job! Read each scenario below and decide which superhero child/ children you would use for the job.

**Superhero Scenario A:** Villains have overrun the city. They have flipped every car upside down and moved them under the shortest bridges. We need a superhero to turn the city right side up again.

Which of your superhero kids are right for the job?

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Why?

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**Superhero Scenario B:** An evil villain has hidden all of the money for the entire town in tight places, high in the trees. We need a superhero to get all of the money back.

Which of your superhero kids are right for the job?

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Why?

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**Superhero Scenario C:** The Super Rail is down! We need a superhero to lift the train cars back to the tallest train bridge.

Which of your superhero kids are right for the job?

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Why?

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**Evaluation Rubric:**

Grading Rubric – For Teacher		
Genetic traits of 10 offspring are clearly identified.	Working knowledge of selective breeding is demonstrated through logical responses to scenarios.	Sections are thoroughly completed on handout.
Score _____/ _____	Score _____/ _____	Score _____/ _____

## Lesson 3 Student Handout: Superhero! (Continued)



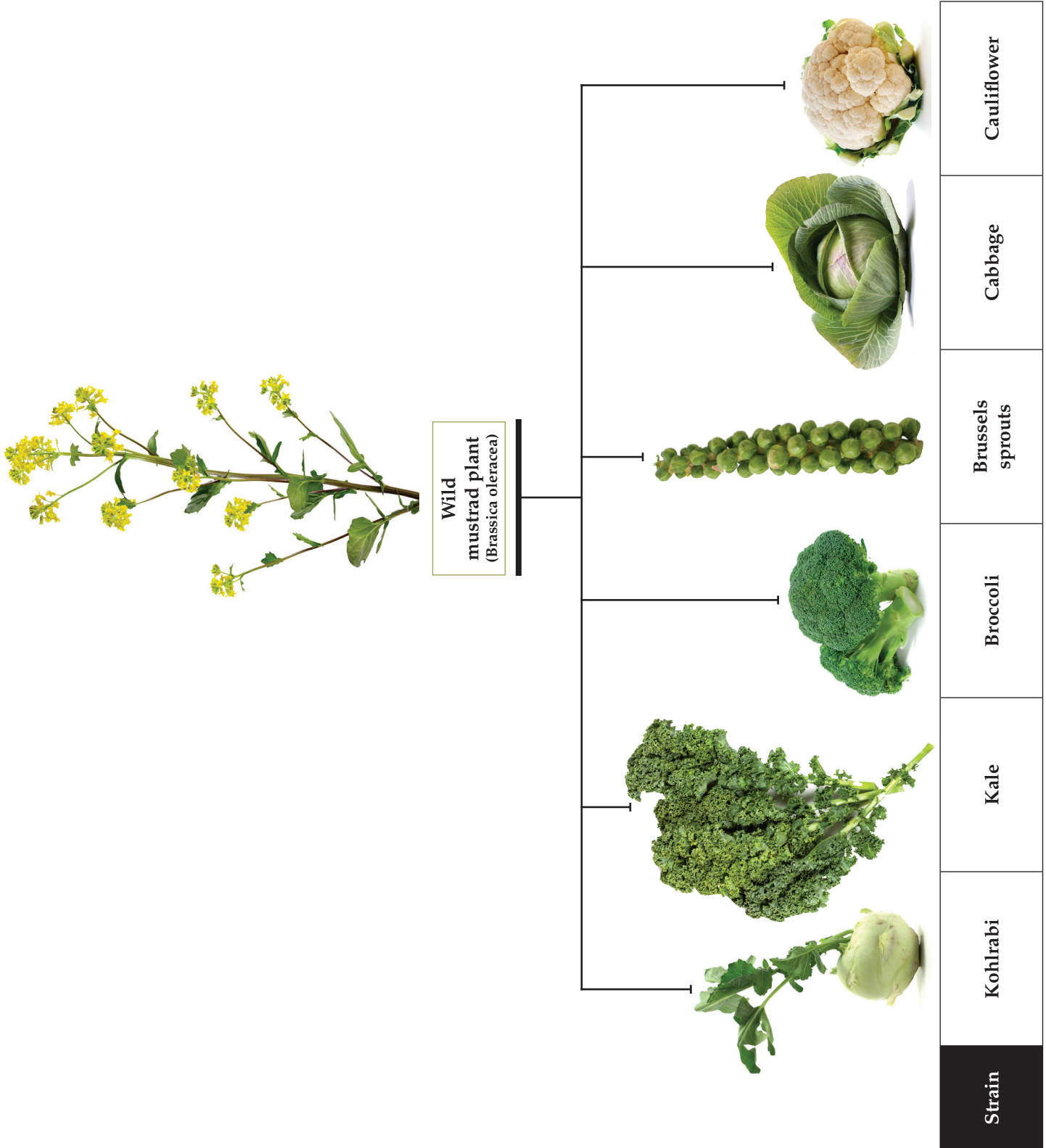
**Genetic Trait**  
Height: Short

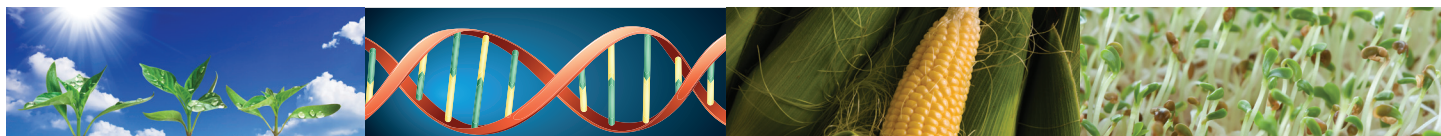
**Genetic Trait**  
Height: Tall

**Genetic Trait**  
Strength: Strong

**Genetic Trait**  
Strength: Weak

# Lesson 3 Student Handout: Wild Mustard Plant





## LESSON 4

### DRIVING QUESTION: WHAT IS BIOTECHNOLOGY?

**Length:** 1 hour

**Objectives:** Students will be able to:

- define biotechnology.
- identify how biotechnology can help the environment.
- identify how biotechnology can improve our food supply.

#### Standards:

*Next Generation Science Standards Addressed*

Disciplinary Core Ideas	Practices	Cross-Cutting Concepts
LS3.A Inheritance of Traits	Asking Questions	Patterns: Observed patterns of forms and events guide organization and classification, and they prompt questions about relationships and the factors that influence them.

*Common Core English Language Arts Standards Addressed*

- Writing Standards 6-12, Text Types and Purposes (2)  
Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through selection, organization, and analysis of relevant content.

#### Materials:

- Copies of Lesson 4 Student Handout: “The Technology of Life” (1 per student)
- TV monitor or projector/screen and speakers
- Internet connection with YouTube access

#### Suggested Video:

“*Your Food, Farm to Table*” by FoodInsightTV

[\(2:41\)](https://www.youtube.com/watch?v=K1XbEpNZ5yk(2:41))

“*Food Biotechnology: Get the Facts*” by FoodInsightTV

[\(1:48\)](https://www.youtube.com/watch?v=b8EDEimG-DY(1:48))

**Key Concepts:** “Food biotechnology uses what is known about plant science and genetics to improve the food we eat and how it is produced. The tools of food biotechnology include both traditional breeding techniques, such as crossbreeding and more modern methods, which involve using what we know about genes, or instructions for specific traits, to improve the quantity and quality of plant species. Modern food biotechnology allows scientists to modify or move desirable traits from one plant to another, with increased precision and efficiency.”<sup>viii</sup> Foods produced using biotechnology are safe for people and they have the potential to greatly improve the quality of the environment and our food supply.

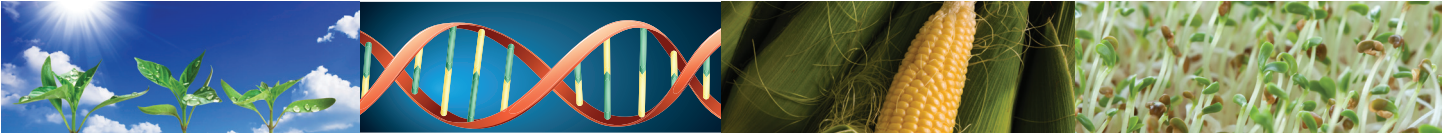
**Setup:** Write the key terms “DNA” and “Selective Breeding” on a white board or display with projector. Preview videos and prepare copies of student handouts.

#### Outline:

1. Set context for lesson by reviewing key concepts from previous lessons. Refer to the terms on the board.

- *What is DNA?* (Listen for: DNA is a large molecule that contains the genetic information for organisms.)
- *What is selective breeding?* (Listen for: Selective breeding is the process of changing a population over time by selecting for desired genetic traits to produce the next generation. Plant breeders and researchers use molecular markers, which are identified gene sequences, to identify these traits without altering the genes in the organism.)<sup>ix</sup>





## LESSON 4: (CONTINUED)

### DRIVING QUESTION: WHAT IS BIOTECHNOLOGY?

- *What do you imagine could be some of the challenges of selective breeding?* (Listen for: Selective breeding takes a significant amount of time, especially in animals. Selective breeding also does not allow you to isolate one trait; many traits are passed on together to each generation, which may have a positive or negative impact in the given scenario.)
2. Play the video “Your Food, Farm to Table” (2:40) by FoodInsightTV at <https://www.youtube.com/watch?v=K1XbEpNZ5yk>.
  3. Add the word “biotechnology” to the white board or projector screen. Ask students to break down the word and define each part.
    - “bio”: life
    - “technology”: using science to invent things or solve problems<sup>x</sup>
  4. Share with the students that there are many definitions of biotechnology. Surprisingly, the term biotechnology was first coined in 1919. Karl Ereky, a Hungarian engineer, first used the term and defined it as “all lines of work involved in creating products from raw materials with the aid of living organisms.” 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.”<sup>xi</sup>
  5. Distribute student handout “The Technology of Life.” Have students capture the definition of biotechnology.
  6. Preview two guiding principles: Biotechnology can help the environment and the food supply. Ask students to look for examples of these two claims as they watch a short video.
  7. Play the video “Food Biotechnology: Get the Facts” (1:47) by FoodInsightTV at <https://www.youtube.com/watch?v=b8EDEimG-DY>.
  8. Have students capture notes and share responses. Ask students: *What is the need driving this technology?* (Listen for students to share about the demands on our environment to produce enough food to sustain a growing population.) Clarify that we will need all farming technologies/practices to feed, fuel, and provide fiber to a growing population, and these methods can coexist.
  9. Direct students’ attention to the second half of the student handout “What’s in a Name?” This section helps students distinguish between the terms “selective breeding,” “genetic engineering,” and “organic production.” Have students begin by writing down their assumptions in the Venn diagram. Next, share the following information:
    - **Selective Breeding** is the process of changing a population over time by selecting for desired genetic traits. Plant breeders and researchers use molecular markers, which are identified DNA, to identify these traits without altering the genes in the organism.<sup>xii</sup> It is actually only very recent that the use of molecular markers has become widespread. For most of the history of selective breeding, the selection has been based on choosing preferred phenotypes, which are characteristics of the visible appearance of a plant or animal.
    - **Biotechnology** is using what is known about plant science and genetics to improve the food we eat and how it is produced. Genetic engineering is a type of biotechnology. With genetic engineering, single genes for new desirable traits can be transferred to crops using plasmids.
    - **Organic Production** refers to the growing process a farmer uses, not the actual seed. Organic production must follow specific guidelines as outlined by the USDA.<sup>xiii</sup> The use of genetically engineered seed is prohibited in organic production.<sup>xiv</sup>
  10. Challenge students to review the organization of these three classifications and generate questions about their relationships.
  11. Create a space on the white board or a bulletin board for unanswered questions. Challenge students to seek answers from reliable sources and bring information back to class.

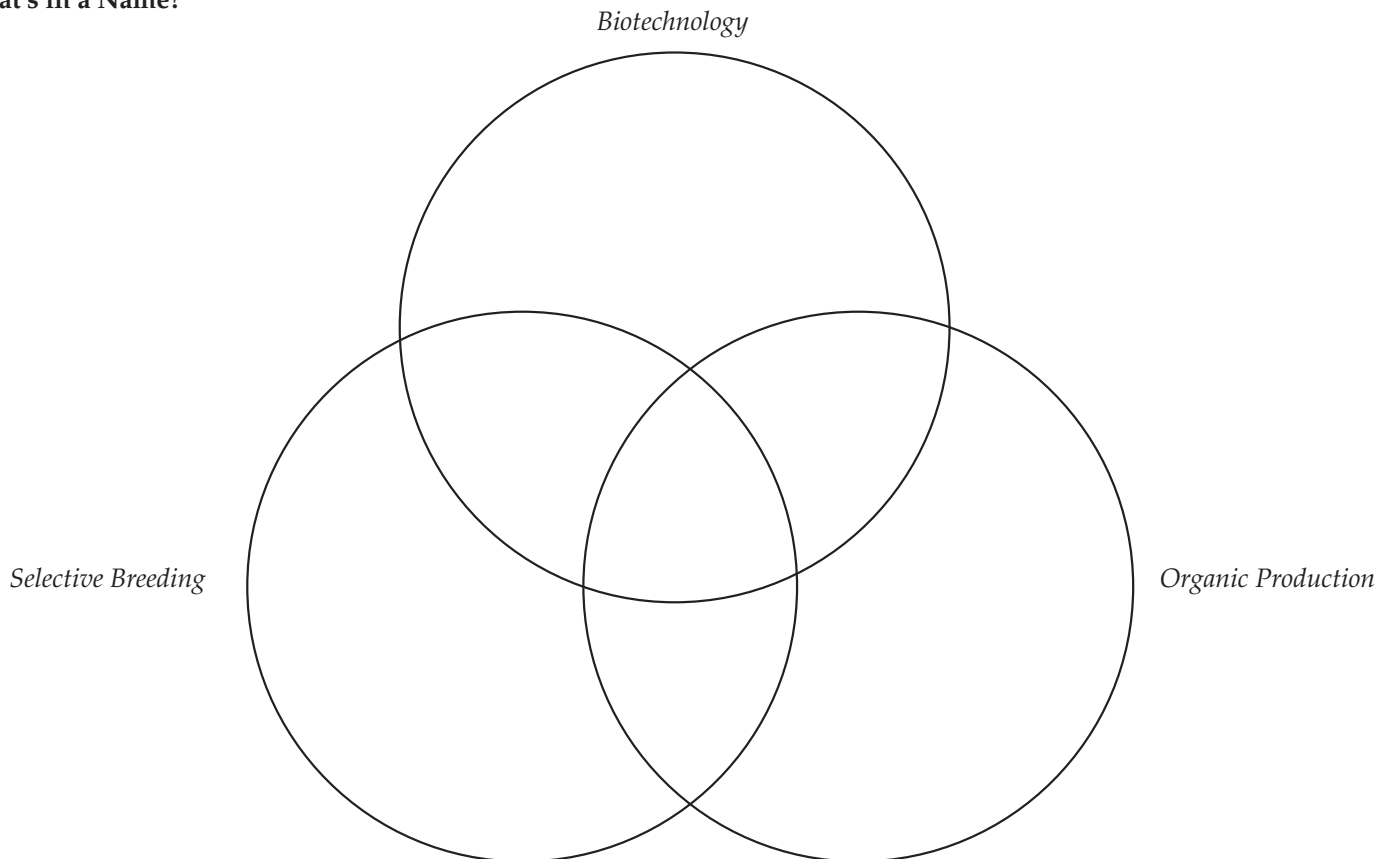
# Lesson 4 Student Handout: The Technology of Life

Names: \_\_\_\_\_ Date: \_\_\_\_\_ Class Period: \_\_\_\_\_

What is biotechnology?

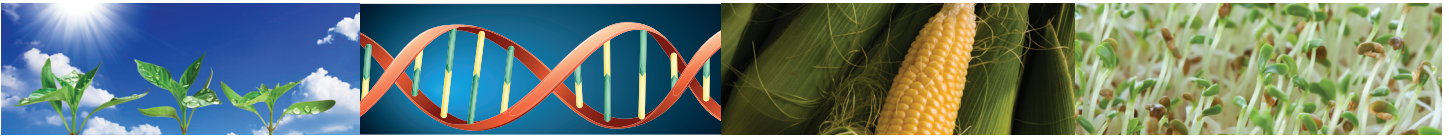
<b>How can biotechnology help the environment?</b>	<b>How can biotechnology help the food supply?</b>

What's in a Name?



**Evaluation Rubric:**

<b>Grading Rubric – For Teacher</b>		
Specific examples for helping the environment and food supply are listed.	Venn diagram shows clear comparison of terms.	Sections are thoroughly completed on handout.
Score _____ / _____	Score _____ / _____	Score _____ / _____



## LESSON 5

### DRIVING QUESTION: HOW IS BIOTECHNOLOGY USED?

**Length:** 1 hour

**Objectives:** Students will be able to:

- identify specific ways biotechnology can improve food nutrition, safety, and quality.
- identify specific ways biotechnology supports social, economic, and environmental sustainability.
- identify specific ways biotechnology helps to meet the increasing needs of the world's growing population.

#### Standards:

*Next Generation Science Standards Addressed*

Disciplinary Core Ideas	Practices	Cross-Cutting Concepts
LS3.A Inheritance of Traits	Engaging in an Argument From Evidence	Cause and Effect: Cause and effect relationships may be used to predict phenomena in natural systems.

*National Standards for Art Education Addressed*

- NA-VA.9-12.1 Understanding and Applying Media, Techniques, and Processes

#### Materials:

- TV monitor or projector/screen and speakers
- Internet connection with YouTube access
- Copies of "Food Biotechnology: A Communicator's Guide to Improve Understanding" (pages 6-11) available at [www.foodinsight.org/biotech](http://www.foodinsight.org/biotech) (1 per group of 2-3 students )
- Blank sheet of paper (1 per group of 2-3 students )
- Coloring utensils (1 set per group of 2-3 students)

- Sample infographic images. Great examples can be found by simply searching Google images for "infographics."

#### Suggested Video:

"What are the Benefits of Food Biotechnology" by FoodInsightTV

<http://www.foodinsight.org/media/food-biotechnology-videos> (2:33)

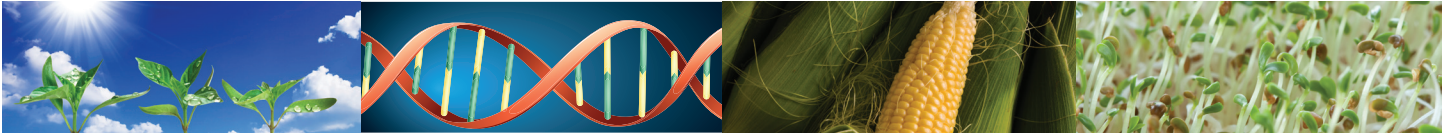
**Key Concepts:** Food biotechnology is being used to improve nutrition and enhance food safety and quality. Biotechnology supports the social, economic, and environmental sustainability of agriculture. Biotechnology has a role to play in ensuring that safe and abundant food can be produced on existing farmland to meet the increasing needs of the world's growing population. In addition to food applications, biotechnology is used in other areas such as pharmaceuticals and environmental protection, such as the use of bacteria to clean up oil spills (bioremediation).

**Setup:** Preview video and find examples of infographics. Set up coloring utensils and supplies. Prepare copies of handouts.

#### Outline:

1. Challenge students to recall five things they have learned in their exploration of biotechnology thus far. When they have five, they are to turn to a partner, share, and give a high five.
2. Play the video "What are the Benefits of Food Biotechnology" (2:33) by FoodInsightTV at <http://www.foodinsight.org/media/food-biotechnology-videos>.
3. Introduce the concept of infographics. Ask students if they are familiar with the term "infographic." Have them speculate what it might mean. (Listen for: An

*(continued)*



## LESSON 5: (CONTINUED)

### DRIVING QUESTION: HOW IS BIOTECHNOLOGY USED?

infographic is an image that conveys information using graphics. They are commonly seen in social media, magazines, commercials, etc.)

4. Share sample infographics found online. Ask students to generate a class checklist for qualities that make a great infographic. (Listen for observations such as purposeful graphics, minimal text, and large numbers.)

5. Introduce infographic design project: In collaborative working groups, students will create an infographic using evidence to create an argument communicating the three key benefits of biotechnology. Break students into groups of two to three. Give each group a copy of "Food Biotechnology: A Communicator's Guide to Improve Understanding" pages 6-11.

- Assign each group one of the three selected key messages:
  - (Message One) Food biotechnology is being used to improve nutrition, enhance food safety, and quality.
  - (Message Two) Biotechnology supports the social, economic, and environmental sustainability of agriculture.

- (Message Three) Biotechnology has a role to play in ensuring that safe and abundant food can be produced on existing farmland to meet the increasing needs of the world's growing population.

6. Instruct students to review the content provided for their section. Challenge student groups to highlight the three to five most interesting facts they discovered. In making their selection, prompt students to identify what they believe to be the most interesting effects caused by biotechnology.

7. Guide students as they work together to create an infographic communicating this information.

8. Collect infographics and post them in a common area.

9. Remind students that fear of change is often driven by a lack of understanding. Effective communication of research-based information is crucial in the process of developing new strategies for solving problems.

# Lesson 5 Student Handout: Infographic Design

Names: \_\_\_\_\_ Date: \_\_\_\_\_ Class Period: \_\_\_\_\_

**Your Task: Create an infographic communicating one of the three key benefits of biotechnology.**

The key message our teacher assigned us is:

- \_\_\_\_\_ Food biotechnology is being used to improve nutrition, enhance food safety, and quality.
- \_\_\_\_\_ Biotechnology supports the social, economic, and environmental sustainability of agriculture.
- \_\_\_\_\_ Biotechnology has a role to play in ensuring that safe and abundant food can be produced on existing farmland to meet the increasing needs of the world's growing population.

**What makes a great infographic? Create a checklist below based on the ideas your class discusses.**

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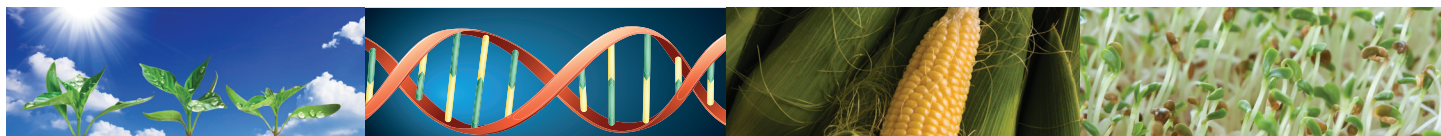
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**Evaluation Rubric:**

Grading Rubric – For Teacher		
Factual information is presented in the infographic.	The infographic focuses on the selected key message.	The infographic follows the student-driven checklist "What makes a great infographic?" established by the class.
Score _____ / _____	Score _____ / _____	Score _____ / _____



## LESSON 6

### DRIVING QUESTION: HOW DO RESEARCHERS COMPARE DNA?

**Length:** 1 hour

**Objectives:** Students will be able to:

- demonstrate knowledge of the gel electrophoresis process.

#### Standards:

*Next Generation Science Standards Addressed*

Disciplinary Core Ideas	Practices	Cross-Cutting Concepts
LS3.A Inheritance of Traits  LS3.B Variation of Traits	Developing and Using Models	Patterns: Observed patterns of forms and events guide organization and classification, and they prompt questions about relationships and the factors that influence them.

#### Materials:

- Computers with internet access (1 per student or class computer with projector)
- Copies of Lesson 6 Student Handout: “Electrophoresis Exploration” (1 per student)
- Optional: gel electrophoresis lab kits for extension

#### Suggested Video:

“What is gel electrophoresis?” by National Genetics and Genomics Education Centre

<http://www.geneticseducation.nhs.uk/laboratory-process-and-testing-techniques/gel-electrophoresis> (1:01)

**Key Concepts:** Gel electrophoresis is a process that enables researchers to take a closer look at DNA. An electrical current passes from a negative electrode, through a gel (like a slab of Jello) to a positive electrode. Samples of DNA of different lengths are placed into the gel at one end, and their negative charge carries them with the current towards the positive electrode. The smaller molecules move faster, and the DNA molecules are thus sorted according to their size. A large number of molecules of a specific size will move at the same rate, and appear as a band in the gel, which can be made visible with UV light. Researchers can compare different bands of DNA to detect changes in the DNA sequence.<sup>xv</sup>

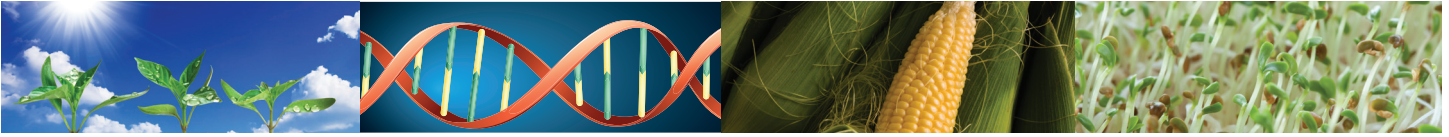
#### Setup:

- Ensure computer settings allow access to the gel electrophoresis simulation site and video.
- Prepare copies of the student handout.

#### Outline:

1. Ask the students: *Have you ever wondered how scientists can distinguish one set of DNA from another?*
2. Explain that scientists discovered that DNA could be made to move through a gel using electrical charge.
3. Distribute student handout “Electrophoresis Exploration.” Preview the handout with students.
4. Play the video “What is gel electrophoresis?” by National Genetics and Genomics Education Centre (1:01) <http://www.geneticseducation.nhs.uk/laboratory-process-and-testing-techniques/gel-electrophoresis>

(continued)



## LESSON 6: (CONTINUED)

### DRIVING QUESTION: HOW DO RESEARCHERS COMPARE DNA?

5. Ask student to recall key words or short pieces of information from the brief video. Have students first capture these on their handout and then share.

6. Walk students through the process in greater detail. Challenge students to listen for key components of the process and capture notes on the student handout.

- Just like a motorcycle can move more quickly through heavy traffic than a large truck, smaller molecules move more quickly than larger molecules through this gel.
- The DNA molecules can be allowed to proceed for a given amount of time and then frozen in place by removing the electrical current before all molecules have time to get to the end. If the whole class were told to run to the end of the hall and when the fastest student got near the end all were told to freeze, the students would be strung out.
- This process is used to sort DNA and protein into a line from small to large strands.
- Strands of the same length appear as though they clump together. These strands form distinct bands. The bands can then be compared with a known DNA composition of the same organism to determine which proteins are present. Each organism has a unique series of bands.
- Whole DNA, like the DNA extracted in Lesson 2, does not show this banding pattern. Cutting the DNA with “restriction enzymes” generates the banding pattern. These enzymes recognize

specific DNA sequences, usually 6-8 base pairs in length, and cut the DNA strand at that site. Fragments of the same length will then move through the gel at the same speed.

7. Have the students access the Genetic Science Learning Center website at the University of Utah at <http://learn.genetics.utah.edu/content/labs/gel/>. If student computers are not available, access the site using a projector and screen. Conduct the step-by-step virtual gel electrophoresis. You may wish to have students work independently or in pairs.

- As students work, have them summarize each step in three to five words on the student handout.

8. After the virtual lab is complete, have students finish the handout by creating an icon for each step in the electrophoresis process covered in the simulation.

- After students have created an initial draft, have students work in pairs to review one another's work and provide feedback.
- Have students revise their process summary and submit.

**Enrichment Opportunity:** You may wish to have students conduct a real gel electrophoresis experiment. You can learn how to build an electrophoresis chamber at [http://learn.genetics.utah.edu/content/labs/gel/build\\_gel\\_box.pdf](http://learn.genetics.utah.edu/content/labs/gel/build_gel_box.pdf) or search a major laboratory supplies distributor for an electrophoresis kit.

# Lesson 6 Student Handout: Electrophoresis Exploration

Names: \_\_\_\_\_ Date: \_\_\_\_\_ Class Period: \_\_\_\_\_

What is gel electrophoresis?

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Why is it used? What is the purpose?

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Complete the virtual lab at <http://learn.genetics.utah.edu/content/labs/gel/>. Summarize each major step you took in the gel electrophoresis laboratory in three to five sentences below.

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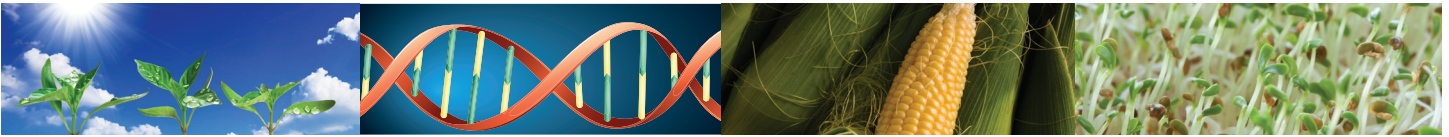
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Create an icon for each major step in the electrophoresis process.

## Evaluation Rubric:

Grading Rubric – For Teacher		
Gel electrophoresis is defined and explained clearly.	Each major step in the electrophoresis process is listed and an icon is included to support.	The student lab is thoroughly completed.
Score _____/ _____	Score _____/ _____	Score _____/ _____





## LESSON 7

### DRIVING QUESTION: WHERE WOULD WE BE WITHOUT “GMOS”?

**Length:** 1 hour

**Objectives:** Students will be able to:

- describe how crops are genetically modified.

#### Standards:

*Next Generation Science Standards Addressed*

Disciplinary Core Ideas	Practices	Cross-Cutting Concepts
LS3.A Inheritance of Traits	Asking Questions and Defining Problems	Cause and Effect: Cause and effect relationships may be used to predict phenomena in natural systems.
LS3.B Variation of Traits	Constructing Explanations	

*Common Core English Language Arts Standards Addressed*

- Speaking and Listening Standards 6-12, Comprehension and Collaboration (1)

#### Materials:

- Copies of Lesson 7 Student Handout: “Genetically Modified Matching Cards” (1 per group of 3-5 students)
- Copies of Lesson 7 Student Handout: “Behind ‘GMOS” (1 per student)
- Copies of Lesson 7 Student Handout: “Discussion Prompts” (1 per student)
- Scissors (for lesson preparation only)
- Student computers (1 per student)

#### Suggested Video:

*“Are There Any Proven Health Risks Associated With Biotech Food?”* by FoodInsightTV

<http://www.foodinsight.org/media/food-biotechnology-videos> (2:04) or

<https://www.youtube.com/watch?v=BwMw9TLOLno> (2:53).

*“The Case for Engineering Our Food”* by Pamela Ronald/TED Talks

[http://www.ted.com/talks/pamela\\_ronald\\_the\\_case\\_for\\_engineering\\_our\\_food?language=en](http://www.ted.com/talks/pamela_ronald_the_case_for_engineering_our_food?language=en) (17:49).

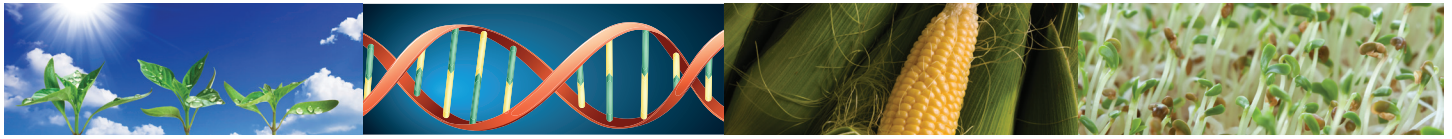
**Key Concepts:** Genetic modification includes traditional breeding, mutagenesis, RNA interference, and transgenics. Products made using transgenics have become known as “GM” (genetically modified) or “GMO” (genetically modified organisms), even though genetic modification through traditional breeding has been occurring for thousands of years.<sup>xvi</sup>

**Setup:** Preview videos listed above. Print student handouts “Genetically Modified Matching Cards.” Cut matching cards apart and place in an envelope for each group. Prepare copies of other handouts.

#### Outline:

1. Briefly walk students back through the objectives of the previous lessons to provide context for this lesson.
2. Write the letters “GMO” on the white board. Ask students to consider the things they hear, read, or see about “GMOs”. Respectfully listen and capture responses on the board around the term.
3. Acknowledge student interest and contributions. Let students know that they will have an opportunity in this lesson to gain a better understanding of the science behind genetically modified organisms (“GMOs”).

*(continued)*



## LESSON 7: (CONTINUED)

### DRIVING QUESTION: WHERE WOULD WE BE WITHOUT “GMOS”?

4. First, define “GMO”: *This term is used to describe the resulting product, after a scientist speeds up the process of selective breeding by moving a specific gene (or genes) from one organism to another. The gene becomes part of the genetic code of the new organism.*

5. Divide students into collaborative working groups of three to five students. Give each group an envelope containing the cut-apart Genetically Modified Matching Cards.

6. Set context for activity: *There are several methods for modifying crops: Traditional Breeding, Mutagenesis, RNA interference, and Transgenics (what we refer to as genetic modification). In the envelope there are a series of cards, which convey important information about how crops are genetically modified.*

- Challenge teams to race to correctly align each process card with its respective number of genes affected and safety testing requirement cards.
- After teams are done, review the correct order using the attached student handout. Award one point for each card that is correctly matched. You may wish to share the infographic for this content at <http://www.geneticliteracyproject.org/2014/04/22/glp-infographic-how-crops-are-modified-are-gmos-more-dangerous/>.
- Provide an opportunity for students to ask questions and share surprising discoveries.

7. Clarify with students that there are only certain genetically engineered crops are on the market. You may wish to display the visual from “GMO” Answers found at <https://gmoanswers.com/sites/default/files/genetictraits.png>. The following genetically engineered crops are grown in the U.S.: field corn, canola, rainbow papaya, soybean, alfalfa, cotton, sugar beet, sweet corn, and summer squash.<sup>xvii</sup>

8. Distribute student handout “Behind ‘GMOs’.” Have students read the three examples of “GMO” products on the top half of the sheet. You may wish to supplement this part of the lesson with additional images or samples of the crops listed. Ask students to consider:

- *What prompted scientists to research new varieties of this crop?*
- *Why was this discovery important?*
- *How do you think things would be different today, if we did not have these “GMO” crops? (Listen for students to identify concepts such as availability of the crop, cost, increased use of pesticides/herbicides, increased soil erosion, higher carbon emissions, increased mortality of non-target/beneficial insects, etc.)*

9. Direct students’ attention to the discussion prompts on the bottom half of the page.<sup>xviii</sup>




- Have students independently read the scenarios and pick one on which to focus.
- Have each student define the problem for his or her selected scenario.
- Based on the information given, have each student write an initial response to the prompt.
- Finally, have each student list additional questions they have about the scenario and proposed solution.
- Share responses.

10. Revisit the initial “GMO” thoughts captured on the white board. Revise and update according to student discussion.

# Lesson 7 Student Handout: Behind "GMOs"

Names: \_\_\_\_\_ Date: \_\_\_\_\_ Class Period: \_\_\_\_\_

We often hear of genetically modified ("GMO") products, but what led to their development? Discover the background behind these "GMO" products.<sup>xx</sup>

		
<p><b>Why did scientists develop genetically engineered corn?</b></p> <p>Pests like the European corn borer can devastate a corn crop by eating through the stalk of the corn plant leaving it brittle and prone to breaking / falling over, known as "lodging." This reduces yields and lowers the quality of the corn that is produced. Scientists developed Bt corn that includes a gene from <i>Bacillus thuringiensis</i>, a very common bacterium that lives in the soil. This bacterium contains a protein that is only activated in the high pH insect gut. Once activated, it produces a toxin that naturally kills pests like the corn borer.<sup>xxi</sup></p> <p><b>Important Traits:</b></p> <ul style="list-style-type: none"> <li>• Herbicide tolerance</li> <li>• Insect Resistance: Bt corn is able to resist pests including the corn borer, corn rootworm, and corn earworm without using pesticides.</li> <li>• Virus / fungi resistance</li> </ul>	<p><b>Why did scientists develop genetically engineered cotton?</b></p> <p>Pests like the tobacco budworm and bollworm can ruin a cotton crop before the cotton has a chance to grow. The pest feeds on the squares, blooms, and bolls of the cotton plant. Like Bt corn, Bt cotton includes a gene from <i>Bacillus thurengiensis</i>, a bacterium that lives in the soil. This bacterium contains a protein that is only activated in the high pH insect gut. Once activated, it produces a toxin that naturally kills pests like the budworm and bollworm.<sup>xxii</sup></p> <p><b>Important Traits:</b></p> <ul style="list-style-type: none"> <li>• Herbicide tolerance</li> <li>• Insect resistance: Bt cotton is able to resist the tobacco budworm, the bollworm, and the pink bollworm without using pesticides.</li> </ul>	<p><b>Why did scientists develop genetically engineered papaya?</b></p> <p>In the mid-1990s the Hawaiian papaya crop was almost entirely wiped out by a virus. Researchers at Cornell University and the University of Hawaii used biotechnology to develop two new varieties of papaya that are resistant to the virus.</p> <p><b>Important Traits:</b></p> <ul style="list-style-type: none"> <li>• Virus / fungi resistance</li> </ul>

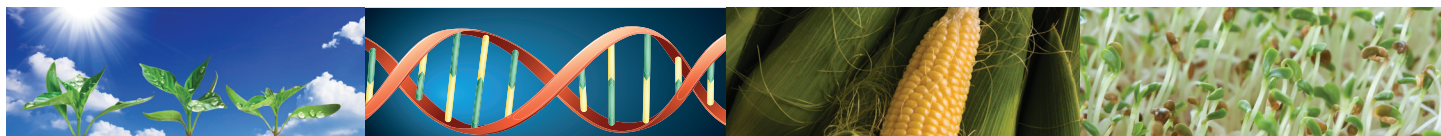
# Lesson 7 Student Handout: Behind “GMOs”

Teacher note: Cut cards apart before activity and place in an envelope. Create one set for each group of three to five students.<sup>xix</sup>

<p><b>Process:</b> <b>Traditional Breeding</b></p> <p>Crossing plants and selecting offspring</p>	<p><b>Process:</b> <b>Mutagenesis</b></p> <p>Exposing seeds to chemicals or radiation</p>	<p><b>Process:</b> <b>RNA Interference</b></p> <p>Switching off selected genes with RNA</p>	<p><b>Process:</b> <b>Genetic Engineering</b></p> <p>Inserting selected genes using recombinant DNA methods</p>
<p>10k-300k+ genes affected</p>	<p>No way to assess number of genes affected, but certain to involve multiple simultaneous unknown changes</p>	<p>1-2 genes affected</p>	<p>1-4 genes affected</p>
<p>No safety testing required</p>	<p>No safety testing required</p>	<p>Safety testing may be required</p>	<p>Safety testing required</p>

# Lesson 7 Student Handout: Discussion Prompts

1. Imagine you are a sugar beet farmer. You love growing sugar beets that provide about half the sugar in the U.S., but managing the weeds on your farm is very difficult. Each year the weeds threaten to choke out your crop, and you have to spray more herbicides to control them. You find out about a new genetically engineered sugar beet that is resistant to glyphosate, a common herbicide. This plant will allow you to spray glyphosate directly on your crop, which is less toxic than the other herbicides you have been using, without harming the sugar beet. What do you do?
2. You are an aid worker in Asia. Rice is a staple crop for most Asian families. It is inexpensive and readily available. You work in a poor area where people do not get enough vitamin A and are at higher risk for many diseases, including blindness. You hear of a rice crop that has been genetically engineered to contain high levels of beta carotene which humans can convert to Vitamin A. What do you do?
3. You are helping farmers in Africa learn new methods for growing cassava. Cassava is a starchy root, like a potato, that is an important part of the diets of many people around the world, especially in Africa. But the people in your community have just lost their entire crop of cassava, again, because of a virus. People are starving. They don't have access to other crops or herbicides. You hear of a new genetically engineered cassava plant that is resistant to the virus, and it contains improved levels of vitamins, proteins, and minerals. What do you do?
4. You just started as the United States Department of Agriculture (USDA) Director for Sustainable Development. Part of your job includes assessing ways to cut down food waste in the U.S. Through your research, you have learned about non-browning Arctic Apples that do not discolor after being exposed to air. You are to write a report with your recommendation of whether or not the U.S. should allow growers to produce this genetically engineered apple. What do you do?<sup>xxiii</sup>



## FINAL PROJECT:

### RESEARCH AND PUBLIC PRESENTATION

**Length:** 1 hour plus additional research and presentation time

**Objectives:** Students will be able to:

- distinguish between fact and opinion.
- use a credibility checklist tool to evaluate online media.
- analyze information gathered or provided and categorize it as fact or opinion.
- form an opinion on biotechnology, genetic engineering, and labeling foods from genetically engineered ingredients using the information gathered.
- write an essay expressing their opinions using correct form, grammar, and spelling.

#### Standards:

*Next Generation Science Standards Addressed*

Disciplinary Core Ideas	Practices	Cross-Cutting Concepts
LS3.A Inheritance of Traits	Engaging in Argument From Evidence	Cause and Effect: Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.
LS3.B Variation of Traits	Obtaining, Evaluating, and Communicating Information	
LS4.B Natural Selection		

*Common Core English Language Arts Standards Addressed*

- Writing Standards 6-12, Text Types and Purposes (1) Write arguments to support claims with clear reasons and relevant evidence.

- Writing Standards 6-12, Text Types and Purposes (2) Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content.
- Writing Standards 6-12, Research to Build and Present Knowledge (7) Conduct short research projects to answer a question, drawing on several sources, and refocusing the inquiry when appropriate.

#### Materials:

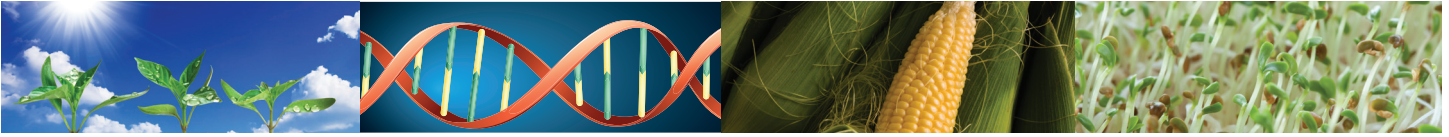
- Copies of Final Project Student Handout: "Credibility Checklist" (1 per student)
- Copies of Final Project: "Student Rubric" (1 per student)

**Key Concepts:** In our democratic society, all people are urged to be responsible citizens. This responsibility involves a willingness to become informed and involved and the willingness to take action. This lesson, designed to illustrate and encourage responsible citizenship, shows students how to become educated about an issue, examine evidence on all sides of the issue from credible sources, and establish a personal position on the issue supported with factual information.

Students will apply knowledge gained from lessons within this unit, and utilize the credibility checklist to evaluate information on a relevant issue. Students will have an opportunity to present their report to individuals from outside their classroom (e.g., other teachers, administrators, community members, agriculture industry representatives, etc.) and engage in meaningful dialogue.

**Setup:** Secure access to student computers and prepare "Final Project: Student Rubric." Identify members to engage in a listening panel for student presentations.

*(continued)*



## FINAL PROJECT: (CONTINUED)

### RESEARCH AND PUBLIC PRESENTATION

#### Outline:

1. Set context for the culminating project by reminding students that they have a tremendous opportunity to engage in their community and our country by voicing their opinion. Understanding the strategies for effective communication of opinion and fact is important for students, as consumers and communicators.

2. Ask students to think about where they get their information on a daily basis. As students share, create a list on the board.

3. Have all students stand along one wall in the classroom. Inform students that one corner of the room represents highly reliable sources – sources you would trust more. Point to the opposite side of the room and tell students that this corner represents unreliable sources – sources you would trust less. Ask students to move in the classroom toward one side or the other, based on how reliable they feel each type of information source is.

- Note: Begin with easy comparisons and gradually work toward more challenging comparisons. It is ok for students to have different opinions about credibility at this stage. The purpose of this activity is to engage critical thinking in preparation for the next step.
- Sample lead-in examples: teacher (reliable), used car salesman (unreliable), someone next to you on the bus (unknown reliability), your doctor (reliable).

4. Ask students why it is often hard to assess reliability. Help students discover on their own that reliability of information on a topic is often dependent on the topic itself. For example, you might go to a professional baseball player for reliable information on how to hit a baseball, but just because they are successful in sports does not necessarily make them a reliable source of information on science. Social media and marketing often confuse this situation even more.

5. Inform students that you have a tool that will help them assess the reliability of information in many areas, especially science. Distribute student handout “Credibility Checklist.” Have students preview the checklist and clarify questions.

6. In class or as a take home exercise, have students complete the credibility checklist for a website related to biotechnology. You may wish to have students search on their own to show a broad variety of sources, or you may wish to direct students’ attention to a reliable database of information found at <http://www.geneticliteracyproject.org/external-resources-links/>.

7. Assess students’ knowledge of the difference between facts and opinions. Define and discuss the differences. (Facts are neutral statements that can be proven. Opinions are points of view, judgments or conclusions.) Explain that opinions are sometimes stated as facts, but that does not make them facts. For example:

- **Fact:** Many groups use fresh water.
- **Opinion:** I believe farmers should be able to use as much water as they need.
- **Opinion Stated as Fact:** It is important for urban areas to have priority in decisions about water use.

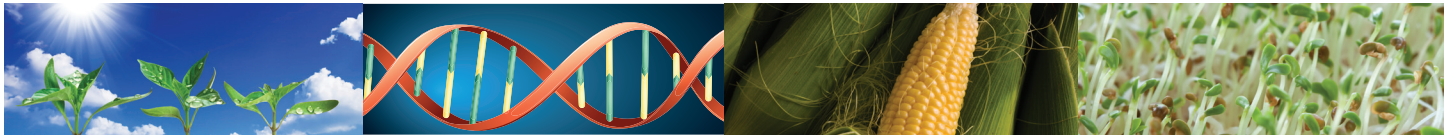
8. To reinforce students’ understanding of the difference between topics and issues, have students identify the topic in the above example (water use). Then have them state the issue (allocation of water).

9. Explore the tone that writers or speakers use when discussing issues. The tone is the attitude or emotion conveyed toward the subject. With advanced students, discuss the use of the techniques of sidestepping and emotional appeal. For example, a writer debating allocation of water sidesteps the issue when he or she discusses levels of water pollution.

10. Have students work independently or in pairs to find an article online about labeling genetically modified organisms. Ask students to scan the article for facts, opinions, and opinions stated as facts. Ask students to share aloud. Capture examples and discuss the importance of being able to read with this “filter” in mind.

11. Have students identify the effect of this article. What does it prompt the reader to do, think, or feel? Next, have students identify the cause of that effect. What strategies did the writer use to elicit that response?

*(continued)*



## FINAL PROJECT: (CONTINUED)

### RESEARCH AND PUBLIC PRESENTATION

12. Help students understand that there are often many sides or positions about an issue. Ask students the following questions with regard to public acceptance of genetically modified organisms.

- *Are there more than two sides to your issue? How many positions are there?*
- *What are some of the different positions about your issue?*
- *What areas of agreement exist between the different positions about your issue?*
- *What are the exact differences which make it so difficult for individuals or groups to agree?*

13. Distribute “Final Project: Student Rubric” to students. Students will draft a short research paper sharing facts about both sides of the issue and their opinion about labeling of genetically modified organisms. Discuss rubric and address questions.

14. Allow student work time and clarify expectations for work done outside of class.

15. After research papers are complete, facilitate a presentation event where students share their papers to people beyond the students’ classmates and engage in meaningful dialogue.

#### Research Tips:

You can quickly find peer-reviewed research using Google Scholar <http://scholar.google.com/>. Want to stay updated on a specific issue? Click on the “Alerts” tab to create an alert for a search topic.

You can also evaluate the credibility of a journal or publishing house by consulting one of the following:

- <http://scholarlyoa.com/2014/01/02/list-of-predatory-publishers-2014/>
- <http://scholarlyoa.com/2015/01/02/bealls-list-of-predatory-publishers-2015/>
- [http://www.researchgate.net/post/Where\\_can\\_I\\_find\\_journals\\_list\\_sorted\\_by\\_impact\\_factor\\_in\\_Thomson\\_Reuters\\_website](http://www.researchgate.net/post/Where_can_I_find_journals_list_sorted_by_impact_factor_in_Thomson_Reuters_website)



# Final Project Student Handout: Credibility Checklist

Every day we are presented with information. We must determine if the information is valid or biased. As you take in new information, use this checklist to help determine credibility.

Source / Website Link:

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Title of Article / Website:

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What can you learn from the web address (.com = company, .edu = academic institution, .gov = U.S. government agency, .mil = U.S. military site, .org = nonprofit)?

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Is there a bibliography included to reference the source(s) of the information?

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If so, are the sources credible?

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Are you able to identify an organization or person responsible for the information?

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What is the track record of the organization sharing the information?

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By what authority are they making claims? Is it research based?

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## Final Project Student Handout: Credibility Checklist (Continued)

Is the information shared factual or opinion?

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How long has the organization been in existence?

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What is the organization's purpose?

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Who funds the organization?

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When was the site last updated?

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Does the site have working links to external web pages?

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Is there contact information to follow up with the organization?

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### Evaluation Rubric:

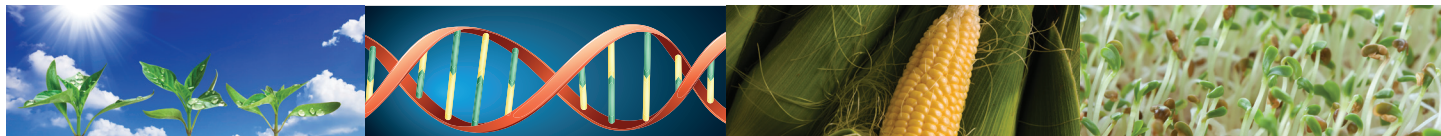
<b>Grading Rubric – For Teacher</b>
Credibility checklist is thoroughly completed for the selected site.
Score _____ / _____

# Final Project: Student Rubric

Names: \_\_\_\_\_ Date: \_\_\_\_\_ Class Period: \_\_\_\_\_

Total Score: \_\_\_\_\_ / \_\_\_\_\_

	Advanced	Proficient	Novice
Description of "GMOs" and biotechnology	Distinction is made between different processes of genetic modification. Biotechnology is clearly explained including the history and evolution of the science.	Genetic modification is explained at a high level without comparison of processes.	Genetic modification and biotechnology are not explained.
Facts are included and referenced from reliable sources.	Ten or more facts are included with citations listed from reliable sources.	Five to nine facts are included with citations listed from reliable sources.	Facts are omitted and/or a majority of sites are not reliable.
Opinion is expressed on the topic of "GMO" labeling.	The student expresses his/her opinion without passing opinion as fact. The opinion is supported by fact.	The student suggests an opinion but may not clearly make a case for this opinion.	The student does not clearly express his/her opinion.
Grammar, punctuation, and fluidity	The student writes with fluid tone, correct grammar, and punctuation.	Minor grammar or punctuation errors exist in the paper.	There are significant grammar and/or punctuation errors in the paper.
Presentation	The student confidently presents his/her paper, including fact and opinion.	The student presents portions of his/her paper.	The student does not present his/her paper to the selected audience.



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