

Find *your* Future in Agriculture

### **AgExplorer and Syngenta Virtual Field Trip** **Educator Guide**

**Watch the Virtual Field Trip:** This activity accompanies the Technology in Agriculture: Feeding the Growing Globe virtual field trip and design to be completed while or immediately after watching the show. [Check it out here.](#)

#### **Overview:**

The AgExplorer and Syngenta Virtual Field Trip introduces students to different strategies to meet the world's food requirements while also focusing on sustainability. The VFT experience provides students with an overview of the challenges facing food production as the world population continues to grow. Students then meet different professionals working to solve this challenge by combining biology, chemistry, mathematics, agricultural science, and marketing in a variety of careers. By the end of the field trip, students will be able to see how many different careers, combined with innovative technology, can make major contributions to food production while also producing less pollution and minimizing environmental degradation.

This Virtual Field Trip will highlight a variety of skills, competencies, and careers necessary to the agriculture and food industries. These companion activities help engage students prior to and during the Virtual Field Trip, and extend the learning from the Virtual Field Trip to the classroom.

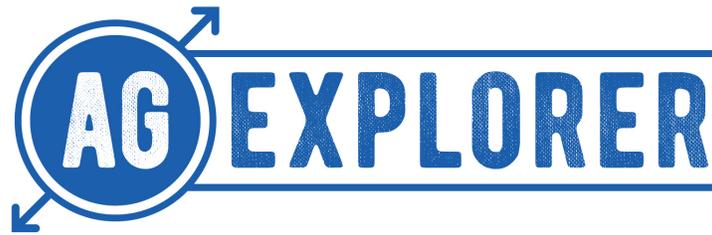
#### **Objectives:**

Students will be able to

- describe the challenges of an increasing world population on natural resources.
- identify the differences between conventional breeding and biotechnology.
- explain how innovations, such as biotechnology and the Syngenta RTP Advanced Crop Lab, help scientists from different careers solve the challenge of an increasing world population in need of food.

#### **Materials**

- ✓ Applying Your Knowledge and Skills to Careers in Agriculture capture sheet
- ✓ AgExplorer and Syngenta Virtual Field Trip capture sheet
- ✓ AgExplorer and Syngenta Virtual Field Trip teacher resource
- ✓ A computer with access to the internet



Find *your* Future in Agriculture

- ✓ A projector and screen

**Engage**

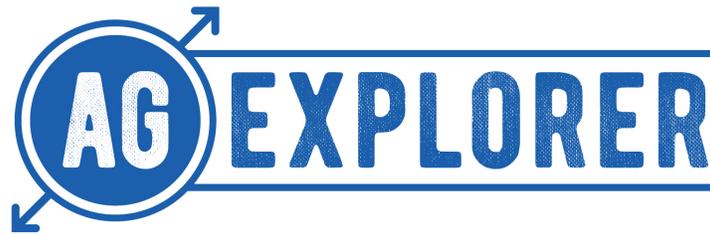
1. Begin class by handing each student a copy of the **AgExplorer and Syngenta Virtual Field Trip** capture sheet.
2. Project the world population clock on the board. A world population clock can be found at <http://www.worldometers.info/world-population/>.
3. Students will then share their observations of the birth and death rates from the world population clock. Then, with elbow partners, students will brainstorm and record challenges that increasing world populations may pose for their communities on their **AgExplorer and Syngenta Virtual Field Trip** capture sheet.
4. Circulating around the room to each group, have each pair share out one challenge from their worksheet. Write a list of the challenges on the board as the students share.
5. Students will then read the goal of the AgExplorer and Syngenta Virtual Field Trip from their worksheet and complete the OWL chart.

Anticipated responses:

<p><b>What I OBSERVED</b> <i>What did you learn in the engage activity?</i></p>	<p><b>What I WONDER</b> <i>What question do you hope to answer at the end of the virtual field trip?</i></p>	<p><b>What I need to LEARN</b> <i>What topics will you need to learn about during the virtual field trip?</i></p>
<p><i>The world population is increasing, which will require more resources.</i></p>	<p><i>How can we use technology to meet the food resource demands of a growing world population?</i></p> <p><i>How can we use innovation to create crops that maximize outputs and protect the environment?</i></p>	<p><i>Genetics in plants</i></p> <p><i>Plant requirements</i></p> <p><i>Careers in agriculture</i></p>

**During the Virtual Field Trip**

1. Distribute **Applying Your Knowledge and Skills to Careers in Agriculture** capture sheet to students.
2. Guide students to brainstorm their personal talents and interests and write them on the capture sheet. Then, direct students to watch the AgExplorer and Syngenta Virtual Field



Find *your* Future in Agriculture

Trip. While they watch, they should look to match some of their talents and interests with the careers featured. Students will also begin to construct definitions of conventional breeding and biotechnology.

### **After the Virtual Field Trip**

1. Students learned during the Virtual Field Trip about how both Conventional Breeding and Biotechnology are used to improve crop yields. Students will now distinguish between the two technologies by labeling each example on their capture sheet either conventional breeding or biotechnology. You may choose to discuss answers to the questions in order to ensure student understanding.
2. Students will then analyze the *Methods of Plant Breeding* diagram on their capture sheet to determine the advantages of using biotechnology over conventional breeding.
3. Students or the teacher will now choose one of the activities below to learn more about how biotechnology can help us face the challenges of a growing world population. Activity #1 will further student understanding of the recombinant DNA process and activity #2 will engage students in the innovation happening at the Advanced Crop Lab. Both activities include a teacher resource that includes anticipated responses from students.

### **Activity #1**

1. Students will review important biotechnology vocabulary prior to analyzing a diagram illustrating the genetic engineering process.
2. Students will then use the biotechnology vocabulary to review their learning from the genetic engineering diagram by answering follow-up questions.

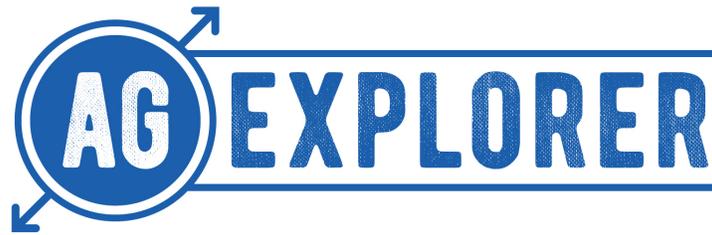
### **Activity #2**

1. Students will watch the introductory video of the [Advanced Crop Lab at the Syngenta RTP Innovation Center](#).
2. Students will review the information in the video by answering the questions on the capture sheet.

### **National Standards**

Next Generation Science Standards

HS-LS2-7. Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.



Find *your* Future in Agriculture

HS-LS3-1. Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring.

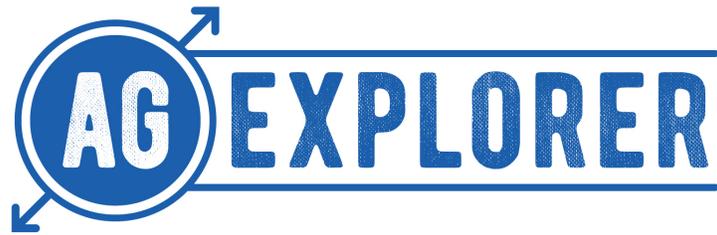
**AgExplorer and Syngenta Virtual Field Trip**  
**Capture Sheet**

**Engage: Prior to the Virtual Field Trip**

1. What do you notice about the birth and death rates on the world population clock?
  
2. Brainstorm some challenges that increasing world populations may pose for our communities.
  
3. Goal of AgExplorer and Syngenta Virtual Field Trip:
  - *Meet different professionals during the AgExplorer and Syngenta Virtual Field Trip who are working to solve some of the challenges you just brainstormed.*
  - *Examine how skills and knowledge from biology, chemistry, mathematics, agricultural science, and marketing work together to help to solve these challenges.*
  - *Explore different strategies to meet the world's food requirements, such as breeding more efficient crops, matching seed varieties with specific climates, and utilizing beneficial genes from native crops.*
  - *Explain how many different careers, combined with innovative technology, can make major contributions to food production.*

**Using the information above, complete the OWL chart below.**

<b>What I OBSERVED</b> <i>What did you learn in the engage activity?</i>	<b>What I WONDER</b> <i>What question do you hope to answer at the end of the virtual field trip?</i>	<b>What I need to LEARN</b> <i>What topics will you need to learn about during the virtual field trip?</i>
---	--	---



Find *your* Future in Agriculture

--	--	--

**During the Virtual Field Trip**

**Applying Your Knowledge and Skills to Careers in Agriculture**

Many careers in agriculture involve working with food science and technology. The demands of a growing population are resulting in strong job opportunities in this area. Your interests, abilities, and goals all influence your career choices.

What are your talents and skills? List at least five.

---



---

What are interests or hobbies you enjoy? List at least five.

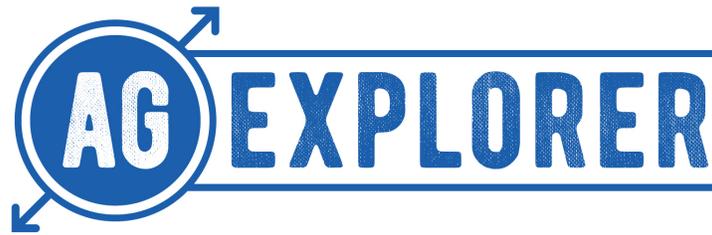
---



---

While watching the AgExplorer and Syngenta Virtual Field Trip, match some of your talents and interests related to each career highlighted.

	Computational Biologist	Biochemist	Entomologist	Agronomist	Marketing Technologist Manager	List the two careers that best match to your talents and/or interests
List two skills the professional highlighted as						



Find *your* Future in Agriculture

being critical to their work.						
List two talents or interests that <b>you</b> have <b>related</b> to this job.						

As you meet these different professionals, you will be introduced to two different vocabulary words. See if you can define them below as you watch.

Conventional Breeding	
Biotechnology	

**After the Virtual Field Trip**

You learned during the Virtual Field Trip about how both Conventional Breeding and Biotechnology are used to improve crop yields. *Can you distinguish between the two techniques?*

*Label each example below either conventional breeding or biotechnology.*

Type of Technique	Example
	Mathematicians builds an algorithm to find desirable genes in order to select the best variety of corn for a specific climate.
	Agronomists recommend the Sunningdale™, a variety of hybrid barley bred for specific traits, for Scotland as it will best perform in that climate.
	Geneticists transfer a piece of DNA with a beneficial trait from a native plant to an agricultural variety.
	Biologists perform test trials for a corn variety that includes an insecticidal trait, the Agrisure Viptera™ gene, which offers resistance to certain corn pests.

Biotechnology includes innovations that use biological processes or organisms to create products. Genetic Engineering is a form of biotechnology where the genes of an organism are altered. *List a biotechnology product you learned about in the Virtual Field Trip.*

But, what are the advantages of using biotechnology over conventional breeding? *Analyze the diagram below and then complete the question boxes.*

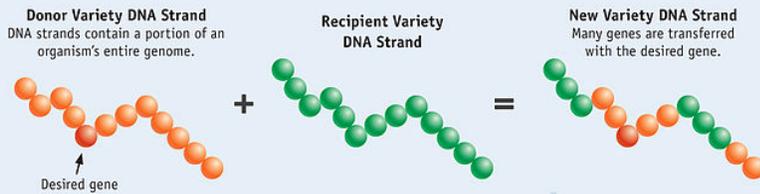
# AG EXPLORER

Find *your* Future in Agriculture

## Methods of Plant Breeding

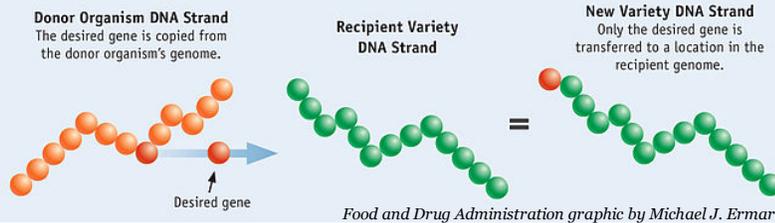
### Traditional

The traditional plant breeding process introduces a number of genes into the plant. These genes may include the gene responsible for the desired characteristic, as well as genes responsible for unwanted characteristics.



### Genetic Engineering

Genetic engineering enables the introduction into the plant of the specific gene or genes responsible for the characteristic(s) of interest. By narrowing the introduction to one or a few identified genes, scientists can introduce the desired characteristic without also introducing genes responsible for unwanted characteristics.



*Describe the process for conventional (traditional) breeding using the picture on the left:*

*Describe the process for Genetic Engineering using the picture on the left:*

*Evaluate genetic engineering using the information above.  
What advantages does this technology have as a strategy to improve crop yields?*

### Activity #1

Biotechnology is often used to genetically engineer or modify plants to create recombinant DNA. The diagram in the previous section showed a simple model of this process. Biotechnology uses a lot of vocabulary though that can be confusing. *Read the definitions below before analyzing the diagram depicting the process of genetic engineering.*

#### Vocabulary Review

<b>Biotechnology</b>	A range of technologies that use biological processes or organisms to create a product.
<b>Genetic Engineering or Genetically modified</b>	A process that includes the direct manipulation of an organism's genome through Biotechnology. Genetically modified organisms (like crops), or GMOs, are plants whose DNA is altered by humans to produce a desired trait. This includes using DNA from one species that is inserted into another.
<b>Gene editing</b>	Changing an organism's DNA by inserting, deleting or changing genes.
<b>Recombinant DNA</b>	DNA comprised of genes from different organisms.

# AG EXPLORER

Find *your* Future in Agriculture

As you analyze the diagram below, write a description of what happens during each step of the genetic engineering process.

**Step #1 Description:**

**Step #2 Description:**

**Step #3 Description:**

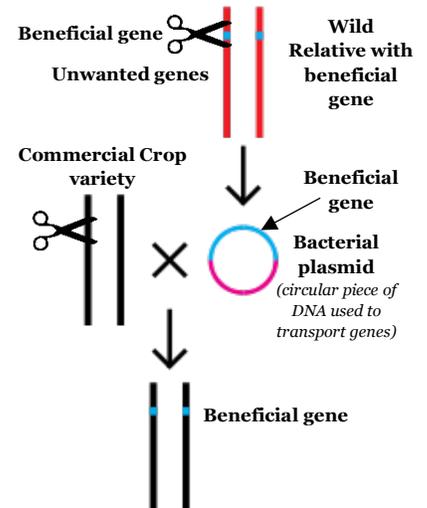
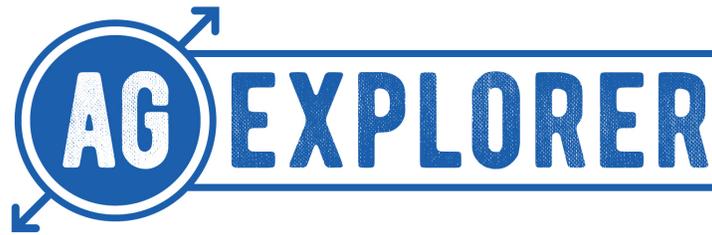


Diagram by Smartse [GFDL (<http://www.gnu.org/copyleft/fdl.html>)] with modification.

Answer the questions below using both the provided definitions, as well as the diagram above.

- The diagram above shows the process of \_\_\_\_\_.
- The DNA created in step 3 is called \_\_\_\_\_, because \_\_\_\_\_.
- Steps 1 through 3 show gene editing, because \_\_\_\_\_.
- This is an example of biotechnology. What is an example of a beneficial gene that may have been inserted into this commercial crop variety? What product would be created? \_\_\_\_\_



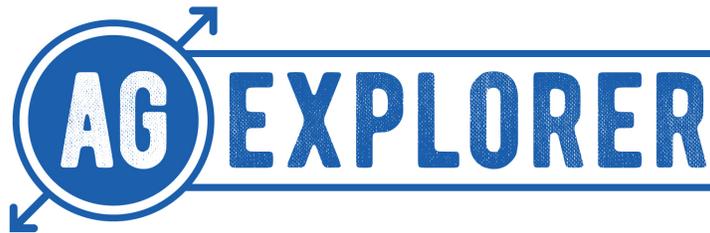
Find *your* Future in Agriculture

### **Activity #2**

Innovative techniques, such as gene editing and native trait breeding, can greatly improve crop efficiency. Whether scientists are using conventional breeding or biotechnology, they need to know if their products are successful. How do companies like Syngenta test these new varieties for effectiveness? Advanced solutions require a state-of-the-art testing facility- the Advanced Crop Lab.

Watch the introductory video of the *Advanced Crop Lab at the Syngenta RTP Innovation Center*.

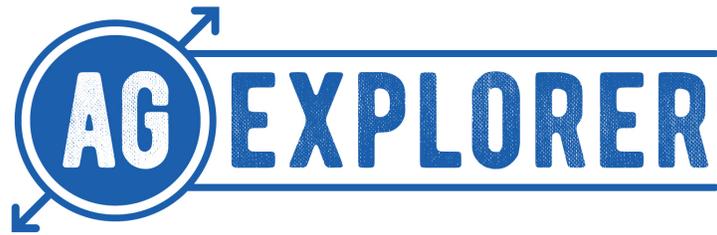
1. What are some variables the lab controls?
2. How does this control allow Syngenta to test new crop varieties?
3. Why is accurately controlling different variables important when evaluating a new crop variety in a scientific study?
4. Pretend you are a scientist at the Advanced Crop Lab. What conditions would you need to set up in a growth room to test new crop varieties for your area?
5. Explain how replicating the growing conditions in your area would help local farmers increase crop yield.
6. During the Virtual Field Trip, you met many different professionals combining biology, chemistry, mathematics, agricultural science, and marketing in a variety of careers. Imagine that you work at the Advanced Crop Lab. Choose one career and consider what role you would play at the Advanced Crop Lab. How can this state of the art facility help you meet the



Find *your* Future in Agriculture

challenge of a growing world population? Fill out the Twitter profile below for your career. After you complete your Twitter profile, you will share it with 3 other students who chose a different career.

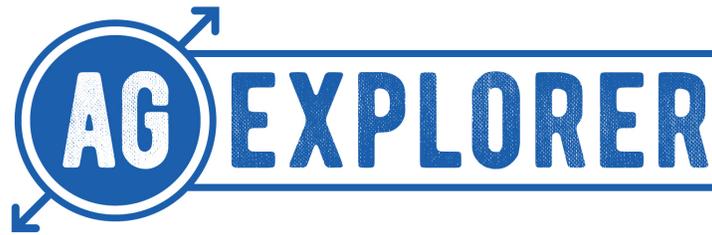
<b>Name:</b> _____	
<b>Career:</b> _____	
<b>Twitter handle/username:</b> @ _____	
<b>Twitter Bio:</b> _____ _____ _____	
<b>Hashtag that summarizes your career:</b> # _____	
<b>Role at the Advanced Crop Lab:</b> _____ _____ _____ _____ _____	 Find <i>your</i> Future in Agriculture



Find *your* Future in Agriculture

7. Create a drawing that communicates a world without genetic engineering in plants. Consider the quantity of crops and global impact as you visually express your thinking and ideas.

A large, empty rectangular box with a thin black border, intended for a student to draw their response to the prompt.



Find *your* Future in Agriculture

**After the Virtual Field Trip TEACHER RESOURCE**

You learned during the Virtual Field Trip about how both Conventional Breeding and Biotechnology are used to improve crop yields. *Can you distinguish between the two techniques?*

*Label each example below either conventional breeding or biotechnology.*

Type of Technique	Example
<i>Conventional breeding</i>	Mathematicians build an algorithm to find desirable genes in order to select the best variety of corn for a specific climate.
<i>Conventional breeding</i>	Agronomists recommend the Sunningdale™, a variety of hybrid barley bred for specific traits, for Scotland as it will best perform in that climate.
<i>Biotechnology</i>	Geneticists transfer a piece of DNA with a beneficial trait from a native plant to an agricultural variety.
<i>Biotechnology</i>	Biologists perform test trials for a corn variety that includes an insecticidal trait, the Agrisure Viptera™ gene, which offers resistance to certain corn pests.

Biotechnology includes innovations that use biological processes or organisms to create products. Genetic Engineering is a form of biotechnology where the genes of an organism are altered. *List a biotechnology product you learned about in the Virtual Field Trip.*

- *Golden rice with beta carotene*

But, what are the advantages of using biotechnology over conventional breeding? *Analyze the diagram below and then complete the question boxes.*

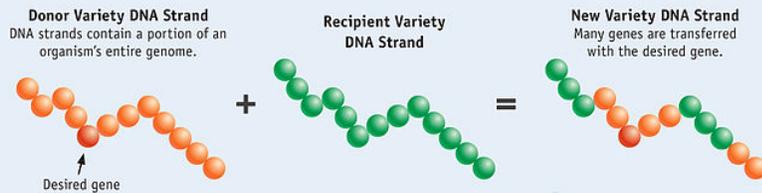
# AG EXPLORER

Find *your* Future in Agriculture

## Methods of Plant Breeding

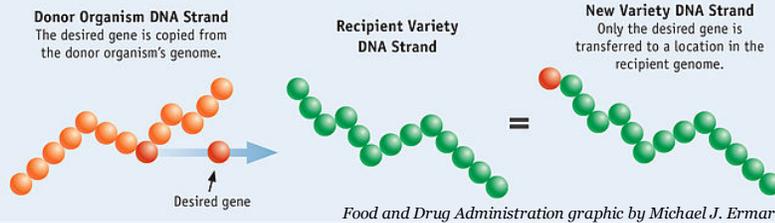
### Traditional

The traditional plant breeding process introduces a number of genes into the plant. These genes may include the gene responsible for the desired characteristic, as well as genes responsible for unwanted characteristics.



### Genetic Engineering

Genetic engineering enables the introduction into the plant of the specific gene or genes responsible for the characteristic(s) of interest. By narrowing the introduction to one or a few identified genes, scientists can introduce the desired characteristic without also introducing genes responsible for unwanted characteristics.



Food and Drug Administration graphic by Michael J. Ermarth

Describe the process for conventional breeding using the picture on the right:

Two plants are bred together to create an offspring that contains a mix of both parent plant genes, including both desired and undesired genes.

Describe the process for Genetic Engineering using the picture on the right:

A desired gene is inserted into another plant's DNA to create an offspring with only the desired gene.

Evaluate genetic engineering using the information above.

What advantages does this technology have as a strategy to improve crop yields?

Genetic engineering saves both time and money. Instead of breeding plants conventionally over many generations to produce offspring that express the desired trait (and other traits), genetic engineering can produce offspring with only the desired trait in one generation.

### Activity #1 TEACHER RESOURCE

Biotechnology is often used to genetically engineer or modify plants to create recombinant DNA. The diagram in the previous section showed a simple model of this process. Biotechnology uses a lot of vocabulary though that can be confusing. *Read the definitions below before analyzing the diagram depicting the process of genetic engineering.*

#### Vocabulary Review

<b>Biotechnology</b>	A range of technologies that use biological processes or organisms to create a product.
<b>Genetic Engineering or Genetically modified</b>	A process that includes the direct manipulation of an organism's genome through Biotechnology. Genetically modified organisms (like crops), or GMOs, are plants whose DNA is altered by humans to produce a desired trait. This includes using DNA from one species that is inserted into another.
<b>Gene editing</b>	Changing an organism's DNA by inserting, deleting or changing genes.
<b>Recombinant DNA</b>	DNA comprised of genes from different organisms.

# AG EXPLORER

Find *your* Future in Agriculture

As you analyze the diagram below, write a description of what happens during each step of the genetic engineering process.

**Step #1 Description:** The beneficial gene is cut from the wild relative.

**Step #2 Description:** The beneficial gene is inserted into a bacteria plasmid, which transports the gene to the commercial crop DNA. The commercial crop DNA is cut to insert the new gene.

**Step #3 Description:** The commercial crop now contains the beneficial gene and will express the beneficial trait!

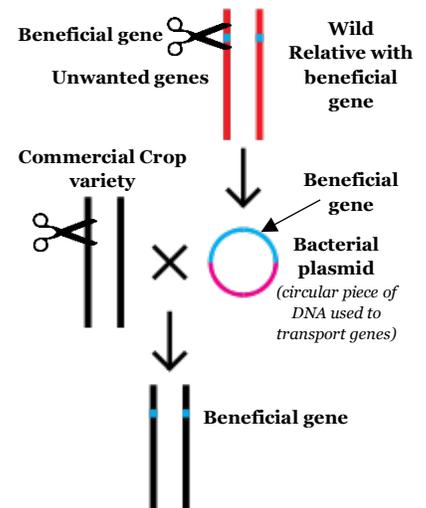
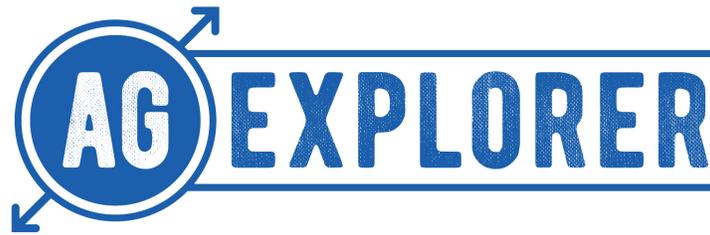


Diagram by Smartse [GFDL (<http://www.gnu.org/copyleft/fdl.html>)] with modification.

Answer the questions below using both the provided definitions, as well as the diagram above.

1. The diagram above shows the process of *Genetics Engineering*.
2. The DNA created in step 3 is called *recombinant DNA* because *the commercial crop now contains DNA from a different organism- the wild relative*.
3. Steps 1 through 3 show gene editing, because *the commercial crop's DNA has been changed with the insertion of the wild relative gene*.
4. This is an example of biotechnology. What is an example of a beneficial gene that may have been inserted into this commercial crop variety? What product would be created? *The scientist may have inserted a gene for resistance to a specific fungus that kills the commercial crop. The product is now a commercial crop that is resistant to the fungus, which would be a beneficial product for farmers.*



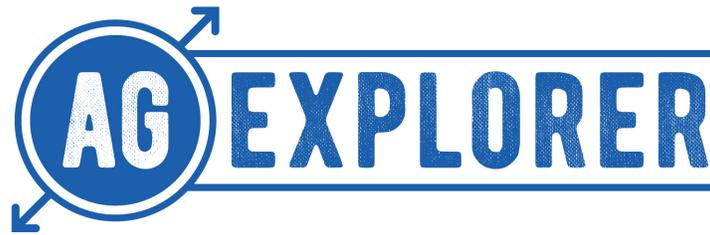
Find *your* Future in Agriculture

**Activity #2 TEACHER RESOURCE**

Innovative techniques, such as gene editing and native trait breeding, can greatly improve crop efficiency. Whether scientists are using conventional breeding or biotechnology, they need to know if their products are successful. How do companies like Syngenta test these new varieties for effectiveness? Advanced solutions require a state-of-the-art testing facility- the Advanced Crop Lab.

Watch the introductory video of the *Advanced Crop Lab at the Syngenta RTP Innovation Center*.

1. What are some variables the lab controls? *Amount of sunlight, temperature, plant food/irrigation and*
2. How does this control allow Syngenta to test new crop varieties? *Since scientists can control so many variables, they can create different environments, which mimic real world locations, to test the success of new varieties of crops.*
3. Why is accurately controlling different variables important when evaluating a new crop variety in a scientific study? *One of the most important parts of a scientific study is controlling all variables, except the one being tested by the scientist. The Advanced Crop Lab allows scientist to be sure that their conclusions are based on accurate data that is not influenced by uncontrolled variables.*
4. Pretend you are a scientist at the Advanced crop lab. What conditions would you need to set up in a growth room to test new crop varieties for your area? *I would want to set my growth room for an average rain of 43 inches per year with 72.5 days with precipitation. The average July temperature is 77°F with moderate humidity.*
5. Explain how replicating the growing conditions in your area would help local farmers increase crop yield. *I could test multiple varieties of a crop in my growth chamber. I could*



Find *your* Future in Agriculture

*then recommend the highest performer to local farmers. This would prevent them from wasting time or money planting different varieties to test their performance.*

6. During the Virtual Field Trip, you met many different professionals combining biology, chemistry, mathematics, agricultural science, and marketing in a variety of careers. Imagine that you work at the Advanced Crop Lab. Choose one career and consider what role you would play at the Advanced Crop Lab. How can this state of the art facility help you meet the challenge of a growing world population? Fill out the Twitter profile below for your career. After you complete your Twitter profile, you will share it with 3 other students who chose a different career.

**Name:** *Dr. Juan Ramos*

**Career:** *Biologist/genotyping*

**Twitter handle/username:** *@JollyGeneGiant*

**Twitter Bio:** *I grew up on a soybean and corn farm. I participated in AgExplorer and found crop science so interesting. I went on to graduate from University of Maryland with a doctorate degree in genetics and I now work at the Advanced Crop Lab.*

**Hashtag that summarizes your career:** *#ChangingDNAtochangelives*

**Role at the Advanced Crop Lab:** *I use genetic engineering to insert beneficial genes into commercial crops. I can then test my products by setting up different climates in the growth chambers at the Advanced Crop Lab. This enables me to match my genetically modified crop to specific climate. I then provide this information to our marketing teams to help farmers select the best crops for their farms.*



7. Create a drawing that communicates a world without genetic engineering in plants. Consider the quantity of crops and global impact as you visually express your thinking and ideas. *Students should illustrate and summarize that our crop yields would decrease. Our greenhouse emissions would increase because of the additional acreage needed to grow crops.*