



## MAKING THE PLANTS WE EAT

**Grade Levels:** Grades 4-5

**Duration:** Varies: 60 minutes to multiple class periods

### Next Generation Science Standards

- **3-LS3-1** Analyze and interpret data to provide evidence that plants and animals have traits inherited from parents and that variation of these traits exists in a group of similar organisms.
- **3-LS4-2** Use evidence to construct and explanation for how the variations in characteristics among individuals of the same species may provide advantages in surviving, finding mates, and reproducing.

### Learning Objectives/Outcomes

- Students will understand:
  - o Goals of conventional breeding and genetic modification in agriculture
  - o Limitations of plant breeding and genetic modification.
  - o Both plant breeding and genetic modification involve changing the plants DNA.
- Students will be able to:
  - o Identify different types of agricultural traits that are desirable for food production and/or consumption
  - o Identify similarities and differences between non-domesticated and domesticated varieties of plants
  - o Interpret graphs to make meaningful conclusions

### DESCRIPTION

Students learn about why farmers/plant scientists would want to improve traits, with students brainstorming the different types of traits that may be desirable for food producers and consumers (e.g. increased fruit size, enhanced taste, efficient production). Students engage in activities related plant domestication (plant breeding), and plant genetic modification. The goal is for students to learn that all of these both of these methods include similar goals – developing safe and nutritious food more efficiently for a growing population, and are currently being used to improve the plants we grow for food. The lesson culminates with students using what they learned to develop a new type of food crop.

### TEACHER BACKGROUND

**DNA** is a self-replicating material present within chromosomes of all living organisms. It is the basic building block of heredity and genetics. DNA is made up of nucleotides and specific sequences of nucleotides comprise a **gene** – the unit of heredity. Specific genes are associated with traits, such as eye color, height, hair color, etc. Traits are sometimes influenced by one gene or can be tied to multiple specific genes that control how the trait is exhibited.

For thousands of years, humans have been domesticating plants to exhibit desired traits through breeding. Traits that simplify production and cultivation were especially desirable. Subsequently, domestication was often focused on improving physical characteristics of the plant (aka “**phenotype**”). Domesticating plants allowed for humans to establish permanent civilizations around their farming areas, instead of hunting and gathering food. This was an important societal transition that allowed individuals to focus more energy into agriculture to feed growing populations in their civilizations and develop more sophisticated farming tools. Additionally, the crops that were originally selected by these early farmers set the stage for the crops that make our modern food supply (e.g. corn/maize, wheat, and rice).

Here is a list of traits that were prioritized during **domestication** breeding efforts (approx. 5,000 –10,000 years ago):

- grew **straighter** and **taller** (as opposed to bush-like structure) to increase productivity by
- increasing the number of plants on a specific land area and simplify harvesting because
- branches/stalks are clearly defined
- had **seeds without shells** (known as “non-shattering seeds”) to make it easier to collect and
- reuse seed from crops
- Had **increased fiber content** (such as cotton plants) to increase fiber availability for cloths and other goods
- **Bigger fruit** to increase calorie availability for human populations

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## Guiding Question

What are the goals of plant breeding and genetically modifying plants to exhibit desired traits?



Agricultural advancements have continued since this time. In the 1950s-60s, there was another large period of agricultural innovation known as the **Green Revolution**. During the early 1900s, agricultural operations were becoming larger and more complex. Industrialization also increased the amount of chemicals that were available within the marketplace, including those for farming. Subsequently, there was a significant increase in the use of chemicals (fertilizers, pesticides, herbicides) to improve productivity on farms. This sparked concern about environmental and human health, prompting scientists and plant breeders to investigate ways to improve plant productivity without requiring extensive use of these types of chemicals. Primarily, these breeding efforts were focused on developing:

- **high yielding varieties** of crops that could produce a greater yield during a single growing season
- varieties with **shorter, stiffer stalks** to support the weight of increased grain production (e.g. rice, wheat) without the plant breaking
- varieties that were **drought resistant** and **herbicide resistant** to simplify production processes.

The advent of biotechnology and the ability to genetically modify plants has expanded the types of traits that can be established. These methods allow scientists to investigate a plant's genetics and edit its' DNA so the plant exhibits a specific trait. Now, scientists are able to establish traits that were not previously available by using DNA/gene sequences from other species. Instead of breeding a trait into a variety over the course of multiple generations, scientists can insert the DNA into the variety to establish the trait. This expedites the process. Although many of the desired traits are focused on improving production and harvesting, scientists have also used genetic modification to develop varieties with benefits for consumers. Some of the primary traits that have come from these advancements include:

- **Herbicide tolerance** varieties (e.g. "Round Up Ready Soybean") that are resistant to specific types of herbicide, simplifying farmer's weed management efforts.
- **Insect and pest resistance** (e.g. Rainbow Papaya – resistant to Ringspot Virus, Bt corn – resistant to a variety of pests) to reduce crop loss from pests and pathogens, which greatly affects productivity and farm profitability.
- **Non-browning** varieties (e.g. Arctic Apple, Innate Potato) that do not brown when cut, reducing food waste, and increasing consumer satisfaction.
- **Increased nutritional content** (e.g. Golden Rice with significantly greater concentrations of beta carotene to facilitate Vitamin A production) to address malnutrition and nutritional deficiencies that greatly affect the developing world.
- **Increased sugar content** (e.g. sweet corn) to improve consumer satisfaction.

Currently, the majority of genetic modification has been focused on improving commodity crops (e.g. corn, soybean, canola, cotton) to impact large-scale production of these crops. **Moving forward**, scientific advancements in genetics may allow scientists to increase resilience for crops, especially in the context of a **changing climate**. These types of applications could help us ensure that our crops are able to withstand the various climatic changes that are anticipated – helping ensure our food supply remains. The National Academies of Sciences expect that we will see genetically modified varieties of crops that express these types of traits in the future:

- Drought tolerance
- Water-use efficiency
- Nitrogen-use efficiency
- Nutrient uptake and use efficiency
- Carbon fixation
- Cold/heat tolerance
- Salt tolerance





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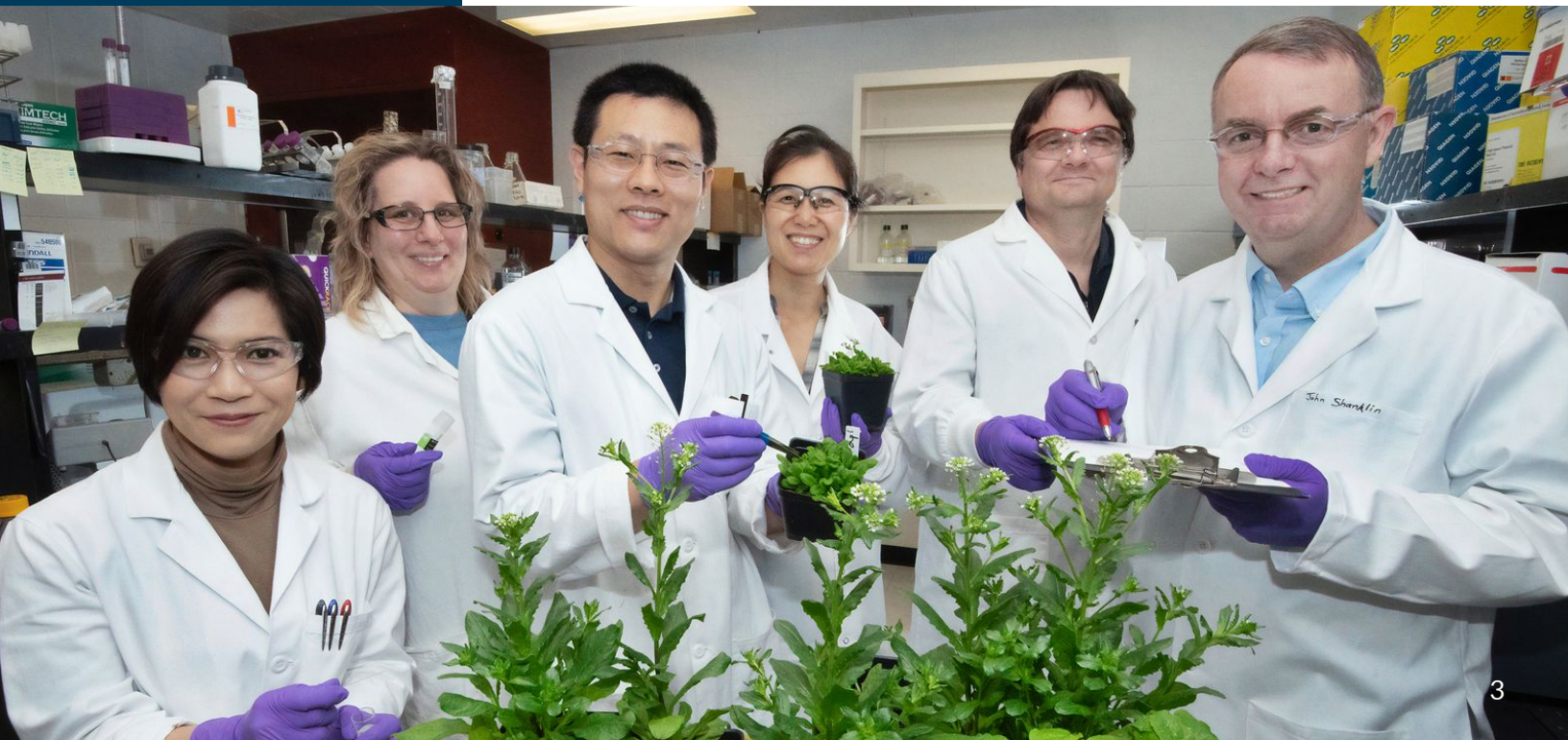
It is likely that these techniques will be used to improve other products, which might be more niche products that are grown at a smaller scale. For example:

- Reduced gluten content in wheat varieties
- Improved oil content/reduced fatty acid content in soybean oil
- Improved nutritional content

Ultimately, whether you are breeding or genetically modifying plants, the goal is to increase farm productivity and efficiency while growing safe and nutritious food for an increasing population. You can learn more about history of plant breeding and genetic modification using the “Eras of Plant Improvement” PowerPoint.

## ACTIVITY INTRODUCTION

- Class brainstorms different traits that are important for agriculture. Provide students with a few minutes to think on their own before sharing out with the group.
  - What do/don't you want as a consumer? What does your perfect apple look like?
  - What would/wouldn't you want as a farmer?
  - Why do the plants we eat look the way they do? Have they always looked the same?
- Write student responses on the board to use later when students develop a new food crop.
- Ask students to think about a banana. What does a banana look like? What does it taste like? Has it always looked and tasted this way?
  - Have students draw what they think a non-domesticated banana looked like. They will be able to compare that with a domestication flashcard in the next part of the lesson to see what it actually looked like.
  - Have students repeat this with corn or another plant from the domestication flashcards.
  - Give students an opportunity to share their drawings before moving on to the next part of the lesson.



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## Materials

- Domestication Activity Flashcards
- Genetic Modification Flashcards
- Making the plants we eat worksheet
- Developing a new food crop worksheet

## Activity Procedure

- Make sure students have access to “Making the plants we eat” worksheet.
- Students rotate through breakout activities. Students use the “Making the plants we eat” worksheet as they look at the flashcards at two stations:
  1. Domestication Activity Flashcards
  2. Genetic Modification Flashcards

*\*\*For distance learning provide each student the flashcards electronically so they can use them to answer the questions on the worksheet.*

- Students share out what they noticed at each of the stations.
  - o Teacher guides discussion toward the idea that domestication focused on phenotypic (physical) characteristics, and genetic modification focuses genotypes (the specific genetic sequence that leads to physical characteristics).
  - o Genetic modification is important in the context of improving complex agricultural systems and food availability, especially in the context of a changing climate.
  - o Both techniques are used today and growers are quick to adapt to a new plant that produces a higher yield.

*\*\*For distance learning this can be done over a video conferencing or during a hybrid in class session.*

- Have students return to the drawings they did of the non-domesticated banana and corn or other food crop in the activity introduction. With what they have learned from the lesson so far have them predict what these crops will look like in 100 years. What will it taste like? What new traits will it have?
- Have students share out before moving on to the next part of the lesson.

## Developing a New Food Crop

- Use the “Developing a new food crop worksheet” to have students use what they have learned to develop a new, realistic, food crop.
  - o Make sure that students only modify a single trait. This makes completing the rest of the worksheet more straightforward.
  - o Have students share their new food crops, emphasizing reasoning on why they choose their modification.

*\*\*For distance learning this can be done over a video conferencing or during a hybrid in class session.*

## Further Discussion

- What are some things you noticed about the different crops?
- Why would farmers and consumers want different types of traits in their food products?
- Would we be able to grow as much food without crop modification? Why or why not?



## ---Resources-----

- International Food Policy Research Institute. 2002. Green Revolution: Curse or Blessing? Link: <https://oregonstate.edu/instruct/css/330/three/Green.pdf>
- Current GMO Crops. GMO Answers. Link: <https://gmoanswers.com/current-gmo-crops>
- Genetically Engineered Crop: Experiences and Prospects. Chapter 8: Future Genetically Engineered Crops. Link: <https://www.nap.edu/read/23395/chapter/11>