Plant Breeding in Specialty Crops

Two 50-minute class periods.

Grades 9-12

Purpose

This lesson introduces students to artificial selection and plant breeding methods. Students will discover more about the methods used to develop popular fruits and vegetables and how they differ from wild varieties. Students will also explore various new plant breeding methods.

Academic Content Standards

MN K-12 Academic Standards and Benchmarks

Science

9.4.3.3.3 Recognize that artificial selection has led to offspring through successive generations that can be very different in appearance and behavior from their distant ancestors.

9.4.4.1.1 Describe the social, economic, and ecological risks and benefits of biotechnology in agriculture and medicine.

National Agricultural Literacy Outcomes

Science, Technology, Engineering, and Mathematics

- Evaluate the benefits and concerns related to the application of technology to agricultural systems. **(T4.9-12 d.)**
- Identify current and emerging scientific discoveries and technologies and their use in agriculture. **(T4.9-12 e.)**

Background—Agricultural Connections

Traditional plant breeding has been used since humans began domesticating plants for food production. Early crop domestication was accomplished by using basic plant selection techniques to identify and promote ideal food plants. This is known as **selective breeding**. **Crossbreeding**, **inbreeding**, and **hybridization** are specific plant breeding methods that fall under the umbrella of selective breeding. These methods have allowed farmers to isolate genes for specific characteristics and progressively create more plants well suited to

Grade Level 9-12

provide an abundant supply of nutritious food (e.g., fruits, vegetables and grains). For example, tomatoes come in many varieties, including large slicing tomatoes and smaller roma, cherry, and grape tomatoes. Tomatoes also come in a variety of colors, including bright red, orange, yellow, and even a dark burgundy color. In addition to color and size, these plants also vary in taste, shelf life, and the amount of time they take to grow from seed to fruit. All of these characteristics were brought about by selective breeding; identifying desirable traits and continually cross-pollinating plants with those traits to eventually create a variety with desirable characteristics. Often in traditional plant breeding processes plants will gain either a resistance or a propensity toward disease. All of these characteristics vary from variety to variety due to the plants changing genetics from generation to generation. While these traditional plant breeding methods have been successful, they can take a significant amount of time (years or decades) to achieve the desired result, and it can be difficult to isolate individual traits such as disease or pest tolerance, color, flavor, or any number of other traits. In addition, the desired gene or characteristic must already be available in the plant's gene pool.

This lesson identifies how common, domesticated crop plants have changed from their wild relatives and also investigates common selective breeding and variety development methods. Finally, students are asked to look closely at new plant breeding technology.

For more background information, links are available at

https://minnesota.agclassroom.org/educator/sclb.cfm

Interest Approach - Engagement

Take a look at The Fruit Hydrids Google Slides presentation accessible at https://minnesota.agclassroom.org/educator/sclb.cfm. The fruit hybrids included in this presentation may or may not be real. Have students guess which ones are real and which ones are fake. Explain that while some of these examples do not exist, many of the fruits and vegetables we enjoy are different from the original and that today's lesson will take a closer look at plant breeding techniques of fruits and vegetables we enjoy today.

Materials

Interest Approach:

- Fruit Hybrid Slides available at https://minnesota.agclassroom.org/educator/sclb.cfm

Activity 1:

- Food Crop and Wild Relative Cards available to print at: https://minnesota.agclassroom.org/educator/sclb.cfm

Activity 2:

- Plant Breeding Matters: the Best Job video available at: https://minnesota.agclassroom.org/educator/sclb.cfm

Activity 3:

- Plant Breeding Technologies student direction sheet available at: https://minnesota.agclassroom.org/educator/sclb.cfm
- Poster paper,Google Slides,Canva or Pictograph
- Student devices (ipads, tablets, laptop computers, etc.) for research

Review:

- Kahoot review game can be created at kahoot.com
- Student devices

Procedures:

Activity 1

Food Plants and Their Wild Relatives

1. Print out the Food Crops and Wild Relative Image Cards. Provide students with these images of common crop and food plants as well as their wild relatives. Ask students to try to match the crop plant with its wild relative.

Vocabulary

Crossing – uses pollen from one plant to pollinate a different plant

Clonally propagated – plant varieties are propagated or reproduced by methods other than seed. Grafting and taking cuttings are examples of clonal propagation techniques. The new plants are genetically identical to their parents.

Hybrid – cross between two different things. A hybrid car uses half, gas and half electric. A hybrid plant results from a cross between two different parents. It has two different alleles at its loci, one from each parent.

Inbred – plant varieties are commonly called lines. Inbred or line varieties are self-pollinated. This means the pollen from the male part of the plant pollinates the female part of the same plant.

Natural selection – the mechanism by which evolution operates - individuals who are best adapted to their environment will have a better chance to pass on their genes to their offspring

Open pollinated – varieties of crops that are cross-pollinated. This means that pollen travels from one plant to fertilize an egg in another plant. The resulting seeds and plants are genetically unique. Many heirloom varieties are open-pollinated.

Selective Breeding – the intentional crossing of two animals or two plants to produce offspring with a desired characteristic

2. After students have tried matching the plants with their wild relatives, provide the actual matches. Ask students to think and discuss the following:

   a. Are there similar characteristics you can see in the images of the plants and their wild relative?

   b. What are the major differences that you see between the plant and its wild relative?

   c. Why are these plants different? How did the wild relative change so it now is grown as the food crop we are familiar with?

3. Draw on students' prior knowledge of science and genetics. Use guided questions to lead them to recognize that methods of natural and artificial selection have been used to improve our food crops for centuries.

   a. **Natural Selection** – a process that occurs in nature and results in the most fit individuals (plants in this example) having the most offspring.

   b. **Artificial Selection** – selection process done by humans toward human goals. Artificial selection and human preference change plants in consistent ways. Fruits become larger. Flavors become sweeter. Grains and fruits remain on the plant longer. Plants flower and mature at the same time making harvests easier and more productive .

4. Inform students that the characteristics in the plants that we eat as well as plants that animals eat is driven by artificial selection in which humans make decisions about what kind of plants they want and/or need. Scientists called plant breeders are important to this plant process. Plant breeders select desirable traits or characteristics in the plant populations they work with and work to ensure the genetics code for these traits. This is known as **selective breeding**. These methods have allowed plant breeders to isolate genes for specific characteristics and progressively create more plants well suited to provide an abundant supply of nutritious food (e.g., fruits, vegetables and grains). Farmers are able to cultivate these plants to feed our growing population.

Activity 2

Developing and Growing Different Crop Varieties

1. Explain to students that there are several different methods used to breed and grow crops. The method that is used for a specific plant is determined by the structure of the plant and how it can easily reproduce. Provide the definitions below to students.

   a. **Open pollinated** varieties of crops that are cross-pollinated plants. This means that pollen travels from one plant to fertilize an egg in another plant. The resulting seeds are genetically unique. Many heirloom varieties are open-pollinated. (Examples: winter squash, pumpkins, radishes and carrots)

   b. **Inbred** plants are commonly called lines. Inbred or line varieties are self-pollinated. Which means the pollen from the male part of the plant pollinates the female part of the same plant..(Examples: soybeans, beans, peas and lettuce)

   c. **Clonally propagated** varieties are propagated or reproduced by methods other than seed. Grafting and taking cuttings are examples of clonal propagation techniques. The new plants are genetically identical to their parents. (Examples: potatoes, grapes, apples and bananas)

   d. **Hybrid** varieties are made by cross-pollinating two specific parent varieties. This first generation of offspring is referred to as the F1 hybrid. Although F1 hybrids often show increased yield and vigor, the plants will not breed true if its seeds are saved. (examples: field corn, sweet corn, summer squash, melons, cucumbers, carrots and some tomatoes)

2. Plant Breeders may use more than one technique above to achieve the desired traits, the examples listed traditionally used that method. We can think of the methods as a tool box. Today's plant breeders have many more tools (methods) to develop new varieties that may meet production needs (disease resistant, drought resistance) or consumer needs (increase nutrition, better flavor).

3. Plant breeding affects all of the food we enjoy in the US and around the globe. Watch the video Plant Breeding Matters: the Best Job available at https://minnesota.agclassroom.org/educator/sclb.cfm. Explain that this video was created by the British Society of Plant Breeders and that there are also countless plant breeders in the US.

Activity 3

New Plant Breeding Technology

1. Explain to students since the beginning of agriculture, humans have adapted plants to their needs. The previous activities today gave you a glimpse into the plant breeding methods that have been used for centuries. Plant breeding is constantly on the move and changing.

2. In groups, you will explore some of the most recent plant breeding technologies and create a poster/google slides/infographic to share with your classmates more details about plant breeding technology.

3. Assign students to each topic.

   - Genome Editing
   - Mutagenesis
   - Genetic Engineering

- Polyploidy
- Cross Breeding
- Marker Assisted Selection

Each plant breeding technology topic has a google folder with resources for students to use in learning more about their assigned technology. Folders an be accessed at https://minnesota.agclassroom.org/educator/sclb.cfm.

4. Provide each group with the Plant Breeding Technologies Student Direction Sheet available at https://minnesota.agclassroom.org/educator/sclb.cfm. Students will be asked to create a poster or Powerpoint or Infographic (using Piktochart or Canva- both of which offer free accounts).

5. Students will then present their research. Student research posters,powerpoints, or infographics should cover the following (also listed in student direction sheet):

   - Describe the process of your plant breeding technology
   - Give real world examples of food crops that utilize your plant breeding technology.
   - Explain the Pros/cons of the process
   - Why is this process used?
   - Other interesting facts about the technology (ex."Could this process be connected to the medical world?" or "Who developed the process and when?")
   - Diagram/Graphic/Illustration/Photo that helps explain the technology

6. Ask students for the review questions they created about their topic.

Activity 4

Review

Use Kahoot game to review basic concepts from the lesson and student presentations. Have students submit one or two questions about their topic.

Enriching Activities

1. Have students brainstorm about what type of fruit or vegetable improvements or hybrids students would like to be created next.(ie, kiwi flavored strawberries or coffee/blueberry hybrid that has caffeine, sweeter strawberries, etc)

2. Explore the AgCultures expedition lesson: All About Seeds at www.agcultures.com

3. Have students research issues regarding genetic diversity in bananas. Lead a discussion regarding possible solutions using the different breeding methods within this lesson. The articles below are linked at https://minnesota.agclassroom.org/educator/sclb.cfm

   a. Can this fruit be saved?

   b. With the familiar cavendish banana in danger, can science help it survive?

   c. Why bananas as we know them, may go extinct.