The Pueblo Farming Project

Lesson Five: The Short Blue Ear

Creating Colorful Corn and Seed Saving for Resilience

Format: One approximately 90 minute session
Grade: 6, 7, 8
This lesson can be taught to each middle school grade with increasing complexity and detail.
Season(s): Fall

Objectives:

- Understand the cultural and geographic origins of corn and seed saving techniques.
- Connect the practice of seed saving to plants' ability to adapt to drought and other extreme weather.

Key terms:

- nomadic
- breed
- cultivate
- genes
- indicator
- desirable traits
- maize
- seed saving
- photosynthesis
- seed endosperm
- starch and carbohydrates

Materials and Tools:

- ❏ Diagram of a corn kernel showing the endosperm: http://media.web.britannica.com/eb-media/54/166754-050-8DEB8E13.jpg
- ❏ Video: *Popped Secret: The Mysterious Origin of Corn* (18 mins): http://www.hhmi.org/biointeractive/popped-secret-mysterious-origin-corn
- ❏ "The Edible Schoolyard: K7-2 Teosinte to Corn Visual Aid": https://edibleschoolyard.org/sites/default/files/K7-2_Teosinte_Visual_Aid_0.pdf
- ❏ Examples of Hopi and other corn varieties, on the cob, to show diversity in size, color, endosperm texture
- ❏ Hand lens/microscope (one for each pair of students)
- ❏ Iodine & potassium iodide: these can be bought on Amazon or in many pharmacies.
- ❏ 1 bottle with a dropper to hold the solution of iodine and potassium iodide
- ❏ Pre-dissected kernels of Hopi corn, treated with iodine
- ❏ Pre-soaked corn kernels for dissection (enough for the total number of students)
- ❏ Whiteboard and markers
- ❏ Plastic knives (one for each pair of students / half of the total number of students)
- ❏ Paper plates (enough for the total number of students)
- ❏ 5–7 dried ears of corn with kernels attached (ideally a variety that is ancestral to to the region; find these by talking to farmers who grow native or ancestral corn varieties.)

- ❏ One corn cob with the kernels removed
- ❏ trays/large bowls to catch corn seed
- ❏ Two colanders OR two galvanized tubs to separate husk and cob material from corn seed
- ❏ Two paper bags
- ❏ Markers for labeling bags
- ❏ 1 electric skillet (and extension cord if necessary)
- ❏ Oil
- ❏ Popcorn kernels
- ❏ Salt
- ❏ Paper dixie cups (one for each student)
- ❏ Two specimens of the one variety of vegetable or fruit for tasting during Closing Circle; choose varieties with easily visible seeds that can be enjoyed raw.
- ❏ A kitchen knife for slicing these specimens into raw tastings.

Before you Begin:

- ❏ As the instructor, review and read the following resources to get an overview of the concepts that will be summarized and condensed in the lesson plan.
    - ❏ Article: Kuwanwisiwma, Leigh. (2005). The Hopi Way: Dry Farming. In *Thirst For Survival*, the Hopi Tribe, Kykotsmovi, Arizona. (Provided with this lesson plan as "Kuwanwisiwma2005_Thirst-for-Survival.pdf" for non-commercial purposes.): https://beyondthemesas.files.wordpress.com/2010/08/thirst-for-survival.pdf
    - ❏ Video: *More Than Planting a Seed* (26:56 minutes): https://www.youtube.com/watch?v=2x23FF_kUyo
    - ❏ Video: *Popped Secret: The Mysterious Origin of Corn* (18 mins): http://www.hhmi.org/biointeractive/popped-secret-mysterious-origin-corn
- ❏ **48 hours prior to dissection:** Soak kernels that students will use for dissection for 48 hours
- ❏ Watch the following instructional video (1:30 mins) on how to conduct a seed dissection of a pre-soaked corn kernel: https://www.youtube.com/watch?v=RA0T-jvldPw
- ❏ Dissect one kernel and treat with iodine to highlight the areas containing starch.
- ❏ Print the "The Edible Schoolyard: K7-2 Teosinte to Corn Visual Aid": https://edibleschoolyard.org/sites/default/files/K7-2_Teosinte_Visual_Aid_0.pdf
- ❏ Print the diagram of a corn kernel showing the endosperm
- ❏ OPTIONAL: Film Guide: *Popped Secret: The Mysterious Origin of Corn*: http://www.hhmi.org/biointeractive/film-guide-popped-secret-mysterious-origin-corn. This guide to the "Popped Secret" film could be used as the basis for a follow-up lesson plan. It supplies discussion questions based on specific sections of the film and a student quiz.

Opening Circle

Read the following bolded text aloud:

- ***Agriculture is an important part of culture.***
- ***The way that people organize themselves around their domesticated plants teaches us a lot about their culture's traditions and customs.***
- ***The Hopi culture, and its connection to the corn plant, is a good example of this.***
- ***Listen to this quote that describes the spiritual importance of corn to the Hopi culture:***

> ***"Since the emergence, Hopis refer to this life as the fourth way. As the Hopi moved from the third to the fourth way of life, they were offered corn by Ma'saw (the Guardian Spirit). The other peoples took the largest ears of corn and Hopis were left with the short blue ear. Each clan history explains how the Hopi received the short blue ear. The Hopis knew that their fourth way of life would be difficult and that they must submit to the corn as a way of life. The themes of humility, cooperation, respect, and universal earth stewardship became the way of life for all Hopis. In this way, the Hopi have always had corn and agriculture."***
>
> (Kuwanwisiwma 2005:16)

- ***The Hopi recognize many different varieties of corn. Most of these varieties were domesticated on Hopi land; a few were brought into the culture from outside of Hopi land.***

- ***The Hopi have saved seeds from their domesticated plants for centuries in order to develop corn varieties that have many different special characteristics and colors.***

- ***Understanding the process of seed saving begins with understanding how domesticated plants can be used for "breeding".***

Survey students' understanding and/or opinions by verbally sharing the following questions or text in italics. Briefly gather input from the students, while steering the discussion toward the answers listed below the question.

How did the Hopi people use domestication to create their beautifully colored corn varieties?

- Corn is a grain; when we eat it, we are eating the grains of a grass plant.
- About 9,000 years ago, people from a region near Mexico City began domesticating a wild grass plant called Teosinte.
- By planting it again and again in their garden spaces, they learned that they could **breed** the plants, which means encouraging plants with special qualities to mix their pollen, thereby sharing their genes with one another.
- The ancient people of Mexico bred teosinte plants until they had totally transformed them from a wild plant into a food crop. This process domesticated Teosinte and transformed it into corn.
- Domesticated corn arrived in the American Southwest region approximately 4,000 years ago.
- The Hopi continued breeding corn to create kernels of many colors, deepening the ways that corn holds and communicates Hopi culture/spirituality.

What change in human lifestyle led to the need to domesticate corn and other plants?

- About 10,000 years ago humans became less **nomadic** (moving their settlements seasonally) and became **settled** (living in one place for a long period of time).
- Soon after settling, humans saw that it would be no longer possible to only gather wild plants to eat from around their settlement.
- These wild food plants would soon be too heavily harvested and would not grow back quickly enough to provide food for the settlement.

- Humans began to collect seeds from their favorite wild plants, planting them near their settlements and manipulating them, through breeding, to better suit their needs.
- Domestication led to the beginning of agriculture and to the plants we now call crops.

What did corn look like when it was a wild grass called Teosinte? How did its appearance change once the ancient farmers began to breed it?

(Use the "Edible Schoolyard: Teosinte to Corn Visual Aid Card" as a teaching tool)

Teosinte:

- Rather than one long main stem, the plant was bushy with many branches and leaves.
- It had clusters of kernel-like seeds, but they were *not* organized onto a cob or surrounded by husk leaves.
- The teosinte kernels could drop off the plant onto the soil, allowing it to "self-seed".
- Over thousands of years, ancestral farmers saved the seed from the teosinte plants that produced something *like* an ear of corn but these ears were short and skinny and had very few kernels attached to the cob.

A Changing Appearance:

- Ancestral farmers collected seed from the teosinte plants that had: (a) shorter side branches and (b) a more distinct cob that had leaves, called husks and (c) husks that grew tight to the cob.
- Over time, some of these domesticated plants changed their appearance:
    - taller with a larger main stalk
    - fewer branches with several larger cobs attached
    - kernels became larger and grew in long rows along the cob
    - the cob became totally enclosed by husks
- Due to the husks, these plants could not drop their kernels to the ground to self-seed; they needed humans to harvest and plant the kernels. This means that wherever corn kernels or cobs are found, it is certain that the site was used by humans.

Maize / Corn:

- Seed saving showed the ancestral farmers how to manipulate the 5 genes that control all the traits that make teosinte different from corn. For example, they learned they could change the gene that made the kernels hard, like popcorn (because kernels are enclosed in a hard fruit case).
- Farmers manipulated this gene and made the kernels more like the soft, exposed kernels we know and enjoy eating off the cob. This made corn much more edible.
- Teosinte still grows as a wild grass throughout Mexico. As teosinte changed, so did its name: it began being called "**maize"** in Spanish and "corn" in English.

Cue up the "Popped Secret" video to view minutes 0:00 – 12:10.

While students watch, write the following list of products in a column on one side of the whiteboard: Aspirin, ink, soap, candy, insulation, syrup, carpets, ketchup, toothpaste, cereal, lotion, tortillas, cleaning spray, margarine, drywall, makeup, mayonnaise, wallpaper, crayons, paint, yogurt, dyes, paper, gum.

Survey students' understanding and/or opinions by verbally sharing the following questions or text in italics. Briefly gather input from the students, while steering the discussion toward the answers listed below the question.

A domesticated plant must be "cultivated". What does this word mean?

Planting seeds by hand, in a specially selected place, is called "cultivation."
Farmers collect and then cultivate seeds from the plants that:

1. produce the most food
2. have other talents, like being able to survive periods of drought (these talents are called desirable traits.)

Even though many crops look different than their wild ancestors, in most cases their wild ancestors can still be found in nature, looking similar to their modern versions.

However, the crop called corn is different: there is nothing in nature that looks like the corn plant that we know.

Why did ancient farmers invent the practice of seed saving?

- Some plants perform better than others: they produce the best crops at harvest time even if the growing season has been challenging.
- Ancient farmers noticed that if they planted the seeds from the best performing plants, their harvest would likely be larger and more dependable.

This process, called **seed saving**, was one way that ancient farmers contributed to the success of of their settlement and its future generations.

How did the ancestral Pueblo farmers decide which corn plants to save seed from?

Write the following categories on the whiteboard, allowing students to brainstorm why each of these traits matter.
Ancient farmers, as well as modern farmers, look for corn plants that have "desirable traits" such as:

1. **Tolerance of harsh conditions:** the ability to survive drought, wind, heat, altitude, floods and pests. Commercial seeds, developed in other parts of the country, often cannot adapt to the difficult local growing conditions on Hopi land.
2. **Kernel Color:** a solid layer of black color at the pointy end of the kernel can signify that a seed is healthy and will germinate well.
   Hopi people also grow corn in order to produce kernels of certain colors that structure their religion and ceremonies. The purity of these kernel colors are important.
3. **Number and arrangement of seeds on each cob:** long, tight lines of kernels, without gaps, are a better food source and are needed for ceremonial purposes.
4. **Time to maturity:** the plant must be able to finish its life cycle and produce a cob within the number of frost-free days on Hopi land.
5. **Survival of long-term storage:** the kernels must be hard, without soft spots, in order to store well throughout the winter, as a food source and as a reserve of seeds that will successfully germinate in the spring.

For the Hopi culture, and many other cultures around the world, seed saving is part their survival (physical and cultural). The corn plant has been crucial for the survival of the Hopi people because it has provided essential food for thousands of years.

How does a corn kernel provide food for humans?

Use the diagram of a corn kernel showing the endosperm to support this discussion.
Use the whiteboard to write the following key terms and review them with the students:

a. **Photosynthesis:** a process used by plants, to make a sugary food that fuels its growth. Plants absorb the energy of the sun through their leaves, combine it with water and carbon dioxide, and make a sugar called glucose.
   Fun Fact: The waste product that this process creates is oxygen!
b. **Starch:** plants store the glucose they've made by converting it into starch. When you eat a starchy plant material, like a corn kernel, you receive its energy.
c. **Endosperm:** the plant stores its starch in this part of the seed.
d. **Carbohydrates:** a food-based energy source. Starchy plant material, like corn, is high in carbohydrates. People like to use "carbs" as a food source because the starch breaks down into glucose sugar and provide us with energy over a long period of time. Glucose that is unused by the body is stored in the body as fat.
e. **Fun Facts**:
   i. Nearly 60% of all corn grown in the U.S.A. is fed to livestock.
   ii. One out of every four food products in our grocery stores has corn in it.

Which of this products in this list do you believe DOES NOT use corn as an ingredient?
Using the list of products that were written on the whiteboard in advance, conduct a survey of the students' awareness of the vast array of products that use corn as an ingredient. Tally the votes next to the item voted for. After a minute or so, inform the students that ALL of these products are made with corn.

Procedure:

1. Divide the class into working groups: "Corn Seed Saving Group" and "Corn Seed Dissection Group".
2. After approximately 30 minutes, rotate the groups.

Corn Seed Saving Group

1. Inform the students how they should organize their seed saving duties: One member of the pair should work on removing seeds from the cob; the other should gather a paper bag and marker, labelling the bag with:
   a. the name of the corn variety
   b. the origin of the corn seed/ where the corn was grown
   c. the date the seeds were gathered
2. After one student has worked on removing seeds for a few minutes, the students should switch jobs: one removes seeds while the other student separate the kernels from pieces of husk and other plant material by sifting them using the colanders or pouring the kernels from one galvanized tub to the other. All cleaned kernels should be stored in the *labelled* paper bag.

Give the students the following context and demonstration on harvesting Hopi corn seeds:

Traditionally, Hopi people stored their corn seeds over the winter by leaving them on the cob and stacking the cobs, similar to how we might stack wood. The cobs are stacked indoors to make sure they remain dry and protected from rodents. In preparation for planting, the kernels are removed from the cob and grouped together by type and/or color. Each kernel is examined carefully for any damage or defect, and then distributed to the men for planting.

We will harvest the corn seed from these cobs using the following method, traditionally used by the Hopi:

Students should detach the dried kernels from the cobs by:

1. Hold one cob, with kernels attached, over a bowl or tray so that seeds do not drop on the ground.
2. Hold another cob at the wide/bottom end just above the stem attachment point (ideally this cob will already have its kernels removed; to avoid confusion, this cob will be referred to as "the cob tool").
3. Hold the cob tool at a 45 degree angle to a cob with the kernels still attached. Starting at the pointy/top of the cob, hit the kernels with the stem attachment point to dislodge the kernels into the bowl or tray. Continue doing this, working down the cob to create a row or strip of cob that is cleared of kernels from tip to bottom. Always hit/push the kernels *toward* the spaces that are *empty* of kernels.
4. The thumb can also be used to push on and dislodge the kernels, but always push attached kernels toward the empty spaces left by removed kernels.
5. As students work, they should examine the kernels for similarities and differences in structure and color that they can share with the group during Closing Circle.
6. Once a small pile has accumulated, one student can gather kernels from the bowl or tray and begin separating the kernels from pieces of husk and other plant material: sift the kernels using the colanders or pour the kernels from one galvanized tub to the other, ideally where a cross wind can catch and blow away the plant materials. Traditionally, the Hopi used baskets loosely woven from strands of yucca leaves for this task, called a sifting basket.
7. Examine and remove seeds that have any defects that may prevent them from germinating:
    a. Soft/moist spots on the seed coat
    b. Mold
    c. Seed coats that have been chewed or otherwise cut/crushed/damaged
8. Place clean corn seed in paper bags and label with the variety/name of the corn, the date, and location where it was grown.

Corn Seed Dissection Group

Prepare for the dissection experiment as a class:

1. **Define the term "indicator":** An indicator is a chemical used to help identify a substance. Many indicators work by producing a color change when they react with a certain substance. A solution of iodine and potassium iodide can be used as an indicator for the presence of a substance called "starch".
2. **Observe the diagram:** the embryo stores all the information about how the plant will look as it moves through its life cycle. This information is coded into the plant's genes, which the ancestral farmers learned to manipulate to meet their needs:
   Diagram of a corn kernel showing the endosperm:
   http://media.web.britannica.com/eb-media/54/166754-050-8DEB8E13.jpg
3. **Observe a pre-dissected kernel:** the pre-dissected kernel that has been treated with iodine will highlight the "endosperm"; this is the part of the kernel where starch is stored.
4. **Combine the solutions:**

a. Dissolve 10 grams (0.35 ounces) of potassium iodide and 5 grams (0.18 ounces) of iodine in 100 milliliters (3.4 fluid ounces) of water.
b. the solution of iodine and potassium iodide should be passed around to student pairs once they have removed the tipcap and cut open their kernel:

Students work independently on a dissection experiment:

1. **Distribute:** paper plates, pre-soaked corn kernels, a hand lens and a plastic knife to the student pairs.
2. **Dissect**: Each student should have their own pre-soaked kernel to identify anatomy and examine the endosperm:
    a. Using a fingernail, pull off the tipcap (pointy end) of the kernel. This makes the pericarp/seed coat loose and easy to pull off. Pull off as much as possible.
    b. Then use the knife to cut the kernel in half, slicing down the narrow middle to create two wide halves.
    c. Use a hand lens or microscope to examine the inside.
    d. Add a solution of iodine and potassium iodide to test for the presence of starch:
        i. To test for starch, place **a few drops** of the mixture on each corn kernel dissected by students. The solution will change color in the presence of starch. Alert the students that the solutions can stain skin and clothes.

Closing Circle

Ancient farmers gave corn to the world. Now it is completely integrated into our modern life: it provides human food, animal food, and even fuel - corn is processed into an engine fuel called "ethanol." We have these innovative ancient farmers to thank for all the ways in which corn has improved our lives. The Hopi people have shown that, if we take seed saving and stewardship of the land seriously, it is possible to protect sacred and productive varieties of corn for centuries.

Report Back: Students from each group share outcomes and observations gained during their work group time, ensuring that the corn kernels have been properly labeled and stored in the paper bags.

Tasting: Cut in half and compare 2 specimens of one vegetable or fruit. Ask the students to look at the size, shape, number of seeds and finally the taste. Ask which specimen they would pick to save seed from and why? Taste!

PFP/MSTFP and Colorado State Education Standards

	Montezuma School to Farm Project's Garden Education Standards	Colorado Academic Standards
6th	Ancestral Puebloan agriculture practices Applied systems thinking: renewable and non-renewable resources	Science 2.1, 2.2, 3.3 Phys Ed 1.2, 3.2 Health 2.1, 2.4 Math Social Studies 1.1, 1.2, 2.2, 3.1
7th	Biodiversity benefits nitrogen, carbon, and nutrient cycles GMO seed: ecosystem health	Science 2.1, 2.4 2.5 Phys Ed 3.1, 3.2 Health 2.1, 3.1 Math Social Studies 2.2
8th	Changing systems: climate and weather in the Southwest Personal Diet: awareness of the connections between choices in diet and state of body and mind.	Science 1.2, 2.1, 2.2, 3.2 Phys Ed 2.3 Health Math Social Studies 1.1, 2.1, 2.2

For further information in regards to the Colorado State Standards, please follow this link:
http://www2.cde.state.co.us/scripts/allstandards/costandards.asp

The Pueblo Farming Project[1] is a collaboration between the Crow Canyon Archaeological Center,[2] the Hopi Tribe Cultural Preservation Office,[3] and the Montezuma School to Farm Project[4] to understand ancient maize (corn) agriculture in the Mesa Verde region through documenting traditional ecological knowledge, experimental farming, and genetic analysis. The development of this lesson plan was funded by a History Colorado State Historical Fund[5] grant to Crow Canyon.

[1] http://www.crowcanyon.org/index.php/pueblo-farming-project
[2] http://www.crowcanyon.org/
[3] http://www8.nau.edu/~hcpo-p/
[4] http://www.sanjuanwatershed.org/mancos-cd/projects/mstfp/
[5] http://www.historycolorado.org/oahp/state-historical-fund
[6] https://creativecommons.org/licenses/by-nc-sa/4.0/