Corn Field Math and Science

Grades 3-5

Math, Science, Social Studies

Objectives

Students will learn about corn's place in the history of the Americas. Students will solve real life math problems using corn production. Students will display an understanding of how humans crossbred and domesticated plants. Students will classify Newtonian and Non-Newtonian substances and create polymers using cornstarch and corn syrup.

Vocabulary

bushel—a unit of measure usually equal to 35 liters or 9.5 gallons
ethanol—a colorless liquid made from corn which can be burned as a fuel
hybrid—an animal or plant that is produced from two animals or plants of different kinds
polymer—a chemical compound that is made of small molecules that are arranged in a simple repeating structure to form a larger molecule
silage—food for farm animals that is stored inside a silo
teosinte—the wild grass plant that corn was domesticated from
yield—to produce or provide (something, such as a plant or crop)

Background

Corn was derived from a native grass, known as **teosinte.** While the exact origin is unknown, tiny ears of corn have been discovered at ancient village sites and in tombs of early Americans. Evidence of corn in central Mexico suggests it was grown there as long as 9000 years ago. Teosinte is still grown in Mexico and Central America today. For more information about the **domestication** of corn or maize**,** have students watch the 17 minute video: "*Popped Secret-the Mysterious Origin of Corn*:" https://www.biointeractive.org/classroom-resources/popped-secret-mysterious-origin-corn

Native Americans and early settlers in the United States have grown domesticated corn, also known as maize, in the southwestern US for at least 3000 years. Since that time is has been used it for both food and practical purposes. Eastern Native American tribes shared their knowledge of corn production with early European settlers, which saved many from starvation. Early American colonists dried corn and ground it as meal for flour. They used the ground corn in porridge, cakes and bread.

Along with wheat and rice, corn is one of the world's major grain crops. It is the largest grain crop grown in the US. About nine (9) percent of all the corn grown is used to produce food for humans. These foods include corn meal, cooking oils, margarine, and corn syrups and sweeteners (fructose). Sixty four (64) percent of all corn grown is used as feed for livestock.

Corn can be grown in much of Oklahoma, but most is produced in the Panhandle area. In Oklahoma, corn is harvested for either grain or silage with most of the grain going to dairies, animal feeding operations and poultry operations. About 330,000 acres of corn are planted for grain each year, with an average **yield** of 137 **bushels** per acre for a total of 45.2 million bushels of grain. One bushel of corn is equal to 56 pounds. An additional 20,000 acres of corn produces 260,000 tons of **silage**.

In addition to the grain, corncobs are used in the manufacturing of nylon **polymers** and as a source for producing biodegradable plastics. **Ethanol**, a renewable fuel made from corn, is often blended with petroleum-based fuel sold today.

Corn Field Math and Science (continued)

Corn is pollinated by the wind and is typically planted in rows that are 30 inches or 2.5 feet apart. A single seed (or kernel) of corn may produce a plant which yields more than 600 kernels of corn per ear. On one acre of land, anywhere from 22,000 to 35,000 individual plants may be grown. **Hybrid** corn is developed to produce from one to two ears per plant. The actual number of ears per plant is often determined by moisture availability and soil fertility.

There are six types of corn kernels: flint, dent, pop, sweet, flour and waxy. There are open pollinated "heirloom" varieties of each type. All types except sweet corn are harvested when the ears are mature and kernels are dry.

Dent corn, which is also known as "field corn," is an easy type of corn to spot -- there's a dent in the crown of each individual kernel of corn. Most dent corn grown in the U.S. winds up as animal feed or in grain in products like chips and masa (a corn flour used to make corn tortillas).

Sweet corn is what you eat as a vegetable. It has a high sugar content, which is why it's desirable as a fresh corn. Sweet corn can occur as a spontaneous mutation in field corn. Early farmers saved seed from this mutation and it was grown by several Native American tribes. The Iroquois gave the first recorded sweet corn (called 'Papoon') to European settlers in 1779.

Flint corn is also known as ornamental corn, and it's hull is even harder than dent corn. In addition to its use for decorating, it can be used for corn meal, corn flour, hominy, polenta, and grits. When you see brightly colored tortilla chips, you can be sure they came from flint corn.

Popcorn is a particular variety of flint corn. The kernels are dried to a moisture level of 13.5%. When the kernels are heated, the remaining moisture turns to steam and the kernels pop inside out. Most of the world's popcorn is grown in the Midwestern United States.

Heirloom is a term for open pollinated plant varieties that have historic significance. Because much of the corn grown commercially or in home gardens is a hybrid (a combination of two or more varieties), there is a movement to preserve and grow heirloom varieties of corn to preserve genetic diversity.

Additional Reading

Chen, Qiuyue; Samayoa, Luis F.; Yang,Chin J.; Bradbury,Peter J.; Olukolu,Bode A.; Neumeyer, Michael A.; Romay,Maria C. Sun, Qi; Lorant, Anne; Buckler, Edward S.; Ross-Ibarra, Jeffrey; Holland, James B.; Doebley, John F., *The genetic architecture of the maize progenitor, teosinte, and how it was altered during maize domestication*, Version 2, PLOS Genetics, May 14, 2020 https://doi.org/10.1371/journal.pgen.100879

Gibbons, Gail, *Corn*, Holiday House, 2009

Giesel, Theodor Seuss, *Bartholomew and the Oobleck*, Random House Children's Books, 1949

Litchfield, Ruth, *High Fructose Corn Syrup - How Sweet it is*, Iowa State University Extension and Outreach Fact Sheet, May 2019 https://lib.dr.iastate.edu/extension_families_pubs/23/

Rhoads, Dorothy, *The Corn Grows Ripe*, Puffin, 1993.

Websites

https://www.smithsonianmag.com/smart-news/rethinking-corny-history-maize-180971038/
http://nativetech.org/cornhusk/cornhusk.html
https://www.biointeractive.org/classroom-resources/popped-secret-mysterious-origin-corn

Corn is part of almost every part of our lives - from toothpaste to diapers to foods to the fuel for our cars. There are both facts and false statements about corn and its many products on the internet. Here are some common items which have corn in them.

Toothpaste: Sorbitol is an ingredient in toothpaste from corn. It helps create toothpaste's flavoring and texture.

Yogurt: Uses high-fructose corn syrup as a sweetener; the cows that make the milk also eat corn in their daily meals.

Chewing Gum: Uses high fructose corn syrup and maltitol as sweeteners and sorbitol for flavoring.

Cosmetics: Blush and eye shadow often contain zea mays, which is another name for corn.

Shampoo: Citric acid is a common ingredient in shampoos and conditioners and is from corn.

Diapers: Corn starch is used to soak up moisture in diapers.

Envelopes: Corn is used to make the glue which holds envelopes closed.

Corn Bread: The main ingredient is corn meal, which gives cornbread its gritty texture.

Handsoap: At least 25% of the ingredients in some hand soaps are from corn.

Windex: This glass cleaner contains at least 5 different ingredients from corn.

Jellybeans and Licorice: These candies not only include corn syrup to give them their texture but also, powdered corn starch is used to coat their molds and allows manufacturers to more easily pop them out after they're finished being molded.

Corn Flakes: If you enjoy a hearty bowl of flakes for breakfast, you're eating the corn grit that has been steamed and flaked**.**

Soft Drinks: Many non-diet soft drinks are sweetened with High Fructose Corn Syrup.

Paper, Recycled Paper and Cardboard: Industrial cornstarch is used in the papermaking process.

Crayons and Chalk: Utilize cornstarch to get them out of their molds and corn products also help the paper labels adhere to the crayons.

Running Shoes: Currently, most shoes are made with oil-based plastics, but Reebok has announced it will begin to make the sole of their new sustainable shoe with petroleum-free, industrial-grown corn.

Spark Plugs: Spark plugs in your car are made from metal and ceramics. When the crystalline structures of cornstarch are heated to very high temperatures, they harden and it becomes a type of ceramic. The ceramic is able to withstand high temperatures and also withstands the corrosive properties of some specific acids.

Rubber Tires: Instead of using oil-based rubber, Goodyear and their research partner Genencor are using cornstarch to chemically bind the ingredients of its new kind of tire.

Fireworks: Some of the compounds in fireworks require a "binder" in order to burn properly. A common binder is dextrin, a light carbohydrate most commonly made from corn.

Popcorn: Popcorn is its own type of corn. There are three common types of corn; sweet corn, popcorn and field corn. The two we eat in their natural form are sweet corn and popcorn.

Pet Food: Pet food is regulated to the same level of safety as human food. Corn is used in pet food to create a balanced diet for all kinds of pets including dogs, cats and even fish.

Batteries: Cornstarch is often used as an electrical conductor in batteries.

Deodorant: Uses corn starch because of its absorbent nature.

Hand Sanitizer: Contains ethanol which typically is made by fermenting corn.

Carpet and Other Textile Products: Corn-based textile products are often preferred to the petroleum based products because they are more environmentally friendly.

Plastic Products: While it's not a widespread use like the other products, bioplastic is being used in many different products such as bags, containers and cups. Corn-based plastics can be composted and use up to 68% less fossil fuels during production than traditional plastics and are estimated to emit 55% less greenhouse gases.

Source: Kansas Corn Growers Association

Activity 1: Corn Field Math, (Math) 1 50 minute class period

Students will use corn to calculate measures of central tendency and solve real world agricultural math problems.

Oklahoma Academic Standards

Activity 1: Corn Field Math (Math)

3.N.3.2	Construct fractions using length, set and area models
3.A.2.1	Find unknowns represented by symbols in arithmetic problems by solving one-step open sentences (equations) and other problems involving addition, subtraction, and multiplication. Generate real-world situations to represent number sentences.
4.N.2.1	Represent and rename equivalent fractions using fraction models (e.g. parts of a set, area models, fraction strips, number lines)
4.D.1.1	Represent data on a frequency table or line plot marked with whole numbers and fractions using appropriate titles, labels, and units.
5.N.3.3	Add and subtract fractions with like and unlike denominators, mixed numbers, and decimals, using efficient and generalizable procedures, including but not limited to standard algorithms in order to solve real-world and mathematical problems including those involving money, measurement, geometry, and data
5.D.1.1	Find the measures of central tendency (mean, median, or mode) and range of a set of data. Understand that the mean is a "leveling out" or central balance point of the data.

Materials:

Dried corn on the cob (one per student or one per group)
Activity 1 Worksheet 1 "**Finding the Middle"**
Activity 1 Worksheet 2 "**Corn Field Math"**
Calculators, computers, and/or resource materials, rulers

Procedures

1. Give each student or group of students one ear of dried corn on the cob.
   - Students will estimate how many kernels are on the ear of corn.
   - Students will count the kernels.
   - According to the background, an ear of corn can have more than 600 kernels of corn. Does your ear have more or less kernels than 600?
   - Hand out Activity 1 Worksheet 1 "**Finding the Middle."**
   - Students will write down the number of kernels from each ear and then find the mean, the median and the mode of the data.
   - Students will perform calculations to project the potential number of kernels their ear of corn might produce.
2. Hand out Activity 1 Worksheet 2 "**Corn Field Math**."
   - Students will work in pairs or groups to solve the math problems.
   - Students will check answers after completing the first two questions before continuing.
   - In a class discussion, students will agree or disagree with the reasoning of other classmates and explain their positions.

Corn Field and Math Science

Activity 1 Worksheet 1: Finding the Middle

Name: _____ Date: _____

An ear of corn has an average of 600 kernels per ear. An average is a measure of central tendency called the mean. To find the mean, you add up all of the numbers and divide by the total number of numbers. Other measures of central tendency are the median and the mode. The median is the number in the middle when all of the numbers are in order. The mode is the number which is repeated the most. After counting the number of kernels on your ear of corn, record the number. Your ear is Ear 1. Record the total for other students/groups for Ears 2-7.

TOTAL NUMBER OF KERNELS FOR EACH EAR

	≤ 525	526-550	551-575	576-600	601-625	626-650	≥ 651
Ear 1							
Ear 2							
Ear 3							
Ear 4							
Ear 5							
Ear 6							
Ear 7							

Did your ear of corn have more or less kernels that the average of 600? Circle your answer.

MORE **LESS**

How many ears had 600 kernels or more? _____

How many ears had less than 600? _____

Calculate the mean for all 7 ears of corn. Write you answer on the line: _____

(the total of all kernels ÷ number of ears = mean)

Did the mean of your classes corn sample have more or less kernels that the average of 600? Circle your answer.

MORE **LESS**

Find the median (the number in the center when numbers are placed in order)**: _____**

Find the mode (the number that appears most often in a set of numbers): **_____**

Does the mean, the median or the mode best describe your set of numbers? _____

If all of the kernels from your ear of corn were planted and each kernel produced one ear of corn with the same number of kernels as the original ear of corn, how many kernels of corn will your ear of corn produce?

Corn Field and Math Science

Activity 1 Worksheet 2: Corn Field Math

Name: _____ Date: _____

You are a farmer and you are preparing to plant corn. You need to figure out how much seed to buy to plant one acre of corn.

1. a) An acre of land is 43,560 sq. ft. Each side of a square acre is 208.7 feet.

b) If the rows are 2.5 ft. apart, how many rows are there?

208.7 ÷ 2.5 = _____

c) How many corn plants will be in each row if there are 22,000 plants in a square acre?

22,000 ÷ (answer to 1.b.) _____ = _____

2. Each corn plant produces one ear of corn. There are 600 kernels per ear. How many kernels are produced on 1 acre of land?

22,000 x 600 = _____

WAIT: CHECK YOUR ANSWERS TO THE FIRST TWO PROBLEMS BEFORE CONTINUING.

3. This field produces 135 bushels of corn per acre. How many kernels of corn are in a bushel?

_____ (answer to #2) ÷ 135 = _____

4. Two farmers each each have 640 acres planted in corn.

a.) Farmer A's crop produces one ear of corn per plant.
At 135 bushels of corn per acre, how many bushels of corn will this field produce?

640 (acres) x 135 (bushels per acre) = _____ total bushels of corn

b.) Farmer B's crop produces two ears of corn per plant. How many bushels of corn will this field produce?

_____ (total from 4a.) x 2 = _____total bushels of corn

5. Corn is selling for $2.40 a bushel. Compare Farmer A and Farmer B's earnings.

Total earnings for Farmer A: $2.40 x 135 = _$_____ x 640 acres = $_____

Total earnings for Farmer B: ($2.40 x 135) x 2 = $_____ x 640 acres = $_____

Use your calculator and other mathematical tools to solve the following problems.

6. A farmer decided to plant 320 acres in three different varieties of corn.

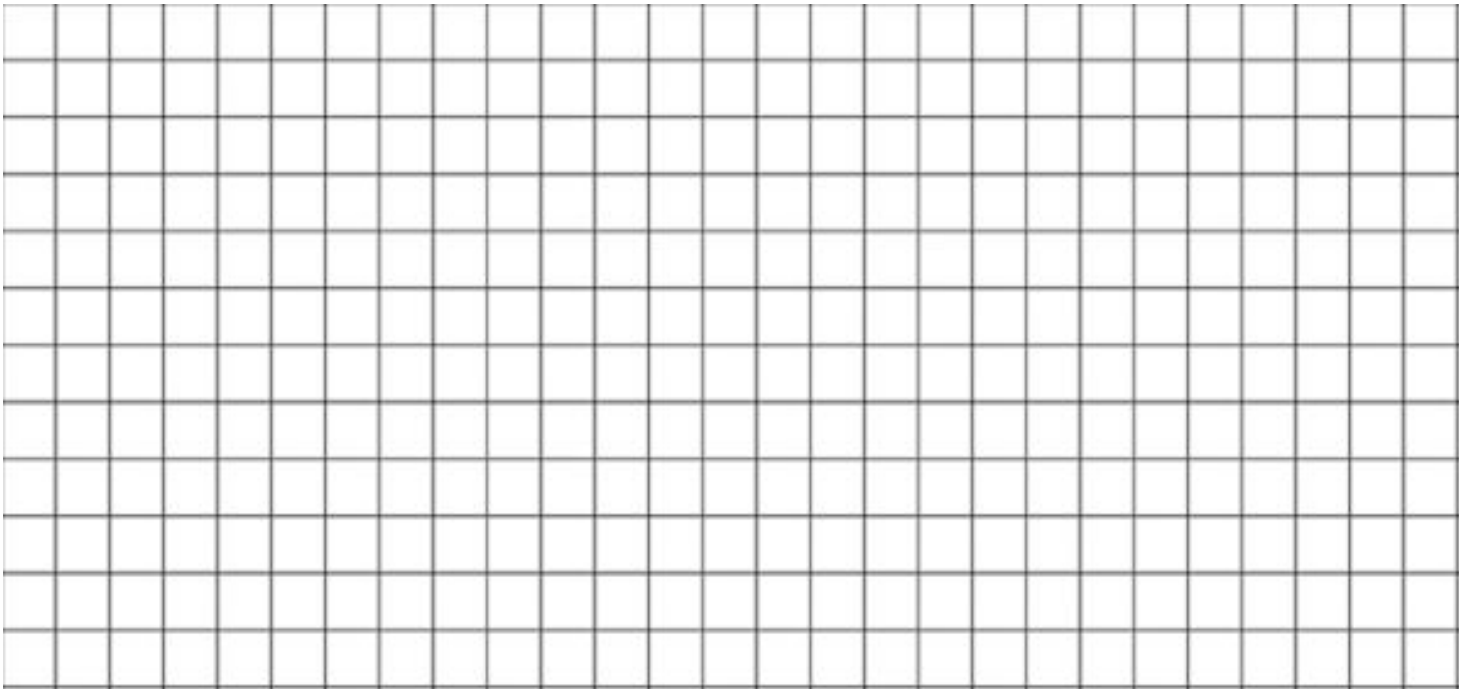
Variety A - ⅓ of total acres ⅓ x 320 = _____ acres

Variety B - ½ of total acres ½ x 320 = _____ acres

Variety C - ?? of total acres (1 - X/6 - X/6) x 320 = _____acres

Convert the fractions to the least common denominator to determine the acres for Variety C

Use the graph below to construct a model of the farmer's land. Label each section, and complete the calculations below. Show your work.



Use your calculator and other mathematical tools to solve the following problems.

Use your answers from the previous problems and calculate bushels per acre for each variety:

a) Variety A produces one ear of corn per plant.

_____ acres x 135 bushels = _____ bushels

b) Variety B produces two ears of corn per plant

_____ acres x (135 x 2) bushels = _____ bushels

c) Variety C produces 1.5 ears of corn per plant (1/2 of plants have ear and ½ of plants have 2 ears)

_____ acres x (135 x 1.5) bushels = _____bushels

d) What is the total yield the farmer can expect for the full 320 acres?

_____ (a) = _____ (b) + _____ (c) = _____ bushels

e) How much money would the farmer receive from the corn at $2.40 per bushel?

_____ (d) x $2.40 = $_____

Corn Field and Math Science

Activity 1 Worksheet 2: Corn Field Math

ANSWER KEY

Name: _____ Date: _____

You are a farmer and you are preparing to plant corn. The following problems will help you decide which varieties to plant.

1. a) An acre of land is 43,560 sq. ft. Each side of a square acre is 208.7 feet.

   b) If the rows are 2.5 ft. apart, how many rows are there?

   208.7 ÷ 2.5 = 83.48

   c)How many corn plants will be in each row if there are 22,000 plants in a square acre?

   22,000 ÷ (answer to 1.b.) 83.48 = 263.54

2. Each corn plant produces one ear of corn. There are 600 kernels per ear. How many kernels are produced on 1 acre of land?

   22,000 x 600 = 13,200,000

WAIT: CHECK YOUR ANSWERS TO THE FIRST TWO PROBLEMS BEFORE CONTINUING.

3. This field produces 135 bushels of corn per acre. How many kernels of corn are in a bushel?

   13,200,000 (answer to #2) ÷ 135 = 97,777.78

4. Two farmers each each have 640 acres planted in corn.

   a.) Farmer A's crop produces one ear of corn per plant. At 135 bushels of corn per acre, how many bushels of corn will this field produce?

   640 (acres) x 135 (bushels per acre) = 86,400 total bushels of corn

   b.) Farmer B's crop produces two ears of corn per plant. How many bushels of corn with this field produce?

   86,400 (total from a.) x 2 = 172,800 total bushels of corn

5. Corn is selling for $2.40 a bushel. Compare Farmer A and Farmer B's earnings. .

   Farmer A: $2.40 x 135 = $ 324.00 x 640 = $ 207,360.00 Total earnings

   Farmer B: ($2.40 x 135) x 2 = $ 648.00 x 640 = $ 414,720.00 Total earnings

Corn Field and Math Science

Activity 1 Worksheet 2: Cornfield Math (continued)

ANSWER KEY

Name: _____ Date: _____

Use your calculator and other mathematical tools to solve the following problems.

6. A farmer decided to plant 320 acres in three different varieties of corn.

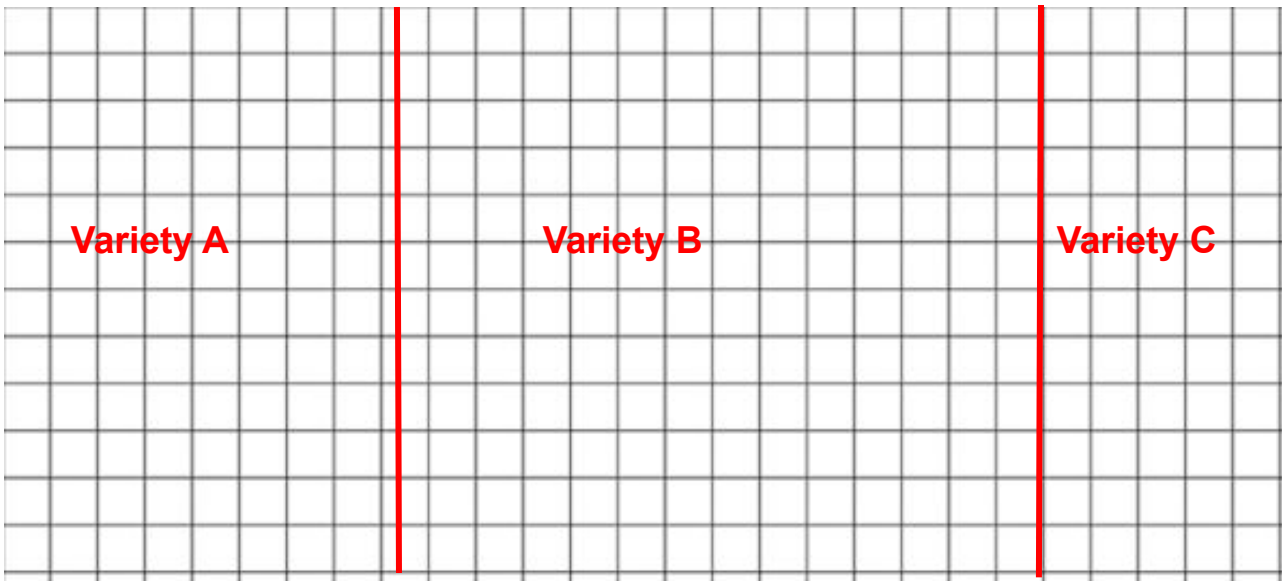
Variety A - ⅓ of total acres ⅓ x 320 = 106.66 acres

Variety B - ½ of total acres ½ x 320 = 160 acres

Variety C - ?? of total acres (1 - X/6 - X/6) x 320 = 53.33 acres

Convert the fractions to the least common denominator to determine the acres for Variety C

Use the graph below to construct a model of the farmer's land. Label each section, and complete the calculations below. Show your work.



Use your answers from above and calculate bushels per acre for each variety:

a) Variety A produces one ear of corn per plant.

106.66 acres x 135 bushels = 14,399.1 bushels

b) Variety B produces two ears of corn per plant

160 acres x (135 x 2) bushels = 43,200 bushels

c) Variety C produces 1.5 ears of corn per plant (1/2 of plants have ear and ½ of plants have 2 ears)

53.33 acres x (135 x 1.5) bushels = 10,799.325 bushels

d) What is the total yield the farmer can expect for the full 320 acres?

14,399.1 (a) = 43,200 (b) + 10,799.325 (c) = 68,398.425 bushels

e) How much money would the farmer receive from the corn at $2.40 per bushel?

68,398.425 (d) x $2.40 = $ 164,156.22

Activity 2: History of Corn, (Social Studies, Science) 1 50 minute class period

Students will learn about the history of corn and how crops have improved through chance breeding and through human modification

Oklahoma Academic Standards

Activity 2: History of Corn (Social Studies, Science)

3.LS1.1	Develop and use models to describe that organisms have unique and diverse life cycles but all have common patterns of birth, growth, reproduction and death.
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.LS3.2	Use evidence to support the explanation that traits can be influenced by the environment.
3.LS4.2	Use evidence to construct an explanation for how the variations in characteristics among individuals of the same species may provide advantages in surviving and reproducing.
3.2.2SS	Examine the interaction of the environment and the peoples of Oklahoma.
4.LS.1.1	Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior and reproduction
5.LS1.1	Support an argument that plants get the materials they need for growth chiefly from air and water.

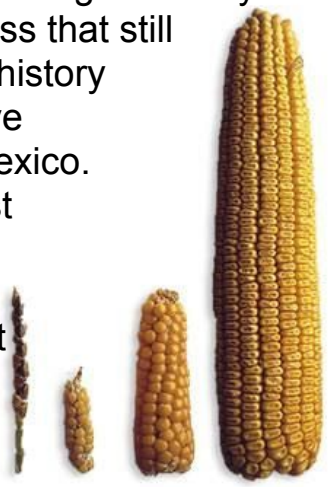
Materials:

Activity 2 Reading Page 1 "**History of Corn"**
Activity 2 Worksheet 1 "**History of Corn"**
Samples of corn— dent (field) corn, sweet corn, popcorn, Indian or ornamental corn.
Internet access for video: Popped Secret: *The Mysterious Origin of Corn*
https://www.biointeractive.org/classroom-resources/popped-secret-mysterious-origin-corn

Procedures

1. Read and discuss Activity 2 Reading Page 1 "**History of Corn."**
2. If you have access to various types of corn (dent corn from the math activity, popcorn, sweet corn, ornamental corn, etc.) show examples to the students. See if they can identify each type of corn using the description in the reading page.
3. Have students complete Activity 2 Worksheet 1 **"History of Corn."**
4. Watch the video "*Popped Secret: The Mysterious Origin of Corn."* It provides a pretty basic overview of plant genetics.
   https://www.biointeractive.org/classroom-resources/popped-secret-mysterious-origin-corn
5. Discuss the information from the video and how it connects to the reading passage students read.

Corn has been an important crop since ancient times. The corn farmers grow today was developed from teosinte (tee-o-sin-ta). Teosinte is a type of grass that still grows in Mexico and Central America. Scientists who study human history have found tiny ears of corn in village sites and tombs of early Native Americans. This shows corn was grown up to 9,000 years ago in Mexico. Corn has been grown for human use in the United States for at least 3,000 years.



Corn is also known as maize. Corn was an important part of the diet for native people in North and Central America. It was so important to some tribes it was thought of as one of the three sacred foods. The other two sacred foods were beans and squash. These three crops were often planted together. The plants seemed to grow stronger when they were planted near each other. When eaten together, the nutrients combined to keep people strong and healthy. Eastern tribes shared their knowledge of how to grow corn with the early European settlers. This saved many colonists from starving.

Most of the corn grown in the United States is dent corn. Dent corn is also called field corn. After harvest it is divided into its different parts. Dent corn is used to make corn syrup, starch, meal, and oil. It is also used to make feed for animals. Corn cobs are used to make nylon fibers and plastic. Ethanol is a fuel made from corn. Ethanol can be blended with gasoline.

Sweet corn is the kind of corn we eat. Sweet corn is the result of a change in field corn. Seed from this new type of corn was saved and grown by Native Americans. The Iroquois gave sweet corn (called 'Papoon') to European settlers in 1779.

Flint corn is also known as ornamental corn. Flint corns hull is even harder than dent corn. It is often brightly colored and used for decorating. It can also be used for corn meal, flour, hominy, polenta, and grits. When you see red or blue tortilla chips, you can be sure they came from flint corn.

Popcorn is a special type of flint corn. The kernels are dried to a moisture level of 13.5%. When the kernels are heated, the moisture turns to steam. The steam causes the kernels to pop inside out.

Heirloom is a term for plants which have a historic importance**.** Much of the corn grown today is a hybrid. A hybrid is a combination of two or more types of corn. Today, some farmers grow heirloom corn to keep historic corn alive.

Corn Field and Math Science

Activity 2 Worksheet 1: History of Corn

Name: _____ Date: _____

After reading the History of Corn, answer the questions below:

1. The corn we grow and use today was developed from this grass, which still grows in Mexico and Central America _____.
2. How many years has domesticated corn has been grown in the United States?

   _____ years.
3. For Native Americans, corn was one of three sacred foods. The other two sacred foods were: _____ and _____
4. Why do you think these foods were considered sacred?

   _____

   _____
5. Name three products made from dent or field corn:

   _____

   _____

   _____
6. Corn cobs can be used to make _____ and _____
7. Sweet corn was the result of a _____ in field corn.
8. The Iroquois gave sweet corn, called _____, to European settlers.
9. The kernels of _____ corn are even harder than dent corn.
10. _____ is a special variety of flint corn which explodes when the moisture inside turns to steam as the kernels are heated.
11. Plants with historic importance are called _____.

Corn Field and Math Science

Activity 2 Worksheet 1: History of Corn

ANSWER KEY

Name: _____ Date: _____

After reading the History of Corn, answer the questions below:

1. The corn we grow and use today was developed from this grass, which still grows in Mexico and Central America teosinte.
2. How many years has domesticated corn has been grown in the United States?
   3,000 years.
3. For Native Americans, corn was one of three sacred foods. The other two sacred foods were: beans and squash
4. Why do you think these foods were considered sacred?

   Answers will vary, but could include: the plants help each other as they grow, the combination of foods keeps people strong and healthy.
5. Name three products made from dent or field corn:

   Answers will vary, but could include: corn syrup, corn meal, corn starch, corn oil, livestock feed, ethanol
6. Corn cobs can be used to make nylon and plastic
7. Sweet corn was the result of a change in field corn.
8. The Iroquois gave sweet corn, called Papoon, to European settlers.
9. The kernels of flint corn are even harder than dent corn.
10. Popcorn is a special variety of flint corn which explodes when the moisture inside turns to steam as the kernels are heated.
11. Plants with historic importance are called heirloom.

Activity 3: What is Oobleck? (Science) 1 50 minute class period

Students will learn how corn is processed. Students will experiment with and classify Newtonian and Non-Newtonian substances and use cornstarch to make Oobleck, a non-Newtonian Fluid

Oklahoma Academic Standards

Activity 3: What is Oobleck? (Science)

4.ESS3.1	Obtain and combine information to describe that energy and fuels are derived from renewable and non-renewable resources and how their uses affect the environment.
5.PS1.2	Measure and graph quantities to provide evidence that regardless of the type of change that occurs when heating, cooling, or mixing substances, the total weight of matter is conserved.
5.PS1.3	Make observations and measurements to identify materials based on their properties.
5.PS1.4	Conduct an investigation to determine whether the mixing of two or more substances results in new substances.

Materials:

- corn starch (½ cup per group)
- zipper bags or bowls
- small plastic cups
- water
- popsicle sticks
- disposable plates and bowls
- Activity 3, Worksheet 1 "**What is Oobleck?"**

Substances to test	Tools needed
Alcohol	wire whip or mixer
Egg Whites	mixer, bowl, sugar
Heavy Cream	mixer, bowl
Jelly	plate, knife, bread
Ketchup (glass bottle)	plate or bowl
Mayonnaise	plate, knife, bread
Peanut butter	plate, knife, bread
Toothpaste	toothbrush,
Wall Paint	paintbrush, cardboard
Water	wire whip or mixer

Procedures

1. Measure cornstarch and prepare work stations to make Oobleck
2. Tell students that today's activity uses cornstarch, one of the minor products that results from refining corn.
3. Pass out Activity 3, Worksheet 1 "**What is Oobleck?"**
4. Have students brainstorm and discuss properties of liquids and solids and record answers.
5. Properties of liquids include:
   a. Liquids have definite volume, but indefinite shape.
   b. When a liquid is inside a container, it will take its shape. If you take 100 ml of water, pour water in a cup, it will take the shape of the cup. Now pour the liquid from cup to a bottle, the liquid has changed its shape and now it has taken the shape of bottle.
   c. They are free to form droplets and puddles when they are not inside a container.
   d. Unlike gases, a liquid will not change its volume completely fill a container.
   e. Liquids are almost incompressible. In liquids molecules are pretty close to each other. The molecules can not squeezed closer to one another.
   f. Liquids flow from higher to lower level.
   g. Liquids have their boiling points above room temperature, under normal conditions.

6. Properties of solids include:
    a. A solid has a definite shape and volume.
    b. Solids in general have higher density than liquids or gasses. Ice is an exception - water expands as it freezes and becomes less dense than the original substance
    c. In solids, intermolecular forces are strong.
    d. Diffusion of a solid into another solid is extremely slow.
    e. Solids have high melting points.
    f. Aside from the regular arrangement of particles, crystalline solids have several other characteristic properties. They are generally incompressible, meaning they cannot be compressed into smaller shapes. Because of the repeating geometric structure of the crystal, all the bonds between the particles have equal strength. This means that a crystalline solid will have a distinct melting point, because applying heat will break all the bonds at the same time
7. Provide materials to make Oobleck.
8. Based on the ingredients provided, students will hypothesize if they will be creating a solid or a liquid. Students will write their hypothesis on the worksheets
9. Students will work in pairs to make Oobleck, as described on the worksheet
10. Students will experiment with the Oobleck before answering the questions on the worksheet and recording their answers.

EXPLAIN: Oobleck is a non-Newtonian fluid. That is, it acts like a liquid when being poured, but like a solid when a force is acting on it. You can grab it and then it will ooze out of your hands. Make enough Oobleck and you can even walk on it!

Other substances have non-newtonian traits. Have students research the substances on the second page of the worksheet and complete the chart. The website below may provide some insight.

https://cravingsofafoodscientist.com/2019/04/17/the-unlikely-physics-of-ketchup-an-introduction-to-non-newtonian-fluids/

To learn more about the behavior of non-Newtonian fluids, watch the following short videos:
Non-Newtonian pothole fillers (1 min): http://youtu.be/XrvzZewPUJA
Oobleck on speakers (1.5 min): http://youtu.be/3zoTKXXNQIU
Walking on oobleck (20 sec): http://youtu.be/bIOGL4eZnjs
Sinking in oobleck (40 sec): http://youtu.be/Lb9kt1z3jAA
Time Warp high-speed (6 min): http://youtu.be/S5SGiwS5L6I

Corn Field Math and Science

Activity 3 Worksheet 1: What is Oobleck?

Name: _____ Date: _____

We usually think of materials around us as being a solid, a liquid or a gas. To prepare for this activity, read the properties of liquids and solids in the table below.

Properties of Liquids	Properties of Solids
1. Liquid takes the shape of the container it is in. 2. The volume stays the same, even if the shape changes. 3. Liquid can pour, splash, spray, form droplets, and/or puddles. 4. Liquid can freeze or boil (become either solid or gas at the right temperature). 5. Liquid naturally flows from higher to lower level. 6. Liquid mixes easily with other liquids and can dissolve some solids.	1. Solids have a definite shape. 2. Solids have a definite volume. 3. Solids do not combine easily with other solids. 4. Generally, solids have a high melting temperature. 5. The bond between molecules in a solid are strong, creating a rigid structure. 6. Solids keep their shape when moved to another container.

Oobleck gets its name from the Dr. Seuss book *Bartholomew and the Oobleck*. In the story, a gooey green substance, called Oobleck, falls from the sky and wreaks havoc in the kingdom. Work with a partner to make Oobleck.

- Place ½ cup cornstarch in a plastic zip-top bag or bowl.
- Slowly mix the water into the corn starch a little at a time until you get a gooey mixture. It should feel like a liquid (check your list above) when mixed slowly.
- Oobleck is done when it is no longer powdery, but doesn't splash when hit with a spoon or popsicle stick.
- Use the list you made above to test whether oobleck behaves like a solid or a liquid. It may be helpful to test a bowl of plain water and something like a wooden block for comparison.

I think oobleck is a (liquid or solid) _____

Explain your answer: _____

_____

Test your hypothesis (use the questions below or design your own experiments)

1. Can you pour the oobleck like water?

   _____

   _____

2. What happens when you drop something into it?

   _____

   _____

3. Can you roll it into a ball? If so, set the ball on a plate and see how long it takes to spread out. Record the time.

   _____

   _____

4. Will the ball bounce on the table? (Do not bounce on the floor)

   _____

   _____

5. What happens when you push an object (popsicle stick, finger, spoon, etc.) into it?

   _____

   _____

6. What happens when you stir it slowly?

   _____

   _____

7. What happens when you stir it quickly?

   _____

   _____

8. What happens when you pour oobleck into various shaped containers?

   _____

   _____

After testing oobleck, compare your results to the list of properties of liquids and solids.

Does oobleck behave like a liquid, a solid or both?

_____

Fluids that exhibit no change in **viscosity** under stress (shear strain) are known as **Newtonian Fluids.** Substances that get thicker or thinner as the rate of stress (shear strain) increases are known as **non-Newtonian fluids**. Substances can exhibit properties of both solids and liquids, depending on the amount of stress or "shear" (how fast you try to move the substance) applied.

Test these substances and use the table to mark how the substance responds to stress or friction.

Substance	Gets thicker under stress	Gets thinner under stress	No change
Alcohol			
Egg Whites			
Heavy Cream			
Jelly			
Ketchup			
Mayonnaise			
Peanut butter			
Toothpaste			
Wall paint			
Water			

Corn Field Math and Science

Activity 3 Worksheet 1: What is Oobleck? (continued)

ANSWER KEY WITH EXPLANATIONS

Name: _____ Date: _____

After testing oobleck, compare your results to your list of properties of liquids and solids.

Does oobleck behave like a liquid, a solid or both? __both_____

Fluids that exhibit no change in **viscosity** under stress (shear strain) are known as **Newtonian Fluids.** Substances that get thicker or thinner as the rate of stress (shear strain) increases are known as **non-Newtonian fluids**. Substances can exhibit properties of both solids and liquids, depending on the amount of stress or "shear" (how fast you try to move the substance) that is applied.

Test these substances and use the table to mark how the substance responds to stress or friction.

Substance	Gets thicker under stress	Gets thinner under stress	No change
Alcohol			Not affected by stress Minimally affected by temperature
Egg Whites	Thicken when whipped with sugar to make meringue. Must be baked (chemical change) to hold shape. Otherwise, will lose volume and go back to original shape.		
Heavy Cream	Thickens when whipped to become whipped cream. Continued whipping makes butter		
Jelly		Gel holds shape, but spreads easily with knife	
Ketchup		Flows only after shaking bottle (or squeezing plastic bottle	
Mayonnaise		Firm but thins easily when spread	
Peanut butter		Solid in jar, but spreads easily on bread. Must be measured like shortening when cooking.	
Toothpaste		Semi-solid that thins with friction	
Wall paint		Designed not to drip, but thins when roller/brush applied to surface	
Water			Temperature causes change in density, but not stress

Activities 4: What are Polymers?, (Science) 1 50 minute class period

Students will learn about physical and chemical changes in corn when heat is applied, Students will evaluate information about corn in popular media for accuracy

Oklahoma Academic Standards

Activities 4: What are Polymers? (Science)

5.PS1.2 Measure and graph quantities to provide evidence that regardless of the type of change that occurs when heating, cooling, or mixing substances, the total weight of matter is conserved.

5.PS1.3 Make observations and measurements to identify materials based on their properties.

5.PS1.4 Conduct an investigation to determine whether the mixing of two or more substances results in new substances.

Materials:

- Activity 4 Reading Page 1 "**What is a Polymer?"**
- hot plate or other heat source
- heavy 2 quart pan (for polymer syrup)
- large mixing bowl (for mixing popcorn balls)
- large metal spoon (for mixing popcorn balls)
- timer or cell phone for timing
- heavy 3 quart pan with see through lid (for popcorn)
  OR use an air popper so students can see kernels explode when heated.
- large wooden or silicone spoon (for stirring caramel mixture while heating)
- Activity 4 Recipe 1 Popcorn Ball Polymers
- Activity 4 Recipe 2 Microwave Popcorn Ball Polymers

The same pan can be used for popping corn and making syrup if you are able to wash the pan between tasks.

Can also use an air popper so students can observe physical change in popcorn.

It may be necessary to pop two batches of popcorn to reach 12 cups.

Ingredients for Popcorn Ball Polymers (makes 12 popcorn balls)

- 1/2 cup corn syrup
- 1 cup sugar
- 1/4 cup butter
- 1/2 teaspoon salt
- 1 teaspoon vanilla
- 1/2 teaspoon baking soda
- 3 quarts (12 cups) warm popped corn
- 3 tablespoons vegetable oil
- ⅓ cup popcorn kernels
- waxed paper or parchment
- clean kitchen towel or wide foil
- non-stick cooking spray
- dishwashing liquid

Alternate Ingredients for Microwave Recipe
1/2 cup butter, cut into pieces
1 cup brown sugar
1/4 cup light corn syrup
1/2 teaspoon baking soda
1 teaspoon pure vanilla extract
Pinch of salt

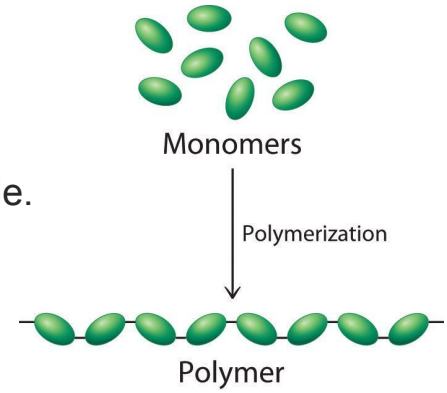
Procedures

1. Assemble and measure all ingredients before beginning.
2. Read and discuss Activity 4, Reading Page 1 "**What are Polymers?"** using the following discussion questions:
   —Ask if anyone has eaten a polymer today. Discuss foods that contain polymers (most fruits and vegetables contain cellulose and simple sugars; gluten provides the structure that holds bread together, cornstarch and or corn syrup give yogurt its creamy texture, etc.)
   —Ask if anyone is wearing a polymer (rubber soled shoes, cotton, rayon, nylon, microfiber, wool, silk, polyester, athletic fabrics that wick moisture, waterproof fabrics, etc.)
   —Ask if anyone used a polymer to cook with (non-stick pans, silicone and rubber scrapers, silicone baking mats and pans, etc.)
   —Were any polymers involved in transporting you to school? (tires on the bus, synthetic leather seats, the coating on leather upholstery, the stain-resistant coating in fabric upholstery, etc.)
3. Pop the popcorn using the instructions on the worksheet. You may need to make two batches so all students have a chance to see the corn pop. Discuss the physical changes in the corn when it pops. *Heat causes the molecules inside the kernel to move faster and expand, creating steam. The steam eventually creates enough pressure for the kernel to explode.* Alternatively, use an air popper so students can observe physical change in the popcorn.
4. Grease a large mixing bowl and add popped popcorn. Cover with a clean towel or foil to keep warm while you make the syrup.
5. Grease a large mixing spoon and Set aside.
6. Before making the syrup for the popcorn balls, explain the role of corn syrup in making candy. *Corn syrup is an invert sugar, which means that it prevents sugar crystals from forming. Microscopically, sugar has jagged edges and when you melt it, sugar liquefies. But if you keep cooking it to a syrup, those jagged edges want to re-attach themselves to others, forming crystals. Corn syrup acts as interfering agent, which emulsifies the sugar (keeps the sugar crystals in suspension). Honey, agave, and other liquid sweeteners, don't have the same properties. Corn syrup also contributes to the glossy surface of candies.*
7. Combine sugar, corn syrup, butter and salt in a heavy 2-quart saucepan.
8. Stirring constantly, bring to a boil over medium heat. Continue stirring and boil 2 minutes.
9. Remove syrup mixture from heat; stir in vanilla and baking soda.
10. Pour syrup over popcorn, stirring to coat well.
11. Let the mixture cool a little while students wash their hands then coat their hands lightly with non-stick cooking spray or oil. Cooling is important - the syrup needs to become tacky for the balls to stick together.
12. Students will work quickly to press the popcorn into balls to make "popcorn polymers."
13. Cool popcorn balls completely on waxed paper or parchment before eating.

Microwave Directions:

1. Place butter, brown sugar and corn syrup in a microwave safe bowl. Cook for one minute. Stir and cook two additional minutes for chewy popcorn balls. If you like crunchy popcorn balls, cook an additional minute.
2. Remove from microwave. Stir in vanilla and baking soda.
3. Pour caramel over popcorn and stir until well coated.

Have you eaten a polymer today? Are you wearing one? Do you think you have used one? If you are not sure, maybe it is because you do not know what a polymer is. A polymer is a chemical compound that is made of small molecules which are arranged in a simple repeating structure to form a larger molecule. Most polymers melt and boil at high temperatures. Polymers are divided into two types, natural and synthetic. Synthetic also means man-made.



Many foods are made of natural polymers. Most fruits and vegetables have cellulose and simple sugars in them. Gluten holds bread together. Cornstarch and/or corn syrup give yogurt its creamy texture.

Clothes can be natural or man-made polymers. Silk clothing is a natural polymer. Silk is made by silkworms. Silk is a smooth, soft, and shiny cloth. Wool comes from sheep and goats. When they are sheared their wool is spun into thread or yarn. Cotton grows on a plant. Cotton is used to make shirts, socks, and jeans. Some clothes come from man-made fabrics. Many clothes are made from nylon. Nylon is a man-made polymer. Often, clothing, carpet, rope, and food packages are made from nylon.

Each day you most likely use man-made polymers in your home. Your parents might use non-stick pans when they cook. They might use man-made rubber scrapers to wash dishes. They may use silicone baking mats to keep cookies from sticking. The tires on your car or school bus might be man-made rubber, instead of natural rubber. If your car has fake leather seats, they are man-made, too.

Plastic Made from Corn

Cornstarch is a natural polymer. Cornstarch is made from corn. Cornstarch is being used to make a substitute for plastic. This substitute is called polylactic acid or PLA. PLA does not let off toxic fumes when burned. PLA is promoted as being biodegradable. However, it is actually compostable. It needs light, water, and heat to decompose. Once buried in a landfill, it takes just as long to break down as “regular” plastic.

It takes 4,000 gallons of water to grow a bushel of corn. Water is a limited natural resource. Water is renewable only through the water cycle. Growing corn to make plastic may not be the best environmental choice in areas where water is in short supply.

Sources: Helmenstine, Anne Marie, Ph.D. "What Is a Polymer?" ThoughtCo, Aug. 27, 2020, thoughtco.com/definition-of-polymer-605912.
West, Larry. "Pros and Cons of PLA: Corn-Based Plastic." ThoughtCo, Aug. 26, 2020, thoughtco.com/pros-cons-corn-based-plastic-pla-1203953.

A polymer is formed when several small molecules (monomers) combine. It consists of repeating structural units. Students will create their own models of polymers by making popcorn balls.

Popcorn
3 Tablespoons vegetable or coconut oil
⅓ cup popcorn kernels
Salt if desired

Polymer Syrup
1/2 cup corn syrup
1 cup sugar
1/4 cup butter
1/2 teaspoon salt
1 teaspoon vanilla
1/2 teaspoon baking soda
3 quarts (12 cups) warm popped corn

Pop the Popcorn
1. Heat the oil in a 3-quart thick-bottomed saucepan on medium high heat. If you are using coconut oil, allow all of the solid oil to melt.
2. Put 3 or 4 popcorn kernels into the oil. Wait for the popcorn kernels to pop.
3. When the kernels pop, add the rest of the 1/3 cup of popcorn kernels in an even layer.
4. Cover the pot, remove from heat and count 30 seconds. This method first heats the oil to the right temperature, then waiting 30 seconds brings all of the other kernels to a near-popping temperature so that when they are put back on the heat, they all pop at about the same time.
5. Return the pan to the heat. The popcorn should begin popping soon, and all at once. Once the popping starts in earnest, gently shake the pan by moving it back and forth over the burner.
6. Once the popping slows to several seconds between pops, remove the pan from the heat, remove the lid, and dump the popcorn immediately into greased bowl.

Make the polymer syrup
1. Combine sugar, corn syrup, butter and salt in a heavy 2-quart saucepan.
2. Grease a large mixing bowl and put in popped popcorn. Grease a mixing spoon. Set aside.
3. Combine corn syrup and sugar in a saucepan. Stirring constantly, bring to a boil over medium heat. Continue stirring and boil 2 minutes.
4. Remove syrup mixture from heat; stir in vanilla and baking soda.
5. Pour syrup over popcorn, stirring to coat well.
6. Let the mixture cool a little while students wash their hands then coat them lightly with non-stick cooking spray or oil.
7. Students will work quickly to press the popcorn into balls to make “popcorn polymers.”
8. Cool completely before eating.

Recipe

A polymer is formed when several small molecules (monomers) combine. It consists of repeating structural units. Students will create their own models of polymers by making popcorn balls.

No heat source (hot plate)? This microwave version will provide the same experience for students

Popcorn	**Microwave Polymer Syrup**
3 Tablespoons vegetable or coconut oil	1/2 cup butter, cut into pieces
⅓ cup popcorn kernels	1 cup brown sugar
Salt if desired	1/4 cup light corn syrup
	1/2 teaspoon baking soda
	1 teaspoon pure vanilla extract
	Pinch of salt

Pop the Popcorn

1. Heat the oil in a 3-quart thick-bottomed saucepan on medium high heat. If you are using coconut oil, allow all of the solid oil to melt.
2. Put 3 or 4 popcorn kernels into the oil. Wait for the popcorn kernels to pop.
3. When the kernels pop, add the rest of the 1/3 cup of popcorn kernels in an even layer.
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5. Return the pan to the heat. The popcorn should begin popping soon, and all at once. Once the popping starts in earnest, gently shake the pan by moving it back and forth over the burner.
6. Once the popping slows to several seconds between pops, remove the pan from the heat, remove the lid, and dump the popcorn immediately into greased bowl.

Make the polymer syrup

1. Lay a piece of wax or parchment paper on the counter or on a baking sheet. Place popped popcorn in a large bowl. Set aside.
2. Place butter, brown sugar and corn syrup in a microwave safe bowl. Cook for one minute. Stir and cook two additional minutes for chewy popcorn balls. If you like crunchy popcorn balls, cook an additional minute.
3. Remove from microwave. Stir in vanilla and baking soda.
4. Pour caramel over popcorn and stir until well coated.
5. Let the mixture cool a little while students wash their hands then coat them lightly with non-stick cooking spray or oil.
6. Students will work quickly to press the popcorn into balls to make “popcorn polymers.”
7. Cool completely before eating.