Binder Tab

October
Taste and Teach
October - Apples

Five Fun Facts About Apples!
• On average, Americans eat more apples than any other fruit.
• 25% of an apple’s volume is air. That’s why they float in water.
• The four leading varieties of California apples are Gala, Granny Smith, Fuji and Pink Lady®.
• It takes about 36 apples to create one gallon of apple cider.
• Apple trees are not typically grown from seed because it takes about 15 years for an apple tree to grow from a seed until it produces its first apple. Instead, most apple trees are grown by grafting. (Learn about grafting in the January section; walnut trees are also grafted.)

Four Fun Teaching Ideas!
• Watch this video on apples from General Produce: https://www.youtube.com/watch?v=0HxaCLyPQtE
• Have students read the story, The Incredible Apples. This was the sixth-grade, winning story in the 2015 Imagine this... Story Writing Contest! Then, have students write their own creative plots related to apples or another California-grown commodity. Submit the top five entries from your class to the contest by November 1, and your students will have a chance to become published authors! See details in the contest flyer, and watch videos at LearnAboutAg.org/imaginethis.
• Compare the earth to an apple! Try the Apples to Earth Ag-Bite activity.
• Have students write a poem about apples, using adjectives to describe the 5 senses. See the A is for Apples lesson plan.

Explore all the great apple resources in this section!
How Produced – Grafting, a horticultural technique that joins two plant structures together, is the first step in apple production to ensure that rootstock and varieties will bare fruit. Once planted, it takes four to five years for the tree to produce the first fruit and will produce fruit for up to 100 years. Most apple varieties are self-sterile, meaning they are unable to pollinate themselves and thus rely upon cross-pollination. The most commonly used pollinator is crab apples (also known as wild apples) in which pollination takes place in the spring, when trees are in blossom. Once pollinated, blossoms fall to the ground and small apples begin to grow in the blossom’s place.

During spring and summer, apple trees require frequent watering. Apple trees can tolerate a great deal of heat if they have sufficient water. The apple crop is harvested by hand in the fall. To insure crop production for the following year, trees must be pruned yearly in the winter to promote new vegetative growth.

History – The first documented history of apples dates back to 300 B.C. in the Persian Empire, where the cultivation and enjoyment of apples was an essential part of civilized life. In the 1400s apples were rediscovered and in the 1500s regained popularity again as a common commodity. During this time, European settlers of the Americas brought with them their English custom varieties, and the first apple orchard was planted in America. William Blackstone was the first pilgrim to plant apples trees grown in the United States in the Massachusetts Bay Colony in 1629.

In the early 1800s, stories began circulating about John Chapman, better known as Johnny Appleseed, who traveled across the Ohio Valley carrying bags of apple seeds. Venturing westward, he planted seeds and grew apple trees wherever he roamed to ensure that settlers living in the western frontier would have nutritious apples to eat. Apples have a place in more recent history, too. In 1962, the first American to orbit the Earth carried pureed applesauce to consume during the flight.

Varieties – The apple, scientifically known as Malus domestica, is a member of the rose family. California has almost 13,000 acres dedicated exclusively to apple production. California grows four main varieties: Gala, Fuji, Granny Smith, and Cripps Pink. Within the United States, roughly 2,500 varieties of apples are grown. The top 10 apple varieties grown within the United States are Red Delicious, Golden Delicious, Fuji, Granny Smith, Rome Beauty, McIntosh, Idared, Jonathan, Gala, and York Imperial.

Commodity Value – The United States’ 7,500 apple producers grow approximately 240 million bushels of apples each year on 322 thousand total acres of land. The wholesale value of the United States apple crop is approximately $4 billion annually. Worldwide, the United States ranks second to China in apple production. California ranks fourth in U.S. apple production, generating 12% of the national apple crop which is approximately 1.5 to 2.5 million (40lb.) boxes of apples per year. Seventy-five percent of the apples produced in California will be shipped domestically and 10% to 15% are exported. Canada, Malaysia, Mexico, Taiwan, and Panama are five of the 27 global destinations California exports to.

Top Producing Counties – There are five major regions in which apples are grown in California. Historically, apple production was limited to the coastal mountains, the Sierra foothills, and in the Southern California mountains. Recently apple production has expanded into the Central Valley with new plantings of Granny Smith, Fuji, Gala, and other varieties. Important coastal apple producing counties are Sonoma, Santa Cruz, and San Luis Obispo. The major apple production areas are in the San Joaquin Valley with Kern, Fresno, San Joaquin, and Madera counties being the leading producers.

Nutritional Value – One medium-sized apple provides 20% (five grams) of the daily requirement for dietary fiber, 8% of the daily requirement for vitamin C, and is a healthy source of potassium. One apple has approximately 80 calories and contains no fat, cholesterol, or sodium.

For additional information:
California Apple Commission
Phone: (559) 225-3000
Website: calapple.org
Apples Activity Sheet

From Apple Tree to You
How are apples consumed?

40% 21%
Fresh market

40% 21%
Processed into
dried fruit, baby
food, and other
products

Lesson Ideas

• Dissect and examine the anatomical parts of an apple. Observe and identify the function of each structure.
• Research and explain the aphorism "an apple a day keeps the doctor away" using nutritional information.
• Observe and practice various grafting techniques used to grow apples.
• Compare hand and machine harvesting methods. Invent a harvesting machine for apples.
• Perform experiments that show the different methods of preserving apples.
• Research and determine what the top ten apple varieties are and why they are most popular amongst consumers.
• Calculate the percentage of water weight in apples by dehydrating the fruit.
• Sprout an apple plant from a seed.

Fantastic Facts

1. The crabapple is the only apple native to North America.
2. Apples are propagated by two methods: grafting or budding.
3. The apple variety "Red Delicious" is the most commonly grown apple variety worldwide.
4. Apples are a member of the rose family.
5. Twenty-five% of an apple’s volume is air, which makes it naturally buoyant.
6. It takes the energy from 50 leaves to produce one apple.
7. World’s top apple producers are China, United States, Turkey, Poland, and Italy.
8. Archeologists have found evidence that humans have been enjoying apples since 6500 B.C.
9. Apples account for 50% of the world’s deciduous fruit tree production.
10. Two-thirds of an apple’s fiber and antioxidants are found in the peel.

Lesson Plan: Sugar or Starch

Introduction: Apples naturally contain starch also known as carbohydrates. When an apple begins its ripening process, starches are converted into sugar. This conversion process starts at the core of the apple and moves outward toward the skin. To check the ripeness of the apple an iodine test can be used to identify the amount of starch present.

Objective: Students will investigate the ripening process of apples by conducting an iodine experiment.

Standards: NGSS: 4-LS1-2, 3-5-ETS1-3; CC ELA: L.W.4-5.7

Materials: Variety of apples, iodine tincture, nitrile gloves, safety goggles, paintbrush, knife, paper plates or towels

Procedure:
1. Safety note: Iodine tincture is a hazardous material and should be handled with care. Wash hands after use and avoid contact with the eyes and skin.
2. Place individual, whole apples on labeled plates (1, 2, 3, 4, etc.) and instruct students to observe each apple’s size, color, texture, and firmness. Have students hypothesize, based on their previous knowledge, which apples are at peak ripeness.
3. Cut apples in half, displaying both sides of the apples on each labeled plate. Have students observe each apple’s internal characteristics.
4. With the paintbrush, evenly apply iodine across the cut surface of each top apple half. Let the apple sit for two minutes. Leave the other apple half untouched as a control to compare changes in each apple.
5. Observe the surfaces of the apples. Large amount of purple indicates high starch/low sugar. Little to no purple indicates low starch/high sugar.
6. Place apples on a continuum from least to most ripe. Make concluding observations.
7. Write a conclusion paragraph on your experimental findings.
Comparing Apples and... Earth?
Explore how much of the Earth’s surface is needed for growing food for a world of people.

Activity
1. Hold up an apple to the class and tell the students that it represents Earth.
2. Slice the apple into fourths. Set aside three of the fourths, as they represent water on the Earth’s surface.
3. Cut the remaining slice in half. Set aside one of the halves as uninhabited deserts, swamps and Arctic areas.
4. Divide the remaining piece into fourths. Set aside three of the pieces for land that is too rocky, wet, hot, or poor for crop production.
5. The remaining piece is $\frac{1}{32}$ of the original apple. Carefully, peel this section. Hold up the peel and explain that it represents the thin layer of soil that is available for producing all of the world’s food crops.

Classroom Discussion
- What is the key message underlying the activity?
- What actions can students take to care for their patch of this precious Earth—as individuals, as a class and school, with their families, in their community?
- How are farmers stewards of the land?
- What is sustainability? Introduce the concepts without using the word itself, which can be difficult to define. Produce concept maps based on discussion.
- How do natural resource management, farming techniques, feeding the world, land care, and environmental management play a role in food production in California or your specific region?

Materials
- Enough for each student:
  - Apple (or a paper cutout of an apple)
  - Knife
  - Chopping board or plates
  - Paper towels or wet wipes

Tip
A demonstrator could cut one apple and students eat an approximate amount.

California Standards:
- Grade 3
  - Math CC: 3.NF.1
  - NGSS: 3-LS4-4
- Grade 4
  - Math CC: 4.NF.3a, 3b
  - NGSS: 4-ESS3-1
- Grade 5
  - Math CC: 5.NF.2
  - NGSS: 5-ESS3-1

Classroom Activities
English Language Arts/History
- Have students journal about this activity, what they learned from the demonstration, and different ways they can take care of the Earth.
- Research different farming practices used in the past and create a chart with the pros and cons of each one. Report your findings to the class.

Visual and Performing Arts
- Create art stamps using different tools (paperclip, toothpick, popsicle stick) to make designs in the apple pieces. Mix paints to produce different colors and dip the stamps in paint to create art.
- Use the activity as a prompt or an example for students to produce a game, puzzle, poster or other means of delivering a similar message.
Hello, my name is Mac McIntosh, and I am the Super Duper Orchard Hero. I have three best friends, Ferris Fuji, Gary Gala, and Hank Honeycrisp. We are the Fantastic Four. My superpower is super speed. My buddy, Ferris, is the flier, Hank has super strength, and Gary can disappear into thin air and withstand harsh weather.

We grew up together in our orchard. Granny Smith took care of us. We were orphans in the beginning; four poor apples in a bushel of Red Delicious. That farmer just left us all alone because we were not the same as the others, but Granny did not care. She loved us anyway. One day, we were playing in our orchard, when we heard a truck pull up and a big cloud of dust engulfed us. We went running to see what was up. Out of the truck, rolled a fine Pink Lady®. YOWZA!! I got bit by the love bug.

After that, I was always trying to impress Penny Pink Lady®, but one day, I looked all over for her and she was missing. I knew it had to be the orchard villain, Benny Bruiser. He knew that would get to me. We had to find her, after all, she was my Pink Lady®. Penny hated Bruiser, and I knew she had to be scared.

My buddies and I got together to make a plan. It was a foggy evening; we could not see much that night. I told Ferris to fly around the perimeter of the orchard. He took Gary with him to search for any evidence. Sure enough, they saw Penny Pink Lady® tied up. She was being guarded by that crazy Apple Jack.

Gary made himself invisible to look for Bruiser. Soon, Gary signaled to us; they were four rows away. I grabbed Bruiser by his stem, spun him around faster than the speed of light. Ferris flew in and punched him right in his core and Hank turned Bruiser into apple sauce.
From that day forward, Penny was pie in my hands. We knew we were meant to be; we got married and had four super fritters of our own. We had three boys and one girl: Cortland, Jonathan, Spy, Ida, and our dog, Spartan.

We were hoping one of them would have a super power, but no… it was a complete turnover. Later in life, we did find that Spartan has the super power of elasticity—he could stretch like caramel on an apple and had the ability to poop apple dumplings. That has nothing to do with this story really, just a little crisp humor. With his elasticity power, he protects our family. Spartan is the protector of our orchard. He keeps out all of the crazy cobblers with his stretching abilities. Thanks to him, we will always be a safe bunch.

Learn more about the “Imagine this.. Story Writing Contest” by visiting LearnAboutAg.org/imaginethis!
A Is For Apples

Grade Level(s)

K - 2

Estimated Time

1.5 hours

Purpose

Students will use the five senses to investigate apples, identify and model the parts of an apple, make applesauce, and learn how apples are grown.

Materials

Activity 1: Five Senses Apple Investigation

- Red, yellow, and green apples
- Cutting board
- Knife
- 5 Senses Chart, 1 per student
- Red, yellow, and green interlocking cubes
- Apple Book Template
- Red, yellow, or green card stock, 2 pieces per student
- Lined paper, 5 pieces per student
- Hole punch
- Ribbon

Activity 2: Identifying Parts of an Apple

- Apple
- Cutting board
- Apple slicer
- Knife
- 1 set of Apple Parts Cards

Activity 3: Apple Model

- Example of Apple Model (make your own following the instructions in Activity 3)
- 4.5" x 9" yellow, red, or green construction paper
- 5" x 9" white construction paper
- 1" x 3" brown construction paper
- Brown, green, and black construction paper
- Glue sticks
- *Apple Parts Cards*, 1 set per student

**Activity 4: Making Applesauce**
- Slow Cooker
- *Crock Pot Applesauce* recipe
- Apple peeler corer slicer
- 8 tart apples
- 1 cup sugar
- 1 teaspoon cinnamon
- 2 cups water
- 2 tablespoons lemon juice
- Liquid measuring cup
- Teaspoon
- Wooden spoon
- Plastic cups, 1 per student
- Plastic spoons, 1 per student

**Essential Files (maps, charts, pictures, or documents)**
- *Crock Pot Applesauce* Recipe  
- *Apple Parts Cards*  
  [https://naitc-api.usu.edu/media/uploads/2015/11/09/Apple_Parts_Cards.pdf]
- *Apple Book Template*  
- *5 Senses Chart*  
  [https://naitc-api.usu.edu/media/uploads/2015/11/09/5_Senses_Chart.pdf]

**Vocabulary**
- **skin**: covers and protects the apple's flesh and seeds
- **flesh**: the sweet part of the apple that you can eat
- **stem**: attaches the apple to the apple tree, bringing water and nutrients to the apple
- **seeds**: can be used to grow new apple trees, but it takes a long time
- **calyx**: what is left of the apple blossom
- **orchard**: a piece of land planted with fruit trees

**Did you know? (Ag Facts)**
- On average, Americans eat more apples than any other fruit.²
- It takes about 36 apples to create one gallon of apple cider.²
- 25% of an apple's volume is air; that's why they float in water.²
Background - Agricultural Connections

The average American consumes approximately 65 apples a year. There are over 7,500 varieties of apples in the world and about 2,500 varieties are grown in the United States. Apples are the fruit of apple trees. They have green, red, pink, or yellow skin and are used to make apple juice, cider, vinegar, applesauce, and many kinds of salads and desserts.

Apple trees do grow in all 50 states, but for efficient fruit production they require a cold period called vernalization. Vernalization takes place during the cold winter months while an apple tree is dormant. Without this cold period, apple trees will not develop sufficient flower buds to produce a good crop of apples. The top three apple producing states in the US are Washington, New York, and Michigan.\(^1\) All three of these states have a significant winter season.

Apple trees are not typically grown from seed because it takes about 15 years for an apple tree grown from seed to produce an apple. Instead, most apple trees are grown by budding or grafting onto rootstocks—sections of tree roots still attached to a part of the tree trunk. Budding involves taking one bud from an existing tree branch and attaching it under the bark of a rootstock with special grafting tape or glue. Grafting is similar, but rather than a single bud, a section of a stem with multiple leaf buds is attached to the rootstock with grafting glue and tape. Grafted or budded trees usually grow in a nursery for about one year before being planted in an orchard.

An apple can be divided into several parts. The skin covers and protects the apple’s flesh and seeds. The flesh is the sweet part of the apple. The stem is what attaches the apple to the apple tree, bringing water and nutrients to the apple. The seeds can be used to grow new apple trees. The calyx is what is left of the apple blossom.

Honeybees are commonly used to pollinate apple trees. Almost all varieties of apples require cross-pollination, meaning that pollen from a different variety is needed to produce fruit. Apple trees require full sunlight and well-drained soil. Most apples are ready to harvest in the late summer or early fall.

We’ve all heard the saying, “An apple a day keeps the doctor away.” While eating apples does not guarantee good health, apples do have healthy benefits. Apples are naturally fat-, sodium-, and cholesterol-free and are an excellent source of dietary fiber and antioxidants. A medium apple contains about 80 calories and is loaded with vitamin C and beta-carotene. Be sure to eat the skin. Most of the fruit’s antioxidants, vitamin C, and fiber are located in, or just under, the skin.

Interest Approach – Engagement

1. Read the book *Up, Up, Up! It's Apple-Picking Time* by Jody Fickes Shapiro. As you read, discuss the following questions with the students:
   - Where do apples grow?
   - What colors can apples be?
   - What are apples used for?

2. After reading the book and answering the questions, transition to Activity 1 by telling students they will be learning more about about apples and their senses.

Procedures

**Activity 1: Five Senses Apple Investigation**

1. Before beginning this activity, students should wash their hands.

2. Ask students to identify their five senses—see, smell, feel, hear, taste. Explain that they will be using their five senses to observe apples. Give each student a 5 Senses Chart.

3. Show students the three different types of apples. Ask them to describe what they see. Point out the skin, stem, and calyx. The calyx is the remaining part of the apple blossom located on the end of the apple opposite of the stem. Cut an apple in half crosswise. Ask the students to describe what they see. Point out the shape of the star, the seeds in the star pockets, and the flesh. Write their descriptive words on the on the board (as pictured) under the “See” column. Explain that descriptive words are called adjectives. The
students should choose at least two adjectives to write on their own 5 Senses Chart. At the end of the activity, they will use the adjectives on their chart to write a poem about apples.

4. Cut each apple into slices. Give a green, red, and yellow slice to each student. Ask them to smell the apples and describe what they smell. Write their adjectives on the poster under the “Smell” column and have them write at least two adjectives on their chart.

5. Ask the students to feel the apple slices and describe what they feel. Write their adjectives on the poster under the “Feel” column and have them write at least two adjectives on their chart.

6. Ask the students to take a bite out of one apple slice and describe what they hear. Write their adjectives on the poster under the “Hear” column and have them write at least two adjectives on their chart.

7. Ask the students to taste each slice of apple and describe what they taste. Write their adjectives on the poster under the “Taste” column and have them write at least two adjectives on their chart.

8. Ask the students to vote on whether they like red, green, or yellow apples best by choosing a red, yellow, or green interlocking cube. Stack the cubes together by color, and create a bar graph to show the preferences of the whole class.

9. Each student will choose adjectives from their 5 Senses Chart to create a poem about apples. For each sense, they will write a sentence about the apples they were able to see, smell, feel, hear, and taste. Using the “Apple Book” template, cut a front and back cover and five pages. Write each sentence on one page of the book. Secure the book using a hole punch and ribbon.

Activity 2: Identifying Parts of an Apple

1. Prior to class, print and cut out one set of the Apple Parts Cards to use as labels throughout this demonstration. Explain to the students that they are going to learn about the different parts of an apple.

2. Cut an apple with an apple slicer. Peel the skin off of one slice. Ask students what it is. Explain that the skin covers and protects the apple’s flesh and seeds. Label the skin by placing it next to the “skin” card.

3. Show the students the peeled apple slice’s flesh. Explain that the flesh is the sweet part of the apple that you can eat. Place the flesh by the “flesh” card.

4. Pull the stem off of the apple core. Ask students what it is. Explain that the stem is what attaches the apple to the apple tree, bringing water and nutrients to the apple. Place the stem by the “stem” card.

5. Pull some seeds out of the core. Ask the students what they are. Explain that the seeds can be used to grow new apple trees. It takes a long time to grow a new apple tree from seeds. Place the seeds by the “seed” card.

6. Slice the bottom off of the core. Show the students the calyx. Explain that apples develop from flowers. The calyx is what is left of the apple blossom. Place the calyx with the “calyx” card.

Activity 3: Apple Model

1. Explain to the students that they will be making a paper model of the parts of an apple.
2. Show the students the example model. Point out each part reviewing what was taught in Activity 2. The skin covers and protects the apple’s flesh and seeds. The flesh is the sweet part of the apple. The stem is what attaches the apple to the apple tree, bringing water and nutrients to the apple. The seeds can be used to grow new apple trees. The calyx is what is left of the apple blossom.

3. Give each student two pieces of either red, yellow, or green construction paper. Have them cut the top and bottom shape of an apple and bite marks on the straight lines to represent the apple’s skin. Glue the colored papers on each end of the white rectangle, which represents the apple’s flesh.

4. Glue the brown rectangle on top of the apple to represent the stem. Cut the green paper into the shape of a leaf and attach it to the bottom of the stem.

5. Cut a brown piece of paper to form the shape of a calyx and glue it onto the bottom of the apple.

6. The black paper can be cut into the shape of seeds and attached to the flesh of the apple.

7. Cut out the Apple Parts Cards. Read the cards together and have the students each part of their apple by gluing the cards in place.

**Activity 4: Making Applesauce**

1. Before beginning this activity, students should wash their hands.

2. Explain to the students that apples are used to make apple juice, cider, vinegar, applesauce, and many different kinds of salads and desserts. Today they will be making and tasting homemade applesauce.

3. Explain the process of making applesauce to the students. Show the students the applesauce recipe, pointing out the ingredients list and directions.

4. The apples need to be peeled, cored, and sliced. Show the students how the apple peeler corer slicer works and which parts are sharp. Allow students to take turns using it to peel, slice, and core the apples.

5. Allow students to place the apples into a large slow cooker and mix in cinnamon and sugar. Several students can take turns mixing with a wooden spoon. Pour water and lemon juice over the apples. Cook on high for 3–4 hours until the apples are soft. Your classroom will smell wonderful!

6. When the apples are ready, allow students to take turns mashing the apples into applesauce using the potato masher. Give each student a cup of applesauce to taste.

**Concept Elaboration and Evaluation:**

After conducting these activities, review and summarize the following key concepts:

- Apples are a fruit that can be eaten fresh or after being made into applesauce, apple cider, or apple juice.
- Apples grow on trees.
- An area where apple trees grow is called an orchard.
- The five senses are sight, smell, hearing, touch, and taste.

**Suggested Companion Resources**

- Farm Pop-Ups (Activity)  
  [https://learnaboutag.org/matrix/resources.cfm?rid=132]
- First Apple (Book)  
  [https://learnaboutag.org/matrix/resources.cfm?rid=661]
- Bring Me Some Apples and I'll Make You a Pie (Book)  
  [https://learnaboutag.org/matrix/resources.cfm?rid=414]
- Apples for Everyone (Book) [https://learnaboutag.org/matrix/resources.cfm?rid=348]
- The Apple Pie Tree (Book) [https://learnaboutag.org/matrix/resources.cfm?rid=349]
- How Do Apples Grow? (Book) [https://learnaboutag.org/matrix/resources.cfm?rid=317]
- From Apples to Applesauce (Book) [https://learnaboutag.org/matrix/resources.cfm?rid=310]
- Apples (Book) [https://learnaboutag.org/matrix/resources.cfm?rid=206]
- Up, Up, Up! It’s Apple-Picking Time (Book) [https://learnaboutag.org/matrix/resources.cfm?rid=279]
- The Apple Orchard Riddle (Book) [https://learnaboutag.org/matrix/resources.cfm?rid=170]
- Apples (Multimedia) [https://learnaboutag.org/matrix/resources.cfm?rid=696]
- All About Apples (Website) [https://learnaboutag.org/matrix/resources.cfm?rid=664]

Sources/Credits

Author(s)
Lynn Wallin

Organization Affiliation
Utah Agriculture in the Classroom

Powered by the National Agricultural Literacy Curriculum Matrix (agclassroom.org)
Apple Genetics: A Tasty Phenomena

Grade Level(s)
6 - 8

Estimated Time
60 minutes

Purpose
Using the context of apples, students will apply their knowledge of heredity and genetics to distinguish between sexual and asexual reproduction as they explain how new varieties of apples are developed and then propagated to meet consumer demand for a tasty, uniform, consistent product.

Materials

**Activity 1:**
- Apple Genetics PowerPoint
- Apple Genetics worksheet, 1 per student

Per group of students:
- 1 Paper Plate
- 1 Whole Braeburn Apple
- 1 Whole Royal Gala Apple
- 1 Whole Jazz Apple
- 1 Knife (or apple slicer to cut apple)

**Activity 2:**

Essential Files (maps, charts, pictures, or documents)

- Apple Genetics worksheet: Teacher Key
- Apple Genetics PowerPoint
- Apple Genetics worksheet
  - [https://naitc-api.usu.edu/media/uploads/2018/12/14/Apple_Genetics_worksheet.pdf](https://naitc-api.usu.edu/media/uploads/2018/12/14/Apple_Genetics_worksheet.pdf)

Vocabulary
- **heredity:** the passing of traits from parents to offspring
- **probability:** a number that describes how likely it is that an event will occur
**Punnet Square:** a diagram used to predict an outcome of a particular cross or breeding experiment

**trait:** a characteristic that an organism can pass on to its offspring through its genes

**phenotype:** an organism's physical appearance or visible trait

**genotype:** an organism's genetic makeup or allele combinations

**recessive allele:** an allele that is masked when a dominant allele is present (written as lower case letter)

**dominant allele:** an allele whose trait always shows up in the organism when the allele is present (written as uppercase letter)

**allele:** a variant of a gene

**gene:** a section of DNA that codes for a certain trait

**heterozygous:** having 2 different alleles for a trait.

**homozygous:** having two identical alleles for a trait.

**Did you know? (Ag Facts)**

- Apples are a member of the rose family.\(^1\)
- More than 2,500 varieties of apples are grown in the United States, but only the crabapple is native to North America.\(^1\)
- The average person eats 65 apples per year.\(^1\)
- Apples are 25% air, which is why they float in water.\(^1\)

**Background - Agricultural Connections**

This lesson can be nested into a storyline as an episode exploring the phenomena of taste and other characteristics that can be observed in apples. In this episode, students investigate the question, "What makes apple characteristics different?" Phenomena-based lessons include storylines which emerge based upon student questions. Other lesson plans in the National Agricultural Literacy Curriculum Matrix may be used as episodes to investigate student questions needing science-based explanations. For more information about phenomena storylines visit nextgenstorylines.org.

Prior to this lesson, students should have a basic understanding of inherited traits and know that all cells of an organism have DNA. DNA is the blueprint providing the organism with coded instructions for proper function and development. Students should also know that **genes** are sections of DNA that are responsible for passing specific **traits** from parent to offspring. Students will need to be familiar with vocabulary such as **phenotype**, **genotype**, **homozygous**, and **heterozygous** to successfully complete the lesson and student worksheet and determine probabilities associated with possible offspring using a **Punnett Square**. Students will be introduced to several varieties of apples and discover how new varieties can be created through crossbreeding.

**Key STEM Ideas**

Genetics is the study of heredity, while **heredity** is the passing of traits from parents to offspring. This lesson will help solidify key genetics vocabulary words.

The main idea of this lesson is to show the application of genetic crossing for the benefit of agriculture by producing apples with a variety of traits.

Gregor Mendel was a priest who worked with the genetic crossing of pea plants. He would cross purebred short pea plants with purebred tall pea plants. Through his experiments he determined that some traits were visible in the plant (dominant traits) while others were not, but were still able to be passed on to future generations (recessive traits). Understanding what we see and what the genetic makeup of an organism is can be quite different. When you look at an organism, its physical characteristics are all dependent on a specific **allele** combination. This is the difference between phenotype and genotype. Students will use Punnett Squares in this lesson to help determine all the possible allele combinations in a genetic cross and their probabilities.
Crossbreeding allows breeders to create better quality apples by incorporating traits from two parent plants into the seeds of a new generation of plants. Breeders must understand both genotypes and phenotypes to accomplish this task. Breeders must also decide which traits are desirable and should be selected. This is an intensive process that involves breeding successive generations of apples with the preferred traits in order to get the final product. There are several crop modification techniques breeders use to develop new plant/fruit varieties.

Connections to Agriculture

Apples are an important agricultural crop. There are about 7,500 apple producers in the United States. Washington, New York, and Michigan are the leaders in apple production. Growers produce a variety of different kinds of apples. Some apples are better for baking while others are typically consumed fresh. Apples are a good snack choice as they satiate hunger, contain no fat and relatively few calories while being high in fiber and vitamin C.

Apples are grown through a process called grafting rather than being grown from seed. This is done because most apple varieties are self-unfruitful, which means their blossoms must be fertilized with the pollen of a separate variety in order to produce fruit. The fruit has traits from the parent tree, but the seeds inside will be a cross of the two varieties. This mixture of genetic material in the seeds means the grower won’t know what traits a tree grown from these seeds will have and what the resulting fruit will taste like.

To avoid this uncertainty apple growers do not grow new trees from seed. Instead, new apple trees are propagated through a process called grafting. In this process a special cut is made into the rootstock of a tree. Then, they graft or transplant a section of a stem with leaf buds called a scion from a variety that has desirable traits into the cut. In time the two pieces fuse together allowing for growth of the scion. Eventually, blossoms on the scion will be pollinated and will produce a consistent variety of fruit with the desired traits. For more information and pictures of the grafting process, please visit the website Apple Tree Propagation: Grafting.

The goal of apple breeding is to continuously produce quality apples with desirable traits. Cross breeding and genetic engineering are two methods that have allowed breeders to produce better quality apples. See Crop Modification Techniques.

Interest Approach – Engagement

This lesson has been adapted for online instruction and can be found on the 6-8th grade eLearning site.

1. Ask students to think about their favorite apple. Ask them why that variety is their favorite. Ask them why they think a green Granny Smith apple is so tart/sour? This should lead to a discussion about various apple traits such as sweetness, tartness, flavors, crunchiness, color, etc.

2. Tell students that there are thousands of varieties of apples grown in the United States. Most of the varieties will not be familiar to them because they are only found in orchards grown for research, the development of new apple varieties, or hobby orchards. Challenge students to try to list the top 10 apple varieties in the United States. These varieties are more likely to be familiar to your students in addition to other local varieties.

3. Ask students if they know how these different apple varieties became available.

4. Ask your students to use their understanding of heredity and genetics to explain how apple varieties could be developed. Use student responses to transition to Activity 1.

Procedures

Important This lesson investigates the phenomenon of apple taste along with other observed apple characteristics. Natural phenomena are observable events that occur in the universe that we can use our science knowledge to explain or predict.

<table>
<thead>
<tr>
<th>Question</th>
<th>Science and Engineering Practices</th>
<th>Student Engagement in Practices</th>
<th>Explanation</th>
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</thead>
<tbody>
<tr>
<td>1. How do apple characteristics differ?</td>
<td>• Planning and Carrying Out Investigations</td>
<td>Students carry out investigations to compare the Braeburn, Royal Gala, and Jazz apples. Students ask and refine questions that lead to descriptions and explanations about the different traits found in apples such as color, taste, texture, and size.</td>
<td>The traits found in apple varieties are determined by their genetic makeup, or genotype. Heritable traits are passed from parent to offspring.</td>
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<tr>
<td>2. How are new varieties of apples created?</td>
<td>• Asking Questions and Defining Problems</td>
<td>Students use science to ask and refine questions that lead to explanations about the process of selectively breeding apples to produce new apple varieties with desirable traits.</td>
<td>Apple breeders cross pollinate the flowers of specific apple varieties (sexual propagation) and then plant the seeds to obtain a tree and apples genetically different than the parent trees. It takes hundreds or even thousands of crosses, to find the desirable result.</td>
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<tr>
<td>3. What makes every apple of a given variety taste and look the same?</td>
<td>• Constructing Explanations and Designing Solutions</td>
<td>Students can use science to explain that forms of asexual propagation produce genetically identical offspring.</td>
<td>In contrast to apple breeders, apple farmers use grafting to produce new apple trees. This form of asexual plant propagation allows the genetics of each variety of apple to be exact clones, therefore producing a consistent crop of apples for consumers.</td>
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**Activity 1: Apple Genetics - Making them Different (Episode Questions 1 and 2)**

1. Give each student one copy of the *Apple Genetics* worksheet. Divide the class into small groups of students (2-4).

2. Give each group of students the following supplies:
   - 1 paper plate (this will be the cutting board as well as an area to keep the apples)
   - 1 Braeburn Apple
   - 1 Royal Gala Apple (Note: DO NOT hand out the Jazz apple yet).
   - 1 knife (or pre-slice apples)

3. Have students draw a line down the center of their paper plate and label each side with "Gala" or "Braeburn." The apples will look similar, so it will be important to avoid confusing the two apples.

4. Have students complete "Part 1" and "Part 2" of the worksheet and then stop.

5. Project the *Apple Genetics* PowerPoint for students to see. Using slide 2, hold a brief class discussion about the traits they have observed in the apples so far. Draw on the student's prior knowledge of heredity and genetics to conclude that each trait is an expression of its genotype.

6. Use slide 3 of the PowerPoint to review vocabulary if needed. Make sure students are familiar with the terms.

7. Have students complete "Part 3" of the worksheet to review the possible genotypes of the Gala and Braeburn apples. These genotypes can be found on the worksheet and slide 4-5 of the PowerPoint.

8. Once students have finished their Punnet squares, give each group of students a Jazz apple. Students will follow the same procedure and complete "Part 4" and "Part 5" of the worksheet.

9. Facilitate a class discussion about the 3 varieties of apple (slide 6). Reveal to the students that the Jazz apple is a cross between the Gala and Braeburn apple. Using slide 7, share a few more facts about the Jazz Apple.

10. Talk about the concept of crossbreeding and how it is used to produce better quality organisms (slide 8).

11. Explain that the Honeycrisp apple (slide 9) was also developed by crossbreeding, and is a competitor of the Jazz apple.
12. Summarize with students by connecting what they know about genetics with what they have learned about apples:
   - Genes determine genetic traits found in apples such as color, taste, and texture.
   - To develop a new, improved variety of apple, apple breeders cross pollinate apple varieties. This form of sexual reproduction results in an offspring (seed) that is genetically different from the parent trees.
   - Scientists use a knowledge of genetics and heredity to cross breed apples and produce new varieties of apples. The Jazz and Honeycrisp apples are examples.

Important

Three Dimensional Learning Proficiency: Crosscutting Concepts
Students engage in scientific investigation as they investigate and build models and theories about the natural world.

Stability and Change: For both designed and natural systems, conditions that affect stability and factors that control rates of change are critical elements to consider and understand.

Activity 2: Apple Genetics - Keeping Them the Same (Episode Question 3)

1. Ask students if they have ever eaten Jelly Belly jelly beans. Have they ever eaten or heard of the Jelly Belly jelly beans that have "bad" flavors like toothpaste, stinkbug, or stinky socks? (Perhaps in the game Beanboozled.) While this may be a fun game or practical joke, have a discussion with your students about what they (as consumers) want in their food. Conclude that every time they purchase milk, meat, bread, vegetables... or an apple, they want it to taste consistently the same without surprises.

2. Students have just learned how new varieties of apples are created. Ask, "How do apple farmers all across the nation grow specific varieties of apple that all taste and look the same? For example, how does a Granny Smith always taste like a Granny Smith and a Gala always taste like a Gala?" Does a [Granny Smith] grown in one region of the country taste the same as a [Granny Smith] grown in another region of the country?

3. To discover the answer, show Apple - How Does it Grow?

4. From the video, students should recognize grafting as the answer to the question. Apple farmers do not grow trees from seed, they use a technique called grafting (slide 10).

5. Ask students, "What is the genetic similarity of two trees grafted from the same source?" (They are genetically identical clones. Therefore, every apple tree grafted from the same source will produce apples with the same genetic makeup.)

6. Summarize with students by connecting what they know about genetics with what they have just learned about apples:
   - Grafting, a form of asexual propagation is used by apple farmers to produce the apples we eat. It produces apples consistent to consumer expectations for each variety of apple by eliminating the genetic variability of sexual propagation methods.
Important In addition to growing a consistent apple crop, farmers use grafting to propagate apple trees because it is significantly faster than growing a tree from seed. An apple tree grown from seed will take 6-10 years to produce fruit. A grafted apple tree will take 2-3 years depending on the type and size of the graft.

Concept Elaboration and Evaluation:
After completing these activities, have students create a Venn Diagram to list both the similarities and differences found in sexual and asexual propagation methods. Discuss the benefits and drawbacks of each.

Phenomena Episode Extensions:
Effective phenomena-based instruction continues to evolve as students learn. New questions should arise throughout the learning process. The following questions may arise providing opportunity for other episodes in this storyline:
- Why can other fruits and vegetables be propagated with sexual reproduction (seeds) and produce a consistent crop, but apples cannot?
- What makes an apple (such as the Honeycrisp) crunchy?
- How was the Opal apple selectively bred to not brown after it is cut?
- How was the Arctic® apple genetically engineered to be non-browning?

Important We welcome your feedback! Please take a minute to tell us how to make this lesson better or to give us a few gold stars!

Enriching Activities
- Show the 4-minute video clip, Have We Engineered The Perfect Apple? to see the science behind the taste of the Honeycrisp apple.
- Listen to the NPR podcast "The Miracle Apple."
- If cut apples are in the room at the end of the lesson, ask students if they see any browning occurring. Discuss what causes this. Teach students about Arctic apples, a genetically modified apple which does not brown. Compare and contrast to the Opal apple, an apple variety selectively bred to be non-browning.
- Watch The Apple That Changed the World.
Suggested Companion Resources

- How CRISPR Lets You Edit DNA (Multimedia)
  [https://learnaboutag.org/teacher/matrix/resources.cfm?rid=968]
- Have We Engineered the Perfect Apple? video (Multimedia)
  [https://learnaboutag.org/teacher/matrix/resources.cfm?rid=839]
- America’s Heartland: Maine-ly Apples (Multimedia)
  [https://learnaboutag.org/teacher/matrix/resources.cfm?rid=663]
- How Mendel’s Pea Plants Helped Us Understand Genetics (Multimedia)
  [https://learnaboutag.org/teacher/matrix/resources.cfm?rid=342]
- Phenomenon (Website)
  [https://learnaboutag.org/teacher/matrix/resources.cfm?rid=960]
- Genetic Science Learning Center (Website)
  [https://learnaboutag.org/teacher/matrix/resources.cfm?rid=255]

Sources/Credits

Activity 1 was originally written in the lesson "Apple Genetics" written by Kevin Atterberg (Culler Middle School, Lincoln NE), Erin Ingram, and Molly Brandt (University of Nebraska-Lincoln, IANR Science Literacy Initiative). The lesson was updated in 2018 to follow a phenomena-based format.

Phenomenon chart adapted from work by Susan German.

Ag Fact Sources:
2. https://extension.illinois.edu/apples/facts.cfm

Author(s)
Kevin Atterberg, Erin Ingram, Molly Brandt, Andrea Gardner, and Debra Spielmaker

Organization Affiliation
National Center for Agricultural Literacy