The Science of Apples

Two 50-minute class periods.
5 stations, 15-20 minutes per station

Grades 9-12

Purpose

This activity serves as an introduction to apple production and biotechnology. This lesson is best done in the fall when more apple varieties are available. Students will gain an appreciation for the variety and importance of apples by completing stations describing the history, production, and science behind one of America's favorite fruits. Stations will be set up around the classroom. At each station there will be a food relevant to the specific station. Background information and challenge questions for students will also be at each station.

Academic Content Standards

MN K-12 Academic Standards and Benchmarks

Science

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

9.4.3.3.4 Explain why genetic variation within a population is essential

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

National Agricultural Literacy Outcomes

Science, Technology, Engineering, and Mathematics

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

Grade Level 9-12

Materials

Food items, equipment and information for each station

Station 1:

- Crabapples or Apple Cider
- Johnny Appleseed/John Chapman biography - this can be accessed at: https://minnesota.agclassroom.org/educator/sclb.cfm

Station 2:

- iPad or device to view video
- How Does it Grow? Apples video accessible at: https://minnesota.agclassroom.org/educator/sclb.cfm

Station 3:

- Applesauce Making materials:
  - 3 golden delicious apples, peeled, cored, and quartered (coat apples with lemon juice to prevent browning if apples are prepped ahead of time)
  - 1 cup apple juice (unfiltered)
  - 2 tablespoons butter
  - If desired: cinnamon, vanilla, nutmeg, maple syrup, brown sugar, or honey
  - Microwave
  - Sealable, microwave-safe container
  - Hand blender or potato masher

Station 4:

- Honeycrisp, Zestar!, and SweeTango apples (or other University of Minnesota developed varieties such as Minnehaha, SnowSweet, and Frostbite)

Station 5:

- Arctic Apple (GM apple) and non-GM apples (all other apples)
- iPad or device to view video
- The following videos, accessible at: https://minnesota.agclassroom.org/educator/sclb.cfm
  - What is Genetic Engineering? video
  - What does GMO mean? video
  - Arctic® Apples video
  - Arctic® Apple 24 Hour Time-Lapse video

All Stations:

- Paper plates, utensils as needed
- Informational 3x5 cards
- Challenge Questions on 3x5 card
- Each student must have a piece of paper and a pencil to record their answers to the challenge questions.

Background—Agricultural Connections

Apples are a popular Minnesota crop that students enjoy eating and learning about. Apples also offer an authentic learning connection into scientific concepts such as investigating states or phases of matter, exploring methods of plant propagation, discovering applications of plant breeding techniques, understanding genetics and heredity, and biotechnology. In this lesson, students are asked to rotate between five stations that introduce them to these scientific connections as well as allow them to sample apple varieties important to Minnesota agriculture.

Interest Approach - Engagement

Raise your hand if you have recently eaten a Red Delicious apple. What did it taste like? Raise your hand if you have recently eaten a Honeycrisp apple. What did it taste like? What are the differences? What qualities make a good apple?"

After students have given a few answers tell them "Today we are going to learn where apples came from, how they got so delicious, and what they might be like in the future."

Procedures:

The teacher must set up stations around the classroom prior to the beginning of class. Each station will depict a specific facet of apple production and processing throughout the past and present. Videos for the Apple Production station and the Apple Engineering station will need to be loaded onto devices prior to class.

The stations to be represented are:

1. Apple History
2. Apple Production
3. Apple Processing
4. Apple Exploration
5. Apple Engineering

The apple stations should be set up as follows:

- Food sample related to topic area, enough for each student to sample the food. For example, Apple History may utilize crabapples with approximately 1 slice per student.
- Any appropriate cup, plate, or utensil needed to sample the food.
- Informational card: Each station has an information card which discusses the food available at the station, background information, and instructions for students.
- Student Challenge Questions card: Each station has a card which has several questions for students to answer.
- Alternatively, Station 5 could be completed with the entire class and include a class discussion on the benefits and drawbacks of genetic engineering and GMO foods.

After the Interest Approach:

- Provide students a brief overview of the stations and provide instructions on how and when they will rotate.
- Divide the class into five groups (group size dependent on class size)
- Instruct students to bring a piece of paper and pencil with them to record their answers to the challenge questions at each station.

Each group will begin at a different station. The group will sample the food, read the information card, complete any instructions listed, and answer the questions on the challenge card. Students should have approximately 10 to 15 minutes at each station. The teacher should announce when it is time to switch stations. Groups should move in a sequential direction so that all groups get to all five stations.

Station 1

Apple History

Suggested Food: Crab Apples or Apple Cider

Info Card: Can you imagine life without sweet, delicious apples? In the early years of America, there was no such thing because the crabapple is the only apple native to North America. Most of us know the story of Johnny Appleseed, a nomad who traveled across the United States randomly dispersing apple seeds. However, the story of the real Johnny Appleseed is a little different.

Read the short biography of Johnny Appleseed/John Chapman. (See Materials section for access to these biographies.)

Challenge Questions: Use information from the biography and info card to answer the following questions.

- What are the similarities and differences in the tale of Johnny Appleseed and the real life of John Chapman? *(Chapman planted for profit, Appleseed planted randomly. Chapman's crops were used for hard cider, Appleseed planted modern apples. Both planted seeds rather than grafting.)*
- What were apples mainly used for in the 1700s and 1800s? *(Making hard cider)*
- Why is this? *(The apples were tart and inedible, but suitable for fermenting into cider)*
- How have apples changed since then? *(Using European varieties, selective breeding, and grafting has brought large, sweet, and delicious apples to the United States.)*

Station 2

Apple Production

Info Card: Apples today are not the same as apples from hundreds of years ago. Apples have been selectively bred for thousands of years to produce the varieties that we know today. Apple breeders, unlike farmers, plant apple trees from seed ONLY to find and develop new traits. Apple trees in most orchards are not grown from seeds. Watch the video *How Does it Grow? Apples* to learn more about how apples are grown. (See Materials section for access to this video.)

Challenge Questions: Use information from the video and info card to answer the following questions.

- Why don't farmers grow apples from seed? *(Each seed is genetically unique, meaning that when it grows into a mature tree, the apples it produces will be different from those produced by its parent trees.)*
- List some desirable traits in apple trees that may be developed through breeding from seed. *(can tolerate cold temperatures, grows fast, strong tree branches, produces big apples, juicy apples, sweet apples, crisp apples.)*
- What is grafting? *(The process of joining a cut stem—or bud—with the trunk of another tree so that the two grow together.)*
- Why do apple farmers graft their trees? *(Grafting* allows farmers to "clone" the apple trees that produce the fruit they want. A grafted branch has the same genetic makeup as the tree it was taken from.)*

*Grafting is an important process in growing apple trees. If you would like to spend more time on this topic with your students look here: https://www.extension.umn.edu/garden/yard-garden/fruit/grafting-and-budding-fruit-trees/

Station 3

Apple Processing

Suggested Food: Student made applesauce

Info Card: One reason apples are so popular is because of their high water content. Apples are made up of 85% water and 10% sugar. How do you think temperature and time can be used to create a "sauce" or liquid version of apples? The main difference between phases is due to amount of energy and arrangement of molecules. Solids have tightly bound molecules that vibrate due to their packed nature and lower energy. Liquids have freely moving atoms and a higher energy state than solids. Explore the difference between liquids and solids by making applesauce!

Applesauce Recipe:

Ingredients

3 apples, peeled, cored, and quartered (coat apples with lemon juice to prevent browning if apples are prepped ahead of time)

1 cup apple juice (unfiltered)

2 tablespoons butter

If desired, include honey, cinnamon, nutmeg, vanilla, brown sugar, molasses, or maple syrup, to experiment with flavors. Students may also experiment by leaving the apple peels on to test different textures.

Directions

1. In a sealable microwave-safe container, combine the apples with all other ingredients.
2. Close the lid, leaving one corner of it open to allow steam to escape. Microwave on high power for 7 minutes.
3. Using a hand blender or potato masher, blend to desired consistency.

Challenge Questions:

- Explain how and why the change from solid to liquid states occurs.
- Compare and contrast the characteristics of liquids and solids. List two characteristics of solids and two characteristics of liquids. *(Solids: definite shape, atoms packed closely together, lower energy, particles vibrate. Liquids: shape changes to fit container, atoms can move freely, higher energy)*

Station 4

Apple Exploration

Suggested Food: Honeycrisp, Zestar!, and SweeTango apples (or other University of Minnesota developed varieties such as Minnehaha, SnowSweet, and Frostbite)

Info Card: The fruit breeding program at the University of Minnesota has developed many well-known apple cultivars. The first variety, **Minnehaha**, was introduced in 1920. More recently, you may have heard of **Honeycrisp**, which was introduced by the University of Minnesota in 1991. Since then **Zestar!**, **Frostbite**, **SnowSweet**, and **SweeTango** have also been introduced to the market.

Cut each apple into small sections and compare and contrast the characteristics among the apples. Pay attention to the texture (crunchy, juicy, etc.) of the apple as well as the flavor. Record your observations. Determine your favorite apple by evaluating taste, texture, browning, and other characteristics. Discuss the variations observed between different apple varieties. These variations are examples of traits that can be passed from parent to offspring.

Challenge Questions:

- What were your favorite apple characteristics?
- If you could create the perfect apple, which varieties would you use and why?

Station 5

Apple Engineering

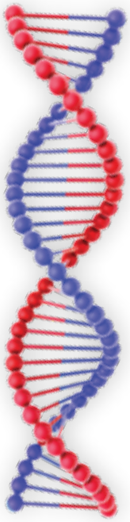
Suggested Food: Arctic Apple (if possible) and non-GM apple (all other apples)

- If these foods are available, complete a taste test. If not, simply complete videos and questions.

Watch the videos What is Genetic Engineering? and "What does GMO mean?"

Next, watch "Arctic Apples" and "Arctic® Apple 24 Hour Time-Lapse". (See Materials section for access to these videos.)

Challenge Questions:



- Viewing the videos "What is Genetic Engineering" and "What Does GMO Mean?" should help you understand more about how GMOs are developed along with potential benefits and drawbacks.
  - What are some benefits of GMOs? *(faster growing crops, nutrient enhanced foods, resistance to herbicides and pesticides, proven safe in all current studies)*
  - What are some drawbacks of GMOs? *(cross contamination aka gene flow, potential new health sensitivities.)*
- After viewing the "Arctic Apple" videos answer the following questions:
  - What are the benefits of the arctic apple? *(Reduces food waste & prevents browning.)*

– What are the drawbacks? *(Consumer pushback to GMOs)*

Here are some examples of other genetically engineered products scientists are working on: foods with enhanced nutrients to prevent deficiencies and disease, salmon that grow larger and faster, lower fat French fries, and pest resistant crops.

- List your favorite apple. What is a new trait that would improve it?
- List your least favorite apple. What is a new trait that would improve it?
- Do you think changing foods through genetic engineering is ok? Why or why not?

Review

After completing the stations, lead a class discussion using the student responses to the challenge questions as a starting point.

Review and summarize the following key concepts:

- Apples have a long history of importance and selective breeding in the United States.
- Most apple trees today are grown through grafting to reduce the genetic variability that seeds would create.
- In apples, characteristics such as color, texture, sweetness/tartness, juiciness, and crunchiness are determined by the genetic make-up of the apple.
- Scientists use a knowledge of genetics and heredity to cross breed apples to produce new varieties of apples.
- Genetic engineering is a tool used in plant and animal breeding. Apples, along with other plants and animals, have been genetically engineered with useful traits.

Enriching Activities:

- Have students interview your school's staff and administration about their knowledge and opinions on genetically engineered products.
- Tour a local apple orchard to view apple production first hand.
- Practice grafting with apple trees, bring in a community expert for additional help.
- Pair students and assign each pair a breeding technology. Have them research and present their findings in a gallery walk.

Station 1 Information Card

Can you imagine life without sweet, delicious apples? In the early years of America, there was no such thing because the crabapple is the only apple native to North America. Most of us know the story of Johnny Appleseed, a nomad who traveled across the United States randomly dispersing apple seeds. However, the story of the real Johnny Appleseed is a little different.

Read the short biography of Johnny Appleseed/John Chapman.

Station 1 Challenge Questions

Use information from the biography and info card to answer the following questions.

1. What are the similarities and differences in the tale of Johnny Appleseed and the real life of John Chapman?
2. What were apples mainly used for in the 1700s and 1800s?
3. Why is this?
4. How have apples changed since then?

Station 2 Information Card

Apples today are not the same as apples from hundreds of years ago. Apples have been selectively bred for thousands of years to produce the varieties that we know today. Apple breeders, unlike farmers, plant apple trees from seed ONLY to find and develop new traits. Apples trees in most orchards are not grown from seeds.

Watch the video ***How Does It Grow? Apples*** to learn more about how apples are grown. Afterwards, complete the challenge questions.

Station 2 Challenge Questions

Use information from the video and info card to answer the following questions.

1. Why don't farmers grow apples from seed?
2. List some desirable traits in apple trees that may be developed through breeding from seed.
3. What is grafting?
4. Why do apple farmers graft their trees?

Station 3 Information Card

One reason apples are so popular is because of their high water content. Apples are made up of 85% water and 10% sugar. How do you think temperature and time can be used to create a "sauce" or liquid version of apples? The main difference between phases is due to amount of energy and arrangement of molecules. Solids have tightly bound molecules that vibrate due to their packed nature and lower energy. Liquids have freely moving atoms and a higher energy state than solids. Explore the difference between liquids and solids by making applesauce!

Applesauce Recipe

Ingredients:

3 apples, peeled, cored, and quartered (You may experiment with texture by keeping the peels on your apple.)

1 cup apple juice (unfiltered)

2 tablespoons butter

Directions:

1. In a sealable microwave-safe container, combine the apples with all other ingredients.
2. Close the lid, leaving one corner of it open to allow steam to escape. Microwave on high power for 7 minutes.
3. Using a hand blender or potato masher, blend to desired consistency.

Station 3 Challenge Questions

Use the information from the info card along with your background knowledge of liquids and solids to answer the following questions.

1. Explain how and why the change from a solid to a liquid occurs.
2. Compare and contrast the characteristics of liquids and solids by listing two characteristics of solids and two characteristics of liquids.

Station 4 Information Card

The fruit breeding program at the University of Minnesota has developed many well-known apple cultivars. The first cultivar, **Minnehaha**, was introduced in 1920. More recently, you may have heard of **Honeycrisp**, which was introduced by the University of Minnesota in 1991. Since then, **Zestar!**, **Frostbite**, **SnowSweet**, and **SweeTango** have also been introduced to the market.

Cut each apple into small sections and compare and contrast the characteristics among the apples. Pay attention to the texture (crunchy, juicy, etc.) of the apple as well as the flavor. Record your observations. Determine your favorite apple by evaluating taste, texture, browning, and other characteristics. Discuss the variations observed between different apple varieties. These variations are examples of traits that can be passed from parent to offspring.

Station 4 Challenge Questions

1. Describe the characteristics of each apple cultivar (appearance, taste, texture, sweetness, browning, and any additional comments).
2. Which characteristics did you like the best?
3. If you could create the perfect apple, which varieties would you use and why?

Station 5 Information Card

1. Watch "What is genetic engineering?"
2. Watch "What does GMO mean?"
3. Watch "Arctic Apples"
4. Watch "Arctic® Apple 24 Hour Time-Lapse"
5. Answer the Challenge Questions on the Next Card

Station 5 Challenge Questions

Viewing the videos "What is Genetic Engineering?" and "What Does GMO Mean?" should help you understand more about how GMOs are developed along with potential benefits and drawbacks.

1. What are some benefits of GMOs?
2. What are some drawbacks of GMOs?

After viewing the "Arctic Apple" videos answer the following questions:

1. What are the benefits of the arctic apple?
2. What are the drawbacks?

Here are some examples of other genetically engineered products scientists are working on: foods with enhanced nutrients to prevent diseases, salmon that grow larger and faster, lower fat French fries, and pest resistant crops, etc.

1. List your favorite apple. What is a new trait that would improve it?
2. List your least favorite apple. What is a new trait that would improve it?
3. Do you think changing foods through genetic engineering is ok? Why or why not?