Apple Genetics
Teacher Resources

Summary
In this standards-aligned, 5-E life science lesson plan, students will learn about apple production. Students will learn where apples are grown, how apples are grown, varieties of apples, and health benefits of eating apples. Students will explore crossbreeding with a hands-on activity in which they will observe three apples. Students will record characteristic they notice in different varieties of apples. Students will use Punnett squares to predict the results of genetic crosses and determine the genotypes and phenotypes of apples in a particular cross.

Grade Level
6-8

Contents address the following Next Generation Science Standards
- MS-LS4-5. Gather and synthesize information about technologies that have changed the way humans influence the inheritance of desired traits in organisms

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Background

Standards

Next Generation Science Standards
- MS-LS4-5. Gather and synthesize information about technologies that have changed the way humans influence the inheritance of desired traits in organisms

Common Core

CCSS.ELA-Literacy.CCRA.R.7
- Integrate and evaluate content presented in diverse media and formats, including visually and quantitatively, as well as in words.

CCSS.Math.Content.7.SP.C.7
- Develop a probability model and use it to find probabilities of events. Compare probabilities from a model to observed frequencies; if the agreement is not good, explain possible sources of the discrepancy.

Estimated Time

One 60-minute class period

Student Materials

Per Student:
- 1 Apple Observations sheet

Per Group of 2 or more:
- 1 Paper Plate
- 1 Whole Braeburn Apple (must be)
- 1 Whole Royal Gala Apple (must be)
- 1 Whole Jazz Apple (must be) *Jazz apples can be found at most grocery stores. The link shows which retailers sell Jazz apples. https://jazzapple.com/get-me/where-buy*
- 1 Knife (to cut apple)
- 1 Sheet of Paper (Printer or Notebook paper)

Vocabulary

- **gene:** a section of DNA that codes for a certain trait
- **allele:** a variant of a gene
- **dominant allele:** an allele whose trait always shows up in the organism when the allele is present (written as uppercase letter)
- **recessive allele:** an allele that is masked when a dominant allele is present (written as lower case letter)
- **genotype:** an organism's genetic makeup or allele combinations.
- **phenotype:** an organism's physical appearance or visible trait.
- **Punnett Square:** a diagram that is used to predict an outcome of a particular cross or breeding experiment
- **probability**: a number that describes how likely it is that an event will occur
- **heredity:** the passing of traits from parents to offspring

- **trait:** a characteristic that an organism can pass on to its offspring through its genes
- **homozygous:** having 2 identical alleles for a trait
- **heterozygous:** having 2 different alleles for a trait

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 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 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.

Students' Prior Knowledge

Students should 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 understand that genes are sections of DNA that are responsible for passing on traits from parent to offspring. Students will need to be familiar with vocabulary such as phenotype, genotype, homozygous, and heterozygous to successfully complete the student worksheet. Students will determine probabilities associated with possible offspring using Punnett Squares. Students will be introduced to varieties of apples. Students may have some knowledge associated with crossbreeding. This lesson will focus on crossbreeding apple 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 used for baking while others are used for eating. Apples are a good snack choice as they 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, growers make a special cut on 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. The two pieces will fuse together allowing for growth of the scion. Eventually, blossoms on the scion will be pollinated and will produce fruit with the desired traits. For more information and picture of the grafting process, please visit: http://articles.extension.org/pages/60602/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.

Essential Links

- Fun Facts: http://www.care2.com/greenliving/22-fun-facts-about-apples.html
- Jazz Apple Website: http://www.jazzapple.com/

Sources/Credits

Apple Facts
- http://www.care2.com/greenliving

Pictures on slideshow
- http://www.usapple.org/index.php?option=com_content&view=article&id=179&Itemid=285
- https://fnic.nal.usda.gov/food-composition/food-fyi/apples
- http://holykaw.alltop.com/the-spectrum-of-apple-flavors-infographic
- http://www.heinens.com/departments/produce/seasonal-best-apples/apple-varieties/
- http://www.writerguy.com/deb/compost/2011Winter/WinterNws10-2011.html
- http://www.homengardeningtips.com/grafted-fruit-trees
- http://www.honeycrisp.com/honeycrisp.html
- http://www.vegetablegardener.com/item/9740/here-comes-honeycrisp-apple-season
- http://www.arcticapples.com/

Lesson Procedures

Engage: Introduction Activity

1. Begin lecture by asking students what their favorite apple is. Ask them why that is their favorite apple. You may even consider having students bring their favorite apple to class.
2. Use slide 2 to give students a brief background on apple production in the United States and world.
3. Share interesting facts about apples (slide 3) with students to give them some general background with this agricultural product.
4. Highlights the nutritional benefits of apples (slide 4). Encourage students to eat an apple as a snack.
5. Bring up the discussion earlier about students' favorite apples. Using slide 5, show students a few different varieties of apples. Ask students if they prefer their apples to be sweet or tart.
6. Introduce the concept of grafting. Make sure students realize that most apple trees are not grown from seed. This is shown in slide 6.

Explore: Part 1 – Apple Observations

7. Give each student their own observation worksheet.
8. Be sure to wash all apples prior to distributing them to the students.
9. Per group of 2 or more students hand out:
   - 1 paper plate (this will be the cutting board as well as an area to keep the apples)
   - 1 Braeburn Apple and 1 Royal Gala Apple (Note: DO NOT hand out the Jazz apple).
   - 1 knife (or have apples already pre-sliced)
   - 1 sheet of paper (This is where students are able to place seeds or other apple particles).
10. 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 and it will be important to avoid confusion when making observations.
11. Have students make observations and record them for both the Royal Gala and Braeburn in the following order (slide 8):
    a. Look, Smell, Touch OUTSIDE of the apple
    b. Cut open and Look, Smell, Touch the INSIDE of the apple
    c. Finally, Taste the apple
12. To cut the apple: Have students hold their apples so the stems are pointing towards them (laying on their side) slice open the apples with a crosscut. Then, have students cut their apple again making it into fourths.
13. After Students have their observations complete they should move onto the Analyzing the Data portion.

Explore: Part 2 – Analyzing the Data

14. Students should find the similarities and differences found between the 2 apples. Facilitate a group discussion using slide 9 so students can share their findings.
15. Review basic genetics vocabulary with students using slide 10. Make sure students are familiar with terms. Instruct them that they will be applying genetics knowledge to apple situations.

Explain: Part 3 – Completing Punnett Squares

16. Have students review the possible genotypes of the Gala and Braeburn apples. These can be found on the worksheet and slide 11 of the presentation.
17. Have students complete Punnett squares on page 3 of worksheet for 6 characteristics of the apples. Students will determine possible probabilities of genotypes.

Extend: Part 4 – Jazz Apple Observations

18. Once the combinations and probabilities are finished hand out the Jazz apple. Students will follow the same procedure and complete page #4 of worksheet.

Extend: Part 5 – Comparing all 3 Apples

19. Once completed with the observations for the Jazz apple have students use their previous data from the Royal Gala and Braeburn apples and the observations from the Jazz apple to find out how they are connected through genetic crossing. Facilitate a class discussion using slide 14. Students will record findings on part 5 of worksheet.
20. Reveal that the Jazz is a cross between the Gala and Braeburn apple. Using slide 15, share a few more facts about the Jazz Apple.
21. Talk about the concept of crossbreeding and how it is used to produce better quality organisms on slide 16.
22. The Honeycrisp apple was also developed by crossbreeding, and it is a competitor of the Jazz apple. Share some facts from slide 17 with students.
    a. Genetic engineering allows breeders to produce better quality apples.
    b. Arctic apples have been developed which are a non-browning apple.
    c. If cut apples are in the room, ask students if they see browning occurring.

Apple Genetics: Answer Key
Part 1: Comparing Royal Gala and Braeburn Apples

	Royal Gala Apple	Braeburn Apple
Look	Explain what you observe on the outside and inside of this particular apple. Write down what you notice, stem structure, seed layout, and coloring.	
Outside of Apple	Red with green speckles, some yellow to green areas, shorter and fatter	Red with green speckles, some yellow to green areas, taller and skinnier
Inside of Apple	White color	White color
Smell	Explain what you observe using your sense of smell.	
Outside of Apple	Little to no smell, smells like apple	Little to no smell, smells like apple
Inside Of Apple	Smells a little like a pumpkin	Nothing distinctive
Touch	Explain what you observe about the texture of the apple. i.e. skin, meat, seed, stem	
Outside of Apple (Texture)	Waxy and smooth	Waxy and smooth
Inside of Apple (Number of seeds and seed shape)	Answers may vary (6-10 seeds is common), teardrop shape	Answers may vary (6-10 seeds is common), teardrop shape
Taste	Explain what you observe when you taste your apple.	
Tartness	Less tart	More tart
Sweetness	More sweet	Less Sweet
Juiciness	Less juicy	Very juicy
Crunchiness	Very crunchy	Very crunchy

Part 2: Analyzing the Data:

1. Explain what similarities you found in the Royal Gala and Braeburn apples?

Both had similar exteriors visually, smell. Both were juicy, crunchy apples good for eating.

2. Explain what differences you found in Royal Gala and Braeburn apples?

Gala was sweeter and less tart, less juicy, and smelled a little like pumpkin while the Braeburn was more tart, less sweet, didn't smell like much of anything, and was VERY juicy and crunchy.

Part 3: Completing Punnett Squares

When making observations in Part 1, you described traits for each apple such as color, juiciness, or sweetness. These traits are determined by the genes in the apple. If we were to crossbreed blossoms on a Royal Gala apple tree with pollen from a Braeburn apple tree, the resulting fruit would look, smell, taste, and feel like a Royal Gala apple, but the seeds inside would possess genes from both of these parents. The seeds could be planted and grown into a new hybrid with fruit that has traits of both the Royal Gala and Braeburn apple.

In this activity, we will imagine that the traits you observed are determined by Mendelian inheritance in which a single gene determines a trait. Each trait is dominant or recessive and the alleles passed down from the parents determine whether the trait will be observed in the offspring. Below are examples of genotypes that the Gala and Braeburn apples may possess.

NOTE: These genotypes are to be used as examples only and do not represent accurate genotypes.

You will use this information to complete Punnett Squares on the following page and calculate probabilities for each genotype.
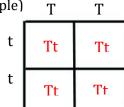   a. Tartness is recessive (Gala's genotype is TT, Braeburn's genotype is tt)
   b. Sweetness is recessive (Gala's genotype is ss, Braeburn's genotype is SS)
   c. Juiciness is dominant (Gala's genotype is JJ, Braeburn's genotype is JJ)
   d. Crunchiness is dominant (Gala's genotype is Cc, Braeburn's genotype is CC)
   e. Red skin coloring is dominant (Gala's genotype is RR, Braeburn's genotype is Rr)
   f. Smooth skin texture is dominant (Gala's genotype is Bb, Braeburn's genotype is Bb)

Complete the Punnett Squares and calculate the probability of each genotype for all traits.
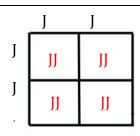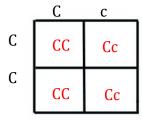
Tartness: (Example)

	T	T
t	Tt	Tt
t	Tt	Tt

Probability of offspring genotypes:

TT= _____0%__

Tt= ____100%_

tt= _____0%__

Sweetness

	s	s
S	Ss	Ss
S	Ss	Ss

Probability of offspring genotypes:

SS= ____0%____

Ss= ____100%____

ss= ____0%____

Juiciness

	J	J
J	JJ	JJ
J	JJ	JJ

Probability of offspring genotypes:

JJ= ___100%_____

Jj= ____0%____

jj= ____0%____

Crunchiness

	C	c
C	CC	Cc
C	CC	Cc

Probability of offspring genotypes:

CC= ____50%____

Cc= ____50%____

cc= _____0%___

Red Skin Coloring

	R	R
R	RR	RR
r	Rr	Rr

Probability of offspring genotypes:

RR= __50%_____

Rr= __50%_____

rr= ___0%_____

Smooth Skin Texture

	B	b
B	BB	Bb
b	Bb	bb

Probability of offspring genotypes:

BB= ___25%_____

Bb= ___50%_____

bb= ___25%_____

Part 4: Jazz Apple Observation

Observe and record observations of the traits of the Jazz apple.

Jazz Apple Observations	
Look	Explain what you observe on the outside and inside of this particular apple. Write down everything you notice, stem structure, seed layout, and coloring.
Outside of Apple	Red apple with yellow patches and yellow dots
Inside of Apple	White color
Smell	Explain what you observe using your sense of smell.
Outside of Apple	Little to no smell, smells like apple
Inside Of Apple	Nothing distinctive
Touch	Explain what you observe about the texture of the apple. i.e. skin, meat, seed, stem
Outside of Apple	Waxy and smooth
Inside of Apple	Answers may vary (6-10 seeds is common), teardrop shape
Taste	Explain what you observe when you taste your apple.
Tartness	Tart, but not as Tart as Braeburn
Sweetness	Sweet, but not as sweet at Gala
Juiciness	VERY Juicy
Crunchiness	VERY Crunchy

Part 5: Comparing Royal Gala, Braeburn, and Jazz Apples

Similarities and differences found:
1. Describe similarities you found among all 3 apple varieties.

   All apples were good "eating" apples. The apples were crunchy and had very similar exterior characteristics.

2. Describe differences you found among all 3 apple varieties.

   Gala was the sweetest while Braeburn was the most tart. Since the Jazz is a cross between the two, it was right in the middle.

Crossbreeding apples
1. Which of the three apples was your favorite? Why?

   Answers will vary.

2. Why do apple breeders crossbreed apple varieties?

   It allows breeders to create higher quality, better tasting varieties.