Genetics in the Vineyards: A Farmer's Challenge to breed the Greatest of Grapes (7th Grade)

Purpose

This lesson exposes students to a real-life application of genetics and technology to improve agriculture production and profit. The lesson specifically addresses bioengineering, biotechnology, and selective breeding. This lesson is ideally conducted over five 90-minute class periods.

Subject Area(s)

English Language Arts, Math, Science

Common Core/Essential Standards

English Language Arts

- **Key ideas and details: 2**. Determine central ideas or themes of a text and analyze their development; summarize the key supporting details and ideas.
- **Integration of Knowledge and Ideas: 7**. Integrate and evaluate content presented in diverse formats and media, including visually or quantitatively, as well as in words.
- **Integration of Knowledge and Ideas: 8**. Delineate and evaluate the argument and specific claims in a text, including the validity of the reasoning as well as the relevance and sufficiency of the evidence.
- **Range of Reading and Level of Text Complexity: 10**. Read and comprehend complex literary and informational texts independently and proficiently.

Math

- **Math 7.N.S – 2:** Apply and extend previous understandings of multiplication and division and of fractions to multiple and divide rational numbers.
- **Math 7.N.S – 3**: Solve real-world and mathematical problems involving the four operations with rational numbers.
- **Math 7.R.P – 1:** Compute unit rates associated with ratios of fractions, including ratios of lengths, areas and other quantities measured in like, or different units.
- **Math 7.R.P – 2**: Recognize and represent proportional relationships between quantities.
- **Math 7.R.P – 3**: Use proportional relationships to solve multistep ratio and percent problems.
- **Math 7.S.P – 5:** Understand that the probability of a chance event is a number between 0 and 1, that expresses the likelihood of a chance event occurring.

- **Math 7.S.P – 7**: Develop a probability model and use it to find the probabilities of events. Compare probabilities from a model to observed frequencies.
- **Math 7.S.p – 8**: Find probabilities of compound events using organized lists, tables, tree diagrams, and simulations.

  NC Science Essential Standards
- **7.L.2.1**: Explain why offspring that result from sexual reproduction (fertilization and meiosis) have greater variation than offspring that result from asexual reproduction (budding and mitosis).
- **7.L.2.2**: Infer patterns of heredity using information from punnett squares and pedigree analysis.
- **7.L.2.3**: Explain the impact of the environment and lifestyle choices on biological inheritance (to include common genetic diseases) and survival.

  Next Generation Science Standards
- **MS-LS1-4**: Use argument based on empirical evidence and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants respectively.
- **MS-LS1-5**: Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.
- **MS-LS3-2:** Develop and use a model to describe why asexual reproduction results in offspring with genetic variation.
- **MS-LS4-5:** Gather and synthesize information about the technologies that have changed the way humans influence the inheritance of desired traits in organisms.

Agricultural Literacy Outcomes

  Science
- Students will describe how both genetic factors and environmental factors influence the growth and reproduction of organisms.
- Students will use pedigrees and pedigree analysis to explain and evaluate the likelihood of genetic diseases being passed down from parents to offspring.
- Students will explain how the science of genetics is applied to modern day agricultural practices.
- Students will explain the importance of using modern science, technology, and engineering in agricultural practices, and specifically biotechnology, bioengineering, and selective breeding.

Essential Questions
1. Explain how the Punnett Square works in relation to genetics.
2. What is Selective Breeding?
3. What is a Pedigree?
4. What is an example of a genetic disorder?
5. Explain the positive and negative aspects of bioengineering and biotechnology.

Vocabulary

Genetics: the study of heredity.

Heredity: the passing along of traits from parents to offspring.

Punnett Square: a tool used to calculate the probability of particular traits being passed along from parents to offspring.

Gene: a unit of genetic information.

Genotype: the genetic code for a particular trait.

Phenotype: the physical or personality traits of a given genotype.

Allele: the different forms of a particular gene.

Dominant Gene: the stronger gene that will always be expressed, represented by a capital letter.

Recessive Gene: the weaker gene that will only be expressed if both genes are recessive and represented by a lower case letter.

Homozygous: a gene with identical alleles.

Heterozygous: a gene with different alleles.

Probability: the likelihood of an event occurring.

Selective Breeding: the process by which humans breed plants or animals for certain desirable traits.

Bioengineering: the application of biology (and other science and math concepts) to real-world problem solving.

Biotechnology: the use of living systems and organisms to develop or make useful products.

Ethical: morally correct.

Unethical: not morally correct.

Controversy: a prolonged public disagreement, dispute, or debate.

Student Motivator

Ask the students *why they have the hair color they have*. Some students may say it is "from their parents." Ask the students *what "from their parents" means*. You may get various answers. Bring the class back together by stating that in this lesson, they will learn about genetics and how it applies to

agriculture. They will learn about how scientists can take certain qualities of a plant or animal and use it to make that plant or animal more desirable for agricultural purposes using biotechnology and bioengineering.

Background Knowledge

Note: This project is to be done midway through the 7th grade genetics unit. Students should have a basic knowledge of the vocabulary listed, and concepts discussed. In this lesson, students will use the vocabulary and concepts they have learned and apply them to a real world, relevant, career oriented activity.

To introduce the students to muscadine/grape production in North Carolina, you may use the *Muscadine Breeding in NC PowerPoint* to familiarize yourself with the Duplin Winery, the region, the climate, the areas of the winery business, growing in the fields, the events they hold, their products, processing, production, agritourism, tours and tastings, etc. Or you can become familiar with an agribusiness more relevant to your school, community and students. The PowerPoint explains the history of Duplin Winery, and the history of the selective breeding of their grapes and how they ended up with the grapes they grow today.

21st century agriculture advances revolve around the application of science, technology, engineering, and mathematics into growing, harvesting, production and processing. It is now a competition to make the best products to sell at the highest costs, while spending the least amount on raw materials and labor. At the Duplin Winery, contract farmers sell their grapes to processing and production and they get paid by the quality and taste of their grapes. It's important for students to conceptualize business and industry components of this process. They need to know the importance of making a competitive product better than what other farmers can produce. Also, students need to be aware of the rapidly growing global population and the global food crisis, and thus, the rising need to produce in mass quantities to feed globally.

Students will use the technique of *selective breeding* in a class competition to make the best and most profitable grapes to sell to local industries. In doing so, they will learn about progressive agriculture science and technology, while covering the 7th grade science genetics standards. They will conduct a series of *Punnett squares* to calculate the probabilities of different *genotypes* and *phenotypes* being passed along, and use coins of 7 desirable vs. undesirable traits in attempt to create the best grapes possible.

Materials
- Smartboard (this is ideal, but not necessary)
- A class set of coins labeled homozygous dominant and heterozygous, 1 coin per student
- A class set of coins labeled dominant and recessive, 1 coin per student

- Lab notebooks
- Computer lab access (this is ideal, but not necessary)

Procedures

Activity 1: Punnett Squares application to Selective Breeding in Agriculture

1. Ask the students, *If you could change your genes and traits, would you? If you could chance the genes of animals or plants and design your own species, would you? Do you think it is okay for humans to change nature in this way? Why or why not?* Tell the students to write at least 8 sentences reflecting their answer. Divide the students into groups of 3-4 and have them share their answers with the class.

2. Building off of the students' prior knowledge about genetics, introduce the new concepts of *bioengineering*, *biotechnology*, and *selective breeding.* Engage the students by showing them the modern research applications of genetics in the following YouTube clips. Lead a class discussion about the ethics of humans using STEM knowledge to temper with the natural world.
   a. Genetically Engineered animals
   b. Super Cow Creators

3. Using the *Selective Breeding 1* and *Selective Breeding 2 PowerPoints*, introduce the idea of Selective breeding and agriculture/farming. *Selective Breeding 1* is a good introduction, and *Selective Breeding 2* is more informational and advanced.

4. Show the What is Selective Breeding video. Using the clip, explain how Duplin Winery has used selective breeding to pick the best traits for grapes. They have used selective breeding and bioengineering technology to select for certain traits, and eliminate other traits. Explain how much of this process is still up to chance/probability.

5. Give the students the *Article Intro Genetics* and *Article DNA, genes, chromosomes worksheets*. Divide the students into groups of 4-5 and each group should complete the pre-readings and comprehension questions.

6. Introduce the class to the Selective Breeding Grape Competition of who can produce the "greatest grapes"! You may offer fun and silly prizes for the students who create the "best" grapes.

7. Hand out the *A Farmer's Challenge Lab Reports*. Read through the instructions together. You can "popcorn style" call on the students, re-emphasize important parts, etc.

8. Instruct students to read through instructions again in their groups. Circulate and ensure that groups understand how to proceed.

9. Once the students have read the instructions, and completed the pre-questions on the lab report, provide the coin sets and allow the students to begin the lab. Students will use the coin sets to

flip for traits to get passed along. They will discover that a lot of the selective breeding process is up to chance. During the activity, circulate frequently and check for understanding within the groups, and correct execution of the activity.

10. Let the students know that they may not finish their lab reports. Assure them that they will have time for completion in the next Activity.

Activity 2: Breed the Greatest of Grapes Lab Activity

1. Ask the students to use at least 8 of the following words in a paragraph of at least 8 sentences: *Genotype, Phenotype, Gene, Trait, Allele, Punnett Square, Homozygous, Heterozygous, Dominant, Recessive, Probability, Selective Breeding, Bioengineering, Biotechnology, Ethical, Unethical, and Controversy.*
2. Have the students pick up where they left off on their lab activities from **Activity 1**.
3. 10 minutes before the end of the period, instruct the students to turn in everything they have completed and clean up materials.
4. Ask the students to write and complete the following questions in their lab notebooks:
    a. Explain the purpose of Punnett Squares.
    b. Explain the purpose of selective breeding.
    c. What is the difference between homozygous and heterozygous?
    d. One parent flower is homozygous for dominant blue petals (BB) and one parent is heterozygous for blue and yellow petals (Bb). Construct a Punnett Square and determine the following probabilities:
        i. Offspring is BB _____
        ii. Offspring is Bb _____
        iii. Offspring is bb _____
        iv. Offspring has blue petals _____
        v. Offspring has yellow petals _____
    e. Both parents are heterozygous for blue and yellow petals. Construct a Punnett Square and determine the following probabilities:
        i. Offspring is BB _____
        ii. Offspring is Bb _____
        iii. Offspring is bb _____
        iv. Offspring has blue petals _____
        v. Offspring has yellow petals _____
5. Review the answers with the students once they have completed the questions.

Activity 3: Pedigrees and pedigree analysis (you will use the *Day 3 Pedigrees and genetic disorders PowerPoint*)

1. Using the Day 3 Pedigrees and genetic disorders PowerPoint, pose the following question to the students, *If you knew you had a dangerous, difficult, or painful disease in your genes that might (25%-50% chance) be passed along to your offspring, would you still have children? Why or why not?*
2. Introduce what a pedigree is and how to read a pedigree (symbols, etc.). Show the What are Pedigree Charts video.
3. Handout the *Pedigree Key*. Discuss with the students and check for their understanding.
4. Watch the following video clips about genetic disorders to show the students the real life relevance:
   a. Tiana & Star's Story—Brittle Bones
   b. Carys and George's Story—Dwarfism
   c. Hemophilia and Kids
   d. Congenital Insensitivity to Pain
   e. Hypohidrotic Ectodermal Dysplasia
5. Divide the students into groups of 2, and give each student a copy of the *Pedigree Practice 1 worksheet*. Next, give the groups a copy of the *Pedigree Practice 2 worksheet*.
6. For this activity, students will create their own pedigree.
   a. They will need to decide the kind of genetic disease they want to represent (colorblindness, albinism, hemophilia, etc.).
   b. They will need to include at least 4 generations, which should be numbered.
   c. They need to include carriers, people who have the disease, and people who do not. All people should be numbered.
   d. Students should write a paragraph explaining their pedigree (who marries who, the children, and who the children marry). Explain who has the disease, who does not, who carries the disease, etc.
7. Divide the students into literacy groups (or groups of 3-4), and give the students copies of the *Article Mutations and Genetic Disorders worksheet*. Have the groups complete the worksheets.
8. Bring the class back together by asking the following questions:
   a. *What is the purpose of a pedigree?*
   b. *What is the difference between a genetic disorder and a regular sickness, like a cold or the flu?*

Activity 4: Modern Genetic Controversies (use the *Day 4 Genetic Controversies PowerPoint*)
1. Ask the students, *Do you think you are the way you are because of your genes or because of how you were raised (your parents, your friends, your school, etc.)?* Have the students write their answers in at least 5 sentences.

2. Introduce the idea of a "controversy" and what this means.
3. Explore the following genetic controversies to engage students in the real life issues happening in the science of genetics right now. Show the following video clips, and follow up with the discussion questions:
    a. Designer Babies
        i. *Would you want to design your own perfect baby?*
        ii. *Is it unfair to people with less money?*
        iii. *Would it lead to more discrimination? (Against certain skin colors, eye colors, hair types, heights, etc.)*
        iv. *Do you think it is unnatural?*
        v. *Would you want your child to have traits that weren't from you or your spouse?*
    b. What is Selective Breeding and Super Cow Creators
        i. *How can selective breeding be helpful?*
        ii. *How do you think selective breeding has impacted our county? (Think about the types of agricultural products produced in your county)*
        iii. *How could selective breeding help with world hunger problems?*
    c. Genetically Engineered Animals
        i. *Do you think Genetic Engineering is cool?*
        ii. *Do you think it's wrong for humans to mess around with animals?*
        iii. *Is it okay for us to mess around with animals for the purpose of science and our own future?*
        iv. *Would you want a genetically engineered pet? Like a glowing cat or fish? Would you feel guilty?*
    d. What is a GMO and GMO a Go Go
        i. *How do you feel about eating fake food? Does it freak you out at all?*
        ii. *How do you feel about the health concerns of Genetically Modified Food?*
        iii. *Given the global food crisis, could genetically modified foods be helpful, given that we can simply create it?*
        iv. *How about the farmers who are losing out as big corporations take over?*
4. Divide the class into literacy groups, and give each student an *Article Cloning worksheet*. Have the groups complete the worksheets.
5. Next, give the students an *Article Nature Nurture worksheet*. After the groups have had time to complete the worksheet, ask the class to write and complete the following questions in their lab notebooks:
    a. *What do scientists mean by the word nature?*
    b. *Provide one example of evidence for the nature argument.*

c. *What do they mean by the word nurture?*

d. *Provide one example of evidence for the nurture argument.*

e. *What was the most interesting genetics controversy to learn about? (Designer babies, Selective Breeding, Genetic Engineering, Cloning, GMOs, Nature vs. Nurture)*

Activity 5: Genetics Project Work Day (this project is optimal with computer lab access)

1. Hand out the *Genetics Project outline* to the students.
2. Read the instructions and guidelines together as a class (cold calling readers, popcorn style, etc.) and ask for any questions and clarifications.
3. If you want students to works in partners/groups, break them into the groups (if you have chosen the groups ahead of time) or allow them 2 minutes to select their own groups.
4. Direct the students to look over project instructions and guidelines for 5 minutes on their own/with their groups.
5. Allow students 5 minutes to decide on their project choices and get approval from you.
6. Direct/allow the students to gather the necessary materials and technology.

Suggested Companion Resources

- Study Stack – Online Biotechnology Flash Cards
  http://www.studystack.com/flashcard-1511040

Essential Files

- [Muscadine Breeding in NC PowerPoint](#)
- [Selective Breeding 1 PowerPoint](#)
- [Selective Breeding 2 PowerPoint](#)
- [Article Intro Genetics worksheet](#)
- [Article DNA, genes, chromosomes worksheet](#)
- [A Farmer's Challenge Lab Report](#)
- [Day 3 Pedigrees and genetic disorders PowerPoint](#)
- [Pedigree Key](#)
- [Pedigree Practice 1 worksheet](#)
- [Pedigree Practice 2 worksheet](#)
- [Article Mutations and Genetic Disorders worksheet](#)
- [Day 4 Genetic Controversies PowerPoint](#)
- [Article Cloning worksheet](#)
- [Article Nature Nurture worksheet](#)
- [Genetics Project outline](#)

Essential Links

- Genetically Engineered Animals
  https://www.youtube.com/watch?v=JVIznPgdQSM
- Super Cow Creators
  https://www.youtube.com/watch?v=rW54_vM9SF0
- What is Selective Breeding
  https://www.youtube.com/watch?v=W_CnR0Ak604
- What are Pedigree Charts
- https://www.youtube.com/watch?v=Wuk0W10EveU
- Tiana & Star's Story
  https://www.youtube.com/watch?v=6b7cWvMlw8Y
- Carys and George's Story
  http://www.youtube.com/watch?v=d8B-rdUrO9U
- Hemophilia and Kids
- https://www.youtube.com/watch?v=FS64UXi74lY
- 12-Year-Old Girl Cannot Feel Pain Due to Genetic Disorder
- https://www.youtube.com/watch?v=s28fCIQKJTA
- Max's Story
- http://www.youtube.com/watch?v=cAl6ZoQ7Mes
- Designing Your Own Baby: Patent Granted
  https://www.youtube.com/watch?v=1sspJ3QNtcY
- Genetically Engineered Animals
- https://www.youtube.com/watch?v=JVIznPgdQSM
- What is a GMO? Let us quickly explain…
- https://www.youtube.com/watch?v=riCQ8R3EG9U
- GMO a Go Go
- https://www.youtube.com/watch?v=KGqQV6ObFCQ

Ag Facts

- The number of people on Earth is expected to increase from the current 6.7 billion to 9 billion by 2050. To accommodate the increased demand for food, world agricultural production needs to rise by 50% by 2030. [1]
- Agribusiness is the number one sector in North Carolina's economy and is projected to exceed $100 billion before 2020. [2]

- North Carolina is the nation's third most diverse agricultural state, with nearly all climatic and soil conditions represented. [3]
- On March 15, 2016, North Carolina voters approved a bond that would fund the construction of a Plant Science Research Complex on North Carolina State University's Centennial Campus. [4]

Extension Activities

- Have students selectively breed other plants or animals while practicing setting up and carrying through Punnett Squares. Set goals for the students to selectively breed for, or students could choose what they would like to selectively breed for.
- Students could research/brainstorm/discuss what sorts of traits workers in agriculture and farming would want to selectively breed for and what they might want to get rid of.
- While examining the genetic controversies of bioengineering, biotechnology, and selective breeding, students could research and discuss other controversies in genetics such as: GMOs, designer babies, and the nature vs. nurture debate.
- Students could research and discuss the potential impacts of selective breeding and agriculture on the global food crisis.

Sources & Credits

1. Royal Society, T., 2009 *Reaping the Benefits: Science and the Sustainable Intensification of Global Agriculture.* The Royal Society, London.
2. http://harvest.cals.ncsu.edu/ckfinder/userfiles/files/Plant%20Sciences%20one-sheet%20091814(2).pdf
3. http://harvest.cals.ncsu.edu/plant-sciences-initiative/about/
4. http://harvest.cals.ncsu.edu/ckfinder/userfiles/files/Plant%20Sciences%20one-sheet%20091814(2).pdf

Lesson Author

This lesson plan was written by Illana Livstrom in partnership with the Kenan Fellowship Program as a 2014-2015 Kenan Fellow. Her mentor throughout the fellowship was Morgan Jackson, General Manager of Duplin Winery located in Rose Hill, North Carolina.