Genetics and Agricultural Efficiency

An educator toolkit of lessons and videos for a 6th-12th grade audience

COMPILED BY NEW YORK AGRICULTURE IN THE CLASSROOM

In partnership with the New York Beef Council.

New York Agriculture in the Classroom

NEW YORK BEEF COUNCIL

Funded by Beef Farmers & Ranchers

Genetics and Agricultural Efficiency

Introduction:
In this agricultural focused phenomenon-based inquiry, learners will engage with the following concepts:

- History of genetics in agriculture
- Natural and selective breeding
- Transgenics and biological engineering techniques
- How genetics are used by agriculturalists and scientists
- Development of new breeds of organisms
- The beef life cycle
- Ruminates
- Heredity and DNA analysis techniques
- Carbon outputs from beef and dairy cows

As students participate in the first part of the experience, they will get a broad understanding of genetics, heredity, and modern processes of breeding.

In the second half of the experience, students will learn how humans can use genetics to create more efficient organisms as well as how these more efficient livestock and crops are able to meet the demands of the global population using less land and fewer resources.

Classroom Application:

The lessons in the experience are developed as a progression with the culminating experience challenging students to create a new conceptual agricultural product or process which will benefit humans needs for food and fiber.

The progression of lessons is developed in a way so that teachers can engage with concepts lesson by lesson, in groups of lessons, or by focusing on concept groupings.

Lessons 1-5 focuses on a broad overview of heredity, breeding, and genetics. Lessons 6-11 helps students understand modern breeding techniques used by agriculturalists and how these techniques improve the “efficiency” of how plants and animals grow, utilize natural resources to survive, and provide greater harvests compared to prior plant and animal populations.

Each lesson is designed with a short informative text for the development of background knowledge of the concepts in the lesson. If a teacher would like to engage in a single lesson or group of lessons, it is suggested that students read through all the informative texts allowing for a more knowledgeable engagement with a single lesson or group of lessons.

Matrix Map

Click on the corresponding numbers to move directly to the lesson information.

	Lesson	Description	Time
Part 1: The Need for Genetics in Agriculture			
1	Populations	Students build an understanding of the growing global population and the worlds carrying capacity and humans' impact on it.	4 x 45-minute Sessions
2	Apples and the Science of Genetic Selection	Students will compare the differences between natural and selective reproduction and identify how these processes have been used in agriculture.	2 x 50-minute sessions
3	Inherent Traits and the Living Corn Necklace	Students will observe the growth of two breeds of corn use their observations to identify heredity concepts.	1 hour
4	Applying Heredity Concepts	Students will practice using monohybrid and dihybrid Punnett squares.	3 x 45-minute sessions
5	A Recipe for Genetics: Selective Breeding and Transgenics	Students will identify technologies that have changed the way humans affect the inheritance of desired traits in organisms; compare and contrast selective breeding methods to genetic engineering techniques; and analyze data to determine the best solution for cultivating selected desired traits in organism.	2 hours
Part 2: Modern Genetic Practices in the Field			
6	Build-a-Calf Workshop	Students will review the foundational concepts of heredity and genetics	45 minutes
7	The Remarkable Ruminant	Students will follow the farm to fork process of producing beef, learn how cattle and other ruminants convert grass into nutrient-rich foods such as milk and meat, discover ways cattle recycle food waste, and identify careers in the beef cattle industry.	3 hours
8	The Use of Biotechnology in Selecting the Right Plants	Students will simulate how a type of biotechnology called Marker Assisted Selection (MAS) is used to identify crop plants that have desirable traits such as sweet tasting fruit or natural resistance to a pest or disease.	50 minutes
9	From Techniques to Traits	Students will explore common biotechnology methods and their applications in agricultural sciences. Students will examine DNA analysis techniques, become familiar with the process of polymerase chain reaction (PCR), and evaluate methods of DNA analysis as they learn how the biological techniques can be used in the process of developing specific traits within a crop.	1 hour
10	Carbon Hoofprint: Cows and Climate Change	Students will explore the carbon cycle and evaluate the carbon footprint of cattle. Using critical thinking skills, students will use the Claim, Evidence, and Reasoning model to determine the effect of cows' methane production on the environment and investigate the extent cattle contribute to climate change.	2 hours
11	Enhancing our World	Students will create solutions to the issues of global population growth and how to sustainably produce food and fiber for these populations.	3 x 45-minute sessions

Phenomena

Lesson 1

Due to an ever-growing population and continuous loss of agricultural lands, there is an ongoing push by agriculturalists to produce more with less: fewer inputs while gaining more efficient and bountiful production. To meet the needs of human's food and fiber consumption, there have been and are ongoing technological innovations and developments of "**best practices**" in the field of agriculture.

Although advancements might look differently across the field of agriculture, the goals of agriculturalists are the same, efficiency. Equipment manufactures work to engineer larger machines which can harvest more products while using less fuel. There has been great momentum to modernize the dairy sector by automating the production processes. Timber machines can cut faster and sawmills more precisely. Global positioning systems (GPS), robotics, and drone technologies are becoming more and more prevalent. In all sectors of agriculture, efficiency means less cost for producers and consumers and more production with less input of resources.

One agricultural sector which has seen major investment is the field of genetics. Modern food and fiber networks are greatly influenced by the centuries of breeding and propagation carried out by agriculturalists. It was early farmers who identified plants and animals which could be cultivated or domesticated. Once identified, they worked to further develop the desired traits found in these plant and animal populations building more efficient and productive crops recognizable today.

Although traditional breeding techniques are still used by modern farmers, there have been major advancements in the field of genetics. With modern processes, agriculturalists can produce desired genetic outcomes in plants and animals in much shorter time. In the realm of genetics, what once took farmers and geneticists a generation or two to produce now takes only a matter of years to be expressed in new generations of plants and animals.

To understand the advancements in these fields students who engage in this agricultural focused phenomena-based inquiry, will learn from a real farmer who has spent his life's work focused on "farming beef genetics" and learn how he uses genetic concepts in the field. Since the first breeding project he did for his fifth-grade science fair project to today, he has seen the ongoing development of beef cattle breeds, evolved his breeding practices with the advancements in breeding, and has identified one possible pitfall of narrowing the genetic diversity in different species.

To build a better understanding of the demands on our global food and fiber networks, have students participate in the following lesson.

Populations		
Interest Approach		
Students will learn about and create solutions for meeting the demands of a rising global population.		
Activities		
Activity 1	Historic growth of global population	45 minutes
Activity 2	Learn about age structure and how it effects population growth	45 minutes
Activity 3	Change of global population demographics	45 minutes
Activity 4	Identify how farming is and must change to meet population demands	45 minutes

Vocabulary

Artificial Selection- The process of humans selecting traits in organisms
Best Practices- Methods developed through experience and research which are identified as being most productive, ethical, humane, and sustainable
Breed- propagate; mate to produce offspring
DNA- genetic material/code in all living organisms which determine organisms breed and traits
Express- process of turning genetic code (genotypes) into functional cells/recognizable traits (phenotypes)
Genetics- collection of an organism's genes
Geneticist- A person that studies genes and heredity
Genomics- Field of biology focus on the structures, function, editing, and mapping of DNA
GMO- genetically modified organism; organism which has been genetic manipulation by humans
Heredity- passing of genetics and expression of genes from one organism to its offspring
Natural Selection- The natural transferring of genes from organisms of one generation to another through breeding
Ruminant- Animal such as cows, sheep, goats, and deer which have multiple chambers stomachs which allow for fermentation to take place assisting digestion
Selective Breeding- The process of humans breeding organisms to produced desired traits in future generations of plants and animals
Sire- Male cow/bull
Trait- Specific characteristics of an organism
Transgenics- The selected insertion of genetic material from one organism into another organism

Genetics in Agriculture

More Productive; More Efficient

Lesson 2

Brooke Trout Alevin
NYAITC

For a species to continue to exist and avoid extinction, they must pass on their **genetic** material through reproduction. When organisms reproduce, their offspring are not exact copies of their parents as they inherit a blend of **traits** from the parent organisms.

If a breeding pair were to produce additional offspring, each of their offspring would share roughly half their genetics. The remaining half of each siblings' genetics would be unique. This variance in genetics within a species is important as it allows a species to adapt to its environment over time. In turn, this insures the continuation of the species.

The natural process of reproduction and blending of genetics ensuring that genetic material is passed from one generation to the next is called **natural selection**.

Early agriculturalist identified that plants and animals could be selectively bred or **artificial selected** to reproduce desirable traits in a species. Over time, selective breeding led to unique breeds of plants and animals. In this lesson, students will learn the difference of natural and artificial selection using apple genetics.

Apples and the Science of Genetic Selection		
Interest Approach		
Students will differentiate between multiple apple breeds.		
Activities		
Station 1	Taste and differentiate between tart apples compared to other breeds.	15 minutes
Station 2	Discover how commercial apples grow	15 minutes
Station 3	Create apple sauce using market apple varieties	15 minutes
Station 4	Discover how apples have been genetically engineered	15 minutes
Station 5	Differentiate between apples that have been naturally or selectively bred	15 minutes

Lesson 3

In this lesson, student will review the concepts of heredity. These concepts are some of the first processes that were used by early agriculturalists. Like humans, different plants and organisms have traits that are unique to a species as well as traits which are unique to a single organism.

Inherent Traits and the Living Corn Necklace		
Interest Approach		
Compare and contrast plant and human traits.		
Activities		
Activity 1	Discover the variations of crop plants	30 minutes
Activity 2	Create a corn necklace of two varieties of corn and observe the difference as they grow	30 minutes Ongoing short observation periods

Lesson 4

Although the process of artificial selection became a common technique used to create new **breeds** of plants and animals from the same species, it was not until the 19th century with Gregor Mendel's experiments with pea plants that a more concrete scientific understanding of **heredity** developed.

Minnow Daffodils
NYAITC

In his experiments Mendel bred pea plants and used six identifiable traits to understand how genes of two parent plants were displayed or **expressed** in their offspring. Mendel found that there was an expected outcome or probability to the types of traits shared from one generation to another.

By using this newfound knowledge, Mendel was able to develop desired traits more accurately in pea plats. For his work, Mendel is accredited with being the father of modern genetics. In the following lesson, students will apply Mendel's concepts to cotton plants.

Applying Heredity Concepts		
Interest Approach		
Identify student knowledge of cotton plants.		
Activities		
Activity 1	Review concepts of heredity	45 minutes
Activity 2	Students conceptual develop a breed of blue cotton using Punnett squares	45 minutes
Activity 3	As a class, identify way that genetics can be used to prevent infestation of newly breed cotton breed	45 minutes

Lesson 5

Tomato Garden
NYAITC

As the scientific field of genetics has progressed, **geneticists** have identified new techniques for ensuring that desired traits are expressed in new generations of organisms. These new practices allow for the development of specialized crops and plants. The most recent breakthroughs are in the field of **transgenics**. By using transgenics, scientists are able identify specific genetic codes within DNA of one organism, use enzymes to isolate and remove the code, and implant the code into another organisms DNA.

This process of alter genetic material is considered genetic engineering. The organisms that have been genetically modified are considered genetically modified organisms or **GMOs**. GMOs are becoming more prevalent in today's food and fiber networks.

In this lesson, students will engage with the process of selective breeding and transgenics to identify solutions to real world problems faced by those who are growing our worlds food and fiber and get a better understanding of how they are used in agriculture as well as discuss the controversy of GMO's.

A Recipe for Genetics: Selective Breeding and Transgenics		
Interest Approach		
Students will Identify how food has been transformed by years of agricultural breeding.		
Activities		
Activity 1	Review the concept of DNA and compare and contrast DNA expression in organisms	30 minutes
Activity 2	Identify the outcomes of natural and selective breeding with cattle	45 minutes
Activity 3	Review the concepts of GMO's and compare and contrast their benefits and concerns	45 minutes

Genetics in the Field

Lesson 6

Phil Trowbridge of Trowbridge Farm
Black Mountain Visuals

Over generations agriculturalists have identified plants and animals in their environment which were able to fill humans needs for food and fiber. They have used artificial selection and selective breeding in place of natural selection to further develop beneficial traits of organisms. By utilizing these techniques, it has allowed for desired traits in plants and animals to be developed in much shorter time.

Through artificial selection, many different variations, or breeds of a single species of plants and animals have been developed. As new generations of plants and animals express certain desired traits, these generations have been further bred to continue to develop these traits within a plant or animal population. Trait selection can range from productivity, drought tolerance, climate hardiness, to fertility, color, fruit size, shape, etc… As the field of genetics progresses, it allows for the development of traits in a plant or animal population to become more efficient as less inputs are needed and populations can be bred more precisely.

To see these concepts in practice you will engage with Mr. Phil Trowbridge of Trowbridge Farm a modern day “genetics farmer”. Phil shares how he uses genetics on his cow-calf beef operation, how he applies genetic concepts to increase his agricultural efficiency, discusses where the field of genetics was when he started breeding beef cows, and shares the advancements which are being made in the field of genetics today.

Click the image below to watch a video introducing Phil Trowbridge, owner of Trowbridge Farms.

Trowbridge Farm
NYAITC

As Phil Trowbridge identified, Trowbridge Farms is a third-generation cow-calf beef farm. Cow-calf operations are the first farms in the beef lifecycle and the place where genetics plays the most vital role in the beef industry. In the following video, Phil discusses the different stages in the beef lifecycle as well as identifies how the genetic makeup of beef cattle can benefit marginal agricultural land in New York State.

Click the image below to learn about the beef lifecycle from Phil Trowbridge as well as the geographical benefits of beef farming on less productive New York Agricultural land.

Phil discussed that it is at the cow-calf operation where farmers and ranchers select the genetics and traits which they want expressed in future generations of cattle. By using artificial selection farmers like Phil are able to choose traits that they want transferred from one generation of beef cattle to the next.

Use the following lesson focused on building traits in beef cows through heredity to review the foundational aspects of how traits from one generation of beef cattle are passed to the next generation.

Build-a-Calf Workshop		
Interest Approach		
Students will explore concepts of heredity in beef cattle and identify dominant and recessive traits.		
Activities		
Activity 1	Brainstorm, identify class knowledge, and research beef cattle	15 minutes
Activity 2	Develop a new generation of beef cattle through the process of natural selection	30 minutes

Angus Cow and Calves
Black Mountain Visuals

Grazing
Black Mountain Visuals

Lesson 7

Phil shared that cows are one species of **ruminants**. Unlike monogastric or single chambered animals like humans, ruminants are mammals which have unique multichambered stomach. Due to their genetic makeup, ruminants' unique digestive systems allow these animals to digest food sources and pull nutrients out of food sources which monogastric animals cannot. This trait allows for ruminants to thrive on lands that might be too difficult to plow or soils are too poor to grow crops.

To learn more about the beef lifecycle, how ruminants can benefit marginal land, and their ability to process complex starchy food sources, engage in the following lesson. To learn more about soil health and how ruminants are an important tool in improving land through regenerative agriculture practices use the following link to our Ecosystems and Soil Health toolkit.

The Remarkable Ruminant		
Interest Approach		
Students will identify what makes ruminants unique.		
Activities		
Activity 1	Engage with the beef lifecycle	45 minutes
Activity 2	Learn about how ruminants can use land which is not suited for other agricultural practices.	45 minutes
Activity 3	Learn about the unique digestive systems and benefits of ruminates in regard to feeding a global populace	45 minutes
Activity 4	Discover different careers in the beef industry	45 minutes

Lesson 8

Bull in a Paddock
Black Mountain Visuals

Phil's goal is to breed the most efficient cattle possible and to do so as efficiently as possible. To do this, Phil first identifies the traits he wants to be expressed in his cattle. Historically, farmers had to visually identify the genes of their herd through the trait expressions in newborn calves. As calves were born, farmers would record the differences from calf to calf such as horns or no horns, size, rate of weight gain, color, etc.… and then breed the cows with bulls that share the expressed traits they desired. Breeding a trait into a herd took time and a larger number of cattle. Today, using such practices is becoming more and more rare.

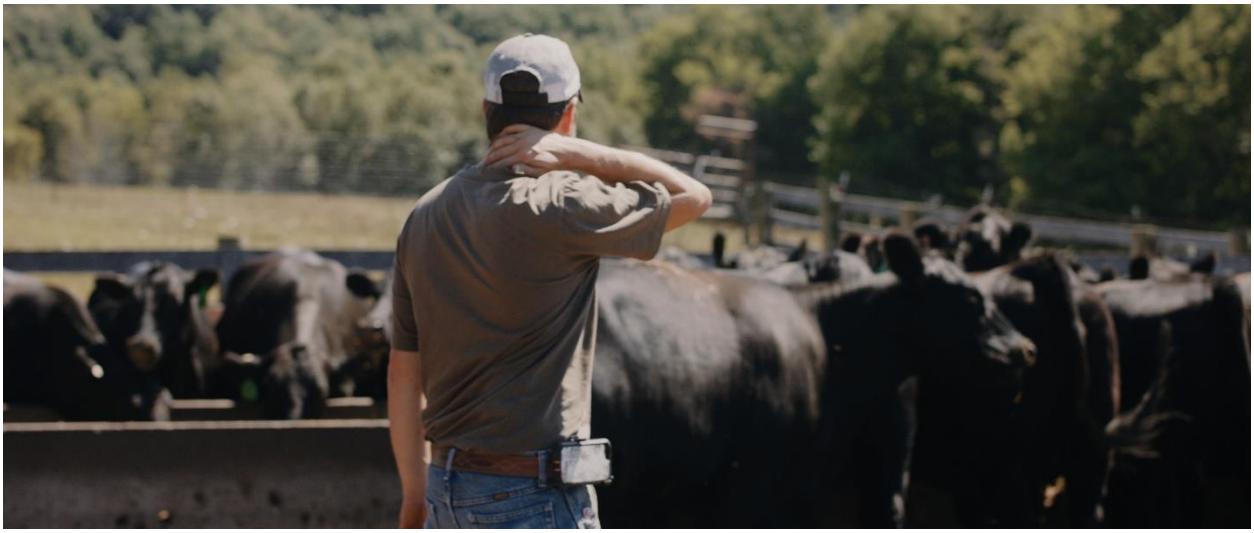
With advancements in **genomics**, the mapping of DNA, beef farmers like Phil can screen their herd by processing genetic material from each animal. Once genetic rich material is processed, a physical map of the genes and corresponding traits of each cow or bull is created. This modern breeding practice allows farmers to identify the cattle that carry the genes and traits they desire before they are bred as well as prevent from breeding in traits they might not want replicated in future generations of cattle.

Once animals are identified as carrying a desired trait, farmers can then selectively breed these animals. These methods allow for a trait to be bred into a herd much more efficiently using many fewer animals when compared to natural selection or early selective breeding methods.

On the farm, Phil actively uses modern processes to build the genetic pool of his herd. Through the refining of breeding techniques such as artificial insemination (AI) and advancements in embryology, the study of the development of embryos and fetus', Phil is able to not only more precisely identify desired genetics but store these genetics for long periods of time and use them in animals that he identifies as genetically superior for the traits he is looking to refine in his herd.

Although Phil is a beef farmer, the process of identifying desired genetics and breeding these genetics into livestock or crops is used across all agricultural fields. Watch the following video to learn how Phil uses these techniques on his farm

Click the image below to hear how Phil Trowbridge has built the genetics in his cattle as well as the techniques he uses to do so.



Farmer Working the Herd
Black Mountain Visuals

Although huge strides have been made in the realm of genetics, Phil identifies that one hazard caused by specialized breeding is the loss of genetic diversity of plants and animals. The limiting of the diversity of genetics or genetic pool in a population can limit the ability of these populations to adapt to unforeseen issues. In severe cases these limitations can lead to extinction of breeds of livestock and crops.

To prevent the loss of genetic diversity or to preserve genetics he desires, genetic material from plants and animals can be saved through a process called cryopreservation. In this process, genetic samples from many plants and animals of the same breed are stored at extremely low temperatures using liquid nitrogen. This process allows geneticists and farmers to store genetic material for extremely long periods of time well past the lifetime of the donor organisms.

Many cow-calf operators as well as breeders have a library of genetic material from sires which they have used for breeding through their careers. Phil's library contains genetic material from sires dating back to the 1960's. Keeping a library of genetic material allows for genetic diversity to be preserved.

In this lesson students will use biotechnology like Phil does on his farm to identify desired traits and conceptually breed new generations of organisms.

The Use of Biotechnology in Selecting the Right Plants		
Interest Approach		
Students will compare and contrast consumer and agriculturalist preferred traits in strawberries.		
Activities		
Activity 1	Discover and use MAS (Marker Assisted Selection) to produce more efficient and flavorful strawberries	50 minutes

Lesson 9

In the following lesson, students will learn about four different DNA analysis techniques which are used in DNA sequencing of traits and how these sequences can be used in breeding plants and animals.

From Techniques to Traits		
Interest Approach		
Students will review how traits are expressions of genetic code (DNA).		
Activities		
Activity 1	Engage with 4 different DNA analysis techniques	50 minutes
Activity 2	Learn more about the PCR (Polymer Chain Reaction) analysis technique	50 minutes
Activity 3	Students will use their knowledge of DNA analysis to	50 minutes

Lesson 10

Phil Trowbridge Accessing Feed
Black Mountain Visuals

As farmers have developed the genetics of plant and animal breeds, to grow “more with less”, they must also consider the inputs needed to sustain them. There have been many advancements made in the science of nutrition, the study of the nutritional needs of animals, and the science of agronomy, study of soil and crops, which have allowed for farmers like Phil to maximize the efficiency of how they farm and what they produce.

In the following video, Phil recognizes how the development of his herds have improved the food product that he is able to produce as well as the benefits that more efficient modern cattle have on the environment compared to those raised, he raised in the past.

Click on the image below to hear from Phil Trowbridge on how he uses genetics and nutrition to increase the efficiency of raising cattle on his beef farm.

In the following lesson, students will build an understanding of cattle's input in the carbon cycle and develop a better understanding on how agriculturalists, like Phil, have bred cows to be more efficient in converting feed to muscle limiting the CO2 outputs of cattle.

Carbon Hoofprint: Cows and Climate Change		
Interest Approach		
Students will brainstorm how carbon, methane, and ruminates are part of the carbon cycle.		
Activities		
Activity 1	Review the carbon cycle and brainstorm cattle's contribution to the carbon cycle	30 minutes
Activity 2	Understand the process of digestion in ruminates and engage with how byproducts from these systems contribute to the carbon cycle	45 minutes
Activity 3	Identify the need for cattle in food networks and identify the level of contribution of gases to the carbon cycle	45 minutes

Lesson 11

Agriculturalists Discussing Farming Practices
NYAITC

With the advancements of the field of genetics and breeding technology and development of best practices, modern agriculture is exponentially changing. In the following concluding lesson, students are challenged to utilize what they have learned about heredity, genetics, and biotechnology to create a new agricultural product that would bolster the food and fiber networks.

Enhancing our World		
Interest Approach		
Students will be introduced to the problems faced by agriculturalists to grow food for an expanding global population.		
Activities		
Activity 1	Develop a company and solution using genetics concepts focused on feeding an expanding global population	3 x 45-minute work sessions

Next Generation Learning Standards	
Lesson	**Standard Alignment**
Populations	**Social Studies** APHG Topic 5.9: The Global System of Agriculture PSO-5.E.3 The main elements of global food distribution networks are affected by political relationships, infrastructure, and patterns of world trade. **Science** HS-LS2 Ecosystems: Interactions, Energy, and Dynamics HS-LS2-1 Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales. HS-LS2-2 Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales. HS-LS2-7 Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.
Apples and the Science of Genetic Selection	**ELA** R 2: Determine central ideas or themes of a text and analyze their development; summarize the key supporting details and ideas. SL 1: Prepare for and participate effectively in a range of conversations and collaborations with diverse partners; express ideas clearly and persuasively, and build on those of others. **Career & Technical Education (CAREER)** AFNR Agriculture, Food, and Natural Resources Cluster Skills CS.01.02 Examine technologies and analyze their impact on AFNR systems. AFNR Biotechnology Systems Career Pathway BS.01.01 Investigate and explain the relationship between past, current and emerging applications of biotechnology in agriculture (e.g., major innovators, historical developments, potential applications of biotechnology, etc.). BS.03.06 Apply biotechnology principles, techniques and processes to improve waste management (e.g., genetically modified organisms, bioremediation, etc.). AFNR Plant Science Systems Career Pathway PS.03.01 Demonstrate plant propagation techniques in plant system activities. **Science** HS-LS4 Biological Evolution: Unity and Diversity HS-LS4-4 Construct an explanation based on evidence for how natural selection leads to adaptation of populations.
Inherent Traits and the Living Corn Necklace	**ELA** L3: Apply knowledge of language to understand how language functions in different contexts, to make effective choices for meaning or style, and to comprehend more fully when reading or listening. **Career & Technical Education (CAREER)** AFNR Biotechnology Systems Career Pathway BS.03.04 Apply biotechnology principles, techniques, and processes to enhance plant and animal care and production (e.g., selective breeding, pharmaceuticals, biodiversity, etc.). **Science (SCIENCE)** MS-LS3 Heredity: Inheritance and Variations of Traits MS-LS3-2 Develop and use a model to describe why asexual reproduction results in offspring with identical genetic information and sexual reproduction results in offspring with genetic variation. MS-LS4 Biological Evolution: Unity and Diversity MS-LS4-5 Gather and synthesize information about technologies that have changed the way humans influence the inheritance of desired traits in organisms.

Applying Heredity Concepts	**ELA** L4: Determine or clarify the meaning of unknown and multiple-meaning words and phrases by using context clues, analyzing meaningful word parts, and consulting general and specialized reference materials, as appropriate. R1: Read closely to determine what the text says explicitly/implicitly and make logical inferences from it; cite specific textual evidence when writing or speaking to support conclusions drawn from the text. R2: Determine central ideas or themes of a text and analyze their development; summarize the key supporting details and ideas. SL1: Prepare for and participate effectively in a range of conversations and collaborations with diverse partners; express ideas clearly and persuasively and build on those of others. **Career & Technical Education (CAREER)** AFNR Biotechnology Systems Career Pathway BS.03.04 Apply biotechnology principles, techniques and processes to enhance plant and animal care and production (e.g., selective breeding, pharmaceuticals, biodiversity, etc.). **Science** MS-LS1 From Molecules to Organisms: Structures and Processes MS-LS1-5 Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms. MS-LS3 Heredity: Inheritance and Variations of Traits MS-LS3-2 Develop and use a model to describe why asexual reproduction results in offspring with identical genetic information and sexual reproduction results in offspring with genetic variation. MS-LS4 Biological Evolution: Unity and Diversity MS-LS4-5 Gather and synthesize information about technologies that have changed the way humans influence the inheritance of desired traits in organisms.
A Recipe for Genetics: Selective Breeding and Transgenics	**ELA** R1 Read closely to determine what the text says explicitly/implicitly and make logical inferences from it; cite specific textual evidence when writing or speaking to support conclusions drawn from the text. SL2 Integrate and evaluate information presented in diverse media and formats (including visual, quantitative, and oral). SL 3 Evaluate a speaker's point of view, reasoning, and use of evidence and rhetoric **Science** MS-LS4 Biological Evolution: Unity and Diversity MS-LS4-5 Gather and synthesize information about technologies that have changed the way humans influence the inheritance of desired traits in organisms.
Build-a-Calf Workshop	**ELA** L1Read closely to determine what the text says explicitly/implicitly and make logical inferences from it; cite specific textual evidence when writing or speaking to support conclusions drawn from the text. R7: Integrate and evaluate content presented in diverse media and formats, including across multiple texts. R9: Analyze how two or more texts address similar themes or topics in order to build knowledge or to compare the approaches the authors take. SL 1: Prepare for and participate effectively in a range of conversations and collaborations with diverse partners; express ideas clearly and persuasively, and build on those of others. SL2 Integrate and evaluate information presented in diverse media and formats (including visual, quantitative, and oral). W5 Draw evidence from literary or informational texts to support analysis, reflection, and research.

	W7: Gather relevant information from multiple sources, assess the credibility and accuracy of each source, and integrate the information in writing while avoiding plagiarism **Science** 3-LS3: Heredity: Inheritance and Variation of Traits 3-LS3-2 Use evidence to support the explanation that traits can be influenced by the environment 3-LS3-1 Analyze the interpret data to provide evidence that plants and animals have traits inherited from parents and that variation of these traits exists in a group of similar organisms.
The Remarkable Ruminant	**ELA** R2 Determine central ideas or themes of a text and analyze their development; summarize the key supporting details and ideas. SL1 Prepare for and participate effectively in a range of conversations and collaborations with diverse partners; express ideas clearly and persuasively and build on those of others. W2 Write informative/explanatory texts to examine and convey complex ideas and information clearly and accurately through the effective selection, organization, and analysis of content. W7 Gather relevant information from multiple sources, assess the credibility and accuracy of each source, and integrate the information in writing while avoiding plagiarism **Career & Technical Education (CAREER)** AFNR Animal Systems Career Pathway AS.01.02 Assess and select animal production methods for use in animal systems based upon their effectiveness and impacts. AS.01.03 Analyze and apply laws and sustainable practices to animal agriculture from a global perspective. AS.02.01 Demonstrate management techniques that ensure animal welfare. AS.08.02 Evaluate the effects of environmental conditions on animals and create plans to ensure favorable environments for animals. **Social Studies - Geography** 5-8 Geography Standard 14: How human actions modify the physical environment. Objective 3 The physical environment can both accommodate and be endangered by human activities. 5-8 Geography Standard 15: How physical systems affect human systems. Objective 1 The characteristics of a physical environment provide opportunities for and impose constraints on human activities. **Science** MS-ESS3: Earth and Human Activity MS-ESS3-3 Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment. MS-LS2 Ecosystems: Interactions, Energy, and Dynamics MS-LS2-1 Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem. MS-LS2-2 Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.
The Use of Biotechnology in Selecting the Right Plants	**ELA** R2 Determine central ideas or themes of a text and analyze their development; summarize the key supporting details and ideas. SL1 Prepare for and participate effectively in a range of conversations and collaborations with diverse partners; express ideas clearly and persuasively and build on those of others. SL2 Integrate and evaluate information presented in diverse media and formats (including visual, quantitative, and oral). **Career & Technical Education (CAREER)** AFNR Biotechnology Systems Career Pathway

	BS.03.04 Apply biotechnology principles, techniques and processes to enhance plant and animal care and production (e.g., selective breeding, pharmaceuticals, biodiversity, etc.). **Science** MS-LS1 From Molecules to Organisms: Structures and Processes MS-LS1-5 Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms. MS-LS3 Heredity: Inheritance and Variations of Traits
From Techniques to Traits	**Ela** R1 Integrate and evaluate content presented in diverse media and formats. W1 Write arguments to support claims in an analysis of substantive topics or texts, using valid reasoning and relevant and sufficient evidence. W5 Draw evidence from literary or informational texts to support analysis, reflection, and research. **Career & Technical Education (CAREER)** AFNR Biotechnology Systems Career Pathway *BS.03.04* Apply biotechnology principles, techniques, and processes to enhance plant and animal care and production (e.g., selective breeding, pharmaceuticals, biodiversity, etc.). **Social Studies - Geography** 9-12 Geography Standard 14: How human actions modify the physical environment. Objective 3 People can either mitigate and/or adapt to the consequences of human modifications of the physical environment. **Science** HS-LS3 Heredity: Inheritance and Variation of Traits HS-LS3-1 Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring. HS-LS4 Biological Evolution: Unity and Diversity HS-LS4-5 Evaluate the evidence supporting claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.
Carbon Hoofprint: Cows and Climate Change	**ELA** R1 Integrate and evaluate content presented in diverse media and formats. SL2 Integrate and evaluate information presented in diverse media and formats (including visual, quantitative, and oral). W1 Write arguments to support claims in an analysis of substantive topics or texts, using valid reasoning and relevant and sufficient evidence. W2 Write informative/explanatory texts to examine and convey complex ideas and information clearly and accurately through the effective selection, organization, and analysis of content. **Science** HS-LS2 Ecosystems: Interactions, Energy, and Dynamics HS-LS2-5 Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere. HS-LS2-7 Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.
Enhancing our World	**ELA** L4: Determine or clarify the meaning of unknown and multiple-meaning words and phrases by using context clues, analyzing meaningful word parts, and consulting general and specialized reference materials, as appropriate. R1: Read closely to determine what the text says explicitly/implicitly and make logical inferences from it; cite specific textual evidence when writing or speaking to support conclusions drawn from the text. R2 Determine central ideas or themes of a text and analyze their development; summarize the key supporting details and ideas.

	SL1 Prepare for and participate effectively in a range of conversations and collaborations with diverse partners; express ideas clearly and persuasively and build on those of others. SL2 Integrate and evaluate information presented in diverse media and formats (including visual, quantitative, and oral). **Career & Technical Education (CAREER)** AFNR Biotechnology Systems Career Pathway BS.03.04 Apply biotechnology principles, techniques and processes to enhance plant and animal care and production (e.g., selective breeding, pharmaceuticals, biodiversity, etc.). **Science** MS-LS1 From Molecules to Organisms: Structures and Processes MS-LS1-5 Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms. MS-LS3 Heredity: Inheritance and Variations of Traits MS-LS3-2 Develop and use a model to describe why asexual reproduction results in offspring with identical genetic information and sexual reproduction results in offspring with genetic variation. MS-LS4 Biological Evolution: Unity and Diversity 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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Lesson Matrix:

Media and photography:

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