INDUSTRY CONNECTION TOOLKIT
THE SCIENCE OF BEEF

Bring science to life with real-world applications of scientific principles that will engage students in purposeful investigation and discussion about the use of science in food production.

Each tool includes a/an:
- Guiding Question to provoke student interest
- Investigation prompt for student-guided learning
- Key Assignment for direct application
- Research Extension for a comprehensive learning experience
- Suggested Resources to support knowledge acquisition
- Career Connections to reinforce future opportunities related to science

Each tool also provides supported Next Generation Science Standards (NGSS) Performance Expectations and Engineering Practices, as well as supported Common Core English Language Arts Standards. Depending on the direction taken and depth of exploration, one or more of the listed standards may be reinforced.

TOOLS ARE ORGANIZED BY NGSS DISCIPLINARY CORE IDEAS FOR MIDDLE AND HIGH SCHOOL.

Disciplinary Core Idea - LS1 From Molecules to Organisms: Structure and Processes
     P1: Exploring Energy and Nutrients
     P3: The Science of Food Safety

Disciplinary Core Idea - LS2 Ecosystems, Interactions, Energy, and Dynamics
     P5: Carrying Capacity
     P7: Grazing and the Ecosystem

Disciplinary Core Idea - LS3 Heredity: Inheritance and Variation of Traits
     P9: Heritable Traits
     P11: Reproductive Technology

Disciplinary Core Idea - LS4 Biological Evolution: Unity and Diversity
     P13: Cattle Evolution
     P15: Domestication and Behavioral Management

www.agfoundation.org email:foundation@fb.org

EXPLORING
ENERGY AND NUTRIENTS

Disciplinary Core Idea: LS 1 From Molecules to Organisms: Structure and Processes

Below you will find a suggested approach designed to engage students in real-world investigation of science application in the beef industry. Depending on the direction you take, and the depth at which you study, one or more of the following standards may be supported.

NGSS Performance Expectations Supported

MS-LS1-3 Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells.

MS-LS1-6 Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms.

MS-LS1-7 Develop a model to describe how food is rearranged through chemical reactions forming new molecules that support growth and/or release energy as this matter moves through an organism.

HS-LS-1 Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins which carry out the essential functions of life through systems of specialized cells.

HS-LS1-7 Use a model to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed resulting in a net transfer of energy.

NGSS Science and Engineering Practices Supported

Developing and Using Models

Constructing Explanations and Designing Solutions

Common Core English Language Arts Standards Supported

Writing Standards 6-12: Text Types and Purposes
– Write arguments to support claims with clear reasons and relevant evidence.

Writing Standards 6-12: Research to Build and Present Knowledge
– Conduct short research projects to answer a question, drawing on several sources and refocusing the inquiry where appropriate.

GUIDING QUESTION:

How does matter and energy flow through the different organizational levels in a beef production environment?

INVESTIGATION:

Identify the major nutrients supplied through beef that have an impact on the human body and compare the systems of both organisms.

KEY ASSIGNMENT:

Develop a school menu providing the most nutrients by caloric intake, include supporting claims and submit via memorandum.
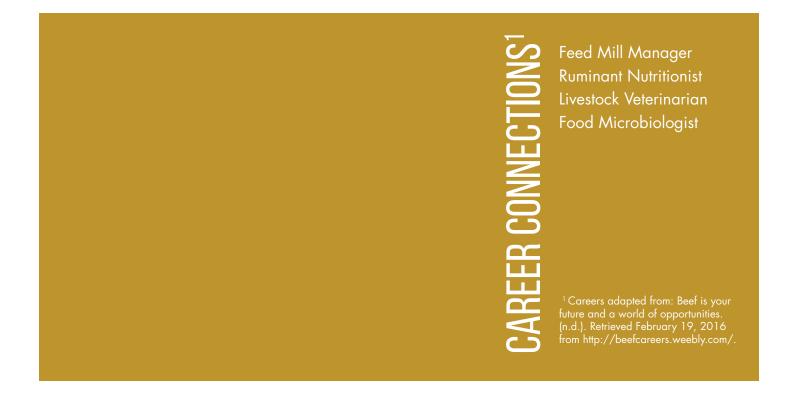
RESEARCH EXTENSION:

Conduct a comparison of foods that provide essential nutrients and their caloric equivalent.

SUGGESTED RESOURCES

BeefNutrion.org: is funded by the Beef Checkoff Program and managed by the <u>National Cattlemen's Beef Association</u>, (a contractor to the Beef Checkoff). Registered dietitians and nutrition communication experts at NCBA work on behalf of America's farmers and ranchers to provide the latest in beef research and resources to help you and your clients live better with lean beef.

BeefNutrition.org/Lifecycle.aspx: Downloadable research summaries and graphics related to human nutritional needs and beef products throughout various stages in life

BeefNutrition.org/BeefNutrients.aspx: Downloadable research summaries and graphics related to nutrients specifically found in beef products

FactAboutBeef.com: Common questions about safety, nutrition, the environment and animal care

FactsAboutBeef.com/research-page/the-beef-lifecycle/: Downloadable infographic summarizing the beef lifecycle at key stages in production

CAREER CONNECTIONS[1]

Feed Mill Manager
Ruminant Nutritionist
Livestock Veterinarian
Food Microbiologist

[1] Careers adapted from: Beef is your future and a world of opportunities. (n.d.). Retrieved February 19, 2016 from http://beefcareers.weebly.com/.

THE SCIENCE OF FOOD SAFETY

Disciplinary Core Idea: LS 1 From Molecules to Organisms: Structure and Processes

Below you will find a suggested approach designed to engage students in real-world investigation of science application in the beef industry. Depending on the direction you take, and the depth at which you study, one or more of the following standards may be supported.

NGSS Performance Expectations Supported

MS-LS1-1 Conduct an investigation to provide evidence that living things are made of cells; either one cell or many different numbers and types of cells.

MS-LS1-2 Develop and use a model to describe the function of a cell as a whole and ways parts of cells contribute to the function.

HS-LS1-4 Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms.

HS-LS-1 Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins which carry out the essential functions of life through systems of specialized cells.

HS-LS1-7 Use a model to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed resulting in a net transfer of energy.

NGSS Science and Engineering Practices Supported

Planning and Carrying out Investigations

Constructing Explanations and Designing Solutions

Common Core English Language Arts Standards Supported

Writing Standards for Literacy in History/Social Studies, Science, and Technical Subjects 6–12:

Text Types and Purposes 2.0 – (6) Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.several sources and refocusing the inquiry where appropriate.

? GUIDING QUESTION:

How is technology used to manage microbial ecology in beef production and processing?

INVESTIGATION:

Identify the most vulnerable points in the anatomic systems and beef production process where microbial growth can occur. Identify the mechanisms in place to protect animal health and food safety.

✓ KEY ASSIGNMENT:

Develop a protocol for implementation at home or at the school to inhibit microbial growth and compare to current protocol for the beef industry.
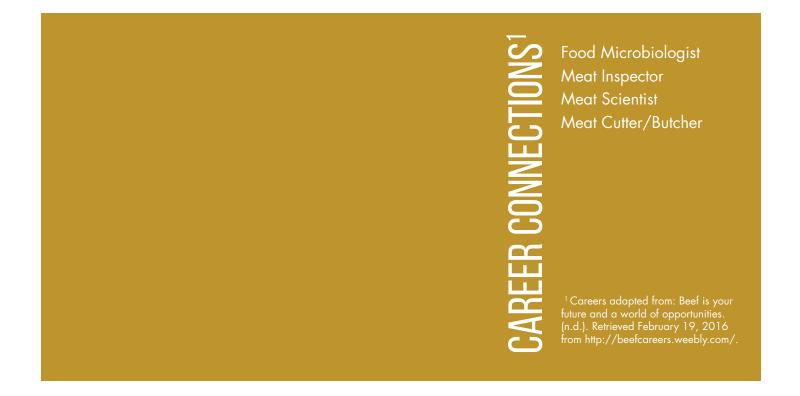
RESEARCH EXTENSION:

Test various methods of microbial control on beef products.

SUGGESTED RESOURCES

Beef Industry Food Safety Council - Resources: Downloadable resources related to food safety procedures throught the beef production process. *www.bifsco.org/resources.aspx*

Beef Research – Safety: The latest research in beef safety *http://www.beefresearch.org/beefsafety.aspx*

FactsAboutBeef.com: Common questions about safety, nutrition, the environment and animal care

Facts About Beef – Lifecycle: Downloadable infographic summarizing the beef lifecycle at key stages in production *http://factsaboutbeef.com/research-page/the-beef-lifecycle/*

USDA Food Safety: Key information for at-home safety and current hot topics *http://www.foodsafety.gov/*

HACCP Principles: Review the seven principles of the food safety process "Hazard Analysis and Critical Control Points". *http://www.fsis.usda.gov/Oa/background/keyhaccp.htm*

CAREER CONNECTIONS[1]

Food Microbiologist
Meat Inspector
Meat Scientist
Meat Cutter/Butcher

[1] Careers adapted from: Beef is your future and a world of opportunities. (n.d.). Retrieved February 19, 2016 from http://beefcareers.weebly.com/.

CARRYING CAPACITY

GUIDING QUESTION:

How are the principles of carrying capacity (also known as stocking rate) applied to manage ecosystem health?

INVESTIGATION:

Describe and explain the factors that influence carrying capacity.

KEY ASSIGNMENT:

You are a consultant to a beef cattle operation. Present a recommendation regarding carrying capacity in a given scenario.

RESEARCH EXTENSION:

Test the impact of forage height on ecosystem biodiversity.

SUGGESTED RESOURCES

Facts about Beef – Environment: Review key information on environmental issues. *http://factsaboutbeef.com/category/environment/*

Beef Research – Sustainability: Review current research related to sustainability of beef production.*http://www.beefresearch.org/beefsustainability.aspx*

Colorado State University Extension Stocking Rate Calculator: Click on the "Domestic Animals" calculator to review factors and determine carrying capacity. *http://www.range.colostate.edu/calculators.shtml*

CAREER CONNECTIONS[1]

Rangeland Ecologist

Rangeland Management Specialist

Soil Scientist

[1] Careers adapted from: Beef is your future and a world of opportunities. (n.d.). Retrieved February 19, 2016 from http://beefcareers.weebly.com/.

GRAZING AND THE ECOSYSTEM

NGSS Performance Expectations Supported

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-LS2-4 Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.

MS-LS2-5 Evaluate competing design solutions for maintaining biodiversity and ecosystem services.

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-LS2-6 Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.

NGSS Science and Engineering Practices Supported

Developing and Using Models

Constructing Explanations and Designing Solutions

Common Core English Language Arts Standards Supported

Writing Standards 6-12: Text Types and Purposes
– Write arguments to support claims with clear reasons and relevant evidence.

Writing Standards 6-12: Research to Build and Present Knowledge
– Conduct short research projects to answer a question, drawing on several sources and refocusing the inquiry where appropriate.

Speaking and Listening Standards 6-12: Presentation of Knowledge and Ideas 4.0
– Present claims and findings, sequencing ideas logically and using pertinent descriptions, facts and details to accentuate main ideas or themes.

GUIDING QUESTION:

What is the role of beef cattle within the complex interactions in an ecosystem?

INVESTIGATION:

Describe the possible relationship between grazers and ecosystem health and how producers make decisions regarding range management.

KEY ASSIGNMENT:

Create a presentation for a conservation agency regarding the introduction of cattle into their ecological preserve.

RESEARCH EXTENSION:

Test the impact of steer manure as a soil amendment on germination and growth rates.

SUGGESTED RESOURCES

Facts about Beef – Environment: Review key information on environmental issues. *http://factsaboutbeef.com/category/environment/*

Beef Research – Sustainability: Review current research related to sustainability of beef production. *http://www.beefresearch.org/beefsustainability.aspx*

CAREER CONNECTIONS[1]

Rangeland Ecologist

Rangeland Management Specialist

Soil Scientist

[1] Careers adapted from: Beef is your future and a world of opportunities. (n.d.). Retrieved February 19, 2016 from http://beefcareers.weebly.com/.

HERITABLE TRAITS

Disciplinary Core Idea: LS3 Heredity: Inheritance and Variation of Traits

Below you will find a suggested approach designed to engage students in real-world investigation of science application in the beef industry. Depending on the direction you take, and the depth at which you study, one or more of the following standards may be supported.

NGSS Performance Expectations Supported

MS-LS3-1 Develop and use a model to describe why structural changes to genes (mutations) located on chromosomes may affect proteins and may result in harmful, beneficial, or neutral effects to the structure and function of the organism.

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.

NGSS Science and Engineering Practices Supported

Developing and Using Models

Asking Questions and Defining Problems

Analyzing and Interpreting Data

Engaging in Argument from Evidence

Common Core English Language Arts Standards Supported

Writing Standards 6-12: Text Types and Purposes
– Write arguments to support claims with clear reasons and relevant evidence.

GUIDING QUESTION:

How do producers make genetic decisions to maximize optimal traits and productivity?

INVESTIGATION:

Identify the heritable traits that impact the productivity of an individual and the herd.

KEY ASSIGNMENT:

Look at excepted progeny difference (EPDs), analyze a scenario, and make a selection. Analyze four animals within a scenario, rank based on their EPDs, and explain selections.

RESEARCH EXTENSION:

Develop your own scenario and identify three actual bulls that would meet your needs from a sire catalog/semen exchange program. (ie. Select Sires *www.selectsires.com*, Accelerated Genetics *www.accelgen.com*, Top Sires *http://topsires.com/*)

SUGGESTED RESOURCES

Beef Magazine – Genetics: Discover the latest research in beef genetics *http://beefmagazine.com/cattle-genetics-0*

University of Nebraska Lincoln – Beef Cattle Breeding, Genetics & Reproduction: A list of resources related to genetics in beef production *http://beef.unl.edu/cattleproduction/breedingreproduction*

University of Nebraska Lincoln – Understanding and Using Expected Progeny Differences (EPDs): | Webinar addressing genetic beef selection considerations *http://beef.unl.edu/learning/epdswebinar.shtml*

CAREER CONNECTIONS[1]

Livestock Geneticist

Artificial Insemination (AI) Technician

[1] Careers adapted from: Beef is your future and a world of opportunities. (n.d.). Retrieved February 19, 2016 from http://beefcareers.weebly.com/.

REPRODUCTIVE TECHNOLOGY

Below you will find a suggested approach designed to engage students in real-world investigation of science application in the beef industry. Depending on the direction you take, and the depth at which you study, one or more of the following standards may be supported.

NGSS Performance Expectations Supported

MS-LS3-1 Develop and use a model to describe why structural changes to genes (mutations) located on chromosomes may affect proteins and may result in harmful, beneficial, or neutral effects to the structure and function of the organism.

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.

NGSS Science and Engineering Practices Supported

Developing and Using Models

Asking Questions and Defining Problems

Analyzing and Interpreting Data

Engaging in Argument from Evidence

Common Core English Language Arts Standards Supported

Writing Standards 6-12: Text Types and Purposes
– Write arguments to support claims with clear reasons and relevant evidence.

? GUIDING QUESTION:

How do producers use reproductive technological advancements to maximize efficiency?

🔍 INVESTIGATION:

List and describe the primary reproductive technological tools to meet specific needs. (i.e. artificial insemination, embryo transfer, estrus synchronization).

✓ KEY ASSIGNMENT:

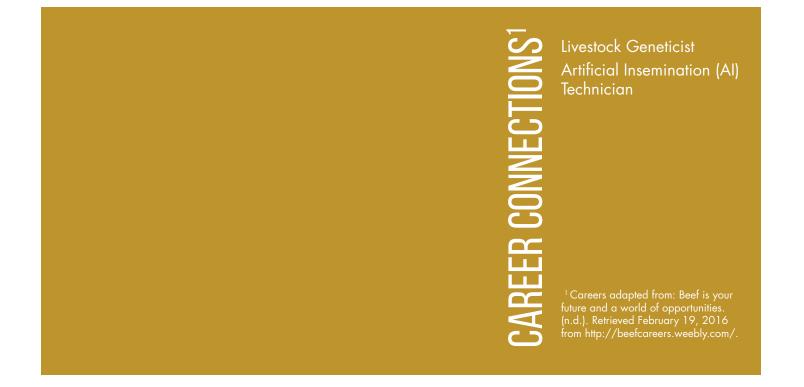Create an argument explaining/justifying the use of reproductive hormones in beef cattle.

RESEARCH EXTENSION:

Create a herd reproductive management plan, including a timeline of estrus synchronization.

SUGGESTED RESOURCES

Beef Magazine – Genetics: Discover the latest research in beef genetics *http://beefmagazine.com/cattle-genetics-0*

University of Nebraska Lincoln – Beef Cattle Breeding, Genetics & Reproduction: A list of resources related to genetics in beef production *http://beef.unl.edu/cattleproduction/breedingreproduction*

University of Nebraska Lincoln – Synchronizing Estrus in Beef Cattle: Key information and resources related to estrus synchronization *http://beef.unl.edu/learning/estrussynch.shtml*

CAREER CONNECTIONS[1]

Livestock Geneticist

Artificial Insemination (AI) Technician

[1] Careers adapted from: Beef is your future and a world of opportunities. (n.d.). Retrieved February 19, 2016 from http://beefcareers.weebly.com/.

CATTLE EVOLUTION

Disciplinary Core Idea: LS4 Biological Evolution: Unity and Diversity

Below you will find a suggested approach designed to engage students in real-world investigation of science application in the beef industry. Depending on the direction you take, and the depth at which you study, one or more of the following standards may be supported.

NGSS Performance Expectations Supported

MS-LS4-2 Apply scientific ideas to construct an explanation for the anatomical similarities and differences among modern organisms and between modern and fossil organisms to infer evolutionary relationships.

MS-LS4-4 Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment.

HS-L4-1 Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence.

HS-LS4-2 Construct an explanation based on evidence that the process of evolution primarily results from four factors: (1) the potential for a species to increase in number, (2) the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment.

NGSS Science and Engineering Practices Supported

Constructing Explanations and Designing Solutions

Engaging in Argument from Evidence

Common Core English Language Arts Standards Supported

Writing Standards 6-12: Text Types and Purposes
– Write arguments to support claims with clear reasons and relevant evidence.

Writing Standards 6-12: Research to Build and Present Knowledge
– Conduct short research projects to answer a question, drawing on several sources and refocusing the inquiry where appropriate.

? GUIDING QUESTION:

How have the two original species of cattle (Bos indicus and Bos taurus) evolved based on environmental conditions?

🔍 INVESTIGATION:

Describe the anatomical similarities and differences that provide evidence for evolution of Bos indicus and Bos taurus cattle and categorize current major beef breeds.

✓ KEY ASSIGNMENT:

Create a new beef breed and describe the ideal environment for that breed to thrive

RESEARCH EXTENSION:

Using current research, develop a lab protocol that could be used to test the suitability of a breed to in given environmental conditions (heat tolerance, pest resistance, disease resistance, etc.).

SUGGESTED RESOURCES

Oklahoma State University - Breeds of Livestock – Cattle Breeds: Review pictures and descriptions of cattle breeds *http://www.ansi.okstate.edu/breeds/cattle/*

University of Nebraska Lincoln – Beef Cattle Breeding, Genetics & Reproduction: A list of resources related to genetics in beef production *http://beef.unl.edu/cattleproduction/breedingreproduction*

University of Georgia Extension – Selecting a Beef Breed: Information relevant to beef breed selection *http://extension.uga.edu/publications/detail.cfm?number=C859#Basics*

CAREER CONNECTIONS[1]

Livestock Geneticist
Ranch Owner/Manager
Breed Organization
Marketing/Management

[1] Careers adapted from: Beef is your future and a world of opportunities. (n.d.). Retrieved February 19, 2016 from http://beefcareers.weebly.com/.

DOMESTICATION AND
BEHAVIORAL MANAGEMENT

Disciplinary Core Idea: LS4 Biological Evolution: Unity and Diversity

Below you will find a suggested approach designed to engage students in real-world investigation of science application in the beef industry. Depending on the direction you take, and the depth at which you study, one or more of the following standards may be supported.

NGSS Performance Expectations Supported

MS-LS4-2 Apply scientific ideas to construct an explanation for the anatomical similarities and differences among modern organisms and between modern and fossil organisms to infer evolutionary relationships.

MS-LS4-4 Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment.

HS-L4-1 Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence.

HS-LS4-2 Construct an explanation based on evidence that the process of evolution primarily results from four factors: (1) the potential for a species to increase in number, (2) the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment.

NGSS Science and Engineering Practices Supported

Constructing Explanations and Designing Solutions

Engaging in Argument from Evidence

Common Core English Language Arts Standards Supported

Writing Standards 6-12: Text Types and Purposes
– Write arguments to support claims with clear reasons and relevant evidence.

Writing Standards 6-12: Research to Build and Present Knowledge
– Conduct short research projects to answer a question, drawing on several sources and refocusing the inquiry where appropriate.

GUIDING QUESTION:

What factors influenced the domestication of cattle and how do they guide current management practices?

INVESTIGATION:

Describe the factors that dictate an animal's ability to be domesticated.

KEY ASSIGNMENT:

Research Dr. Temple Grandin's protocol and principles of behavioral management and stress reduction in cattle production.

RESEARCH EXTENSION:

Create a cost-benefit analysis of implementing research based behavior management when handling livestock.

SUGGESTED RESOURCES

Temple Grandin Livestock Research: Links to guidelines and research developed by Dr. Temple Grandin. *http://www.grandin.com/*

National Geographic Animal Domestication: Genetic rationale for successful animal species domestication *http://ngm.nationalgeographic.com/2011/03/taming-wild-animals/ratliff-text*

Oklahoma State University - Breeds of Livestock – Cattle Breeds: Review pictures and descriptions of cattle breeds *http://www.ansi.okstate.edu/breeds/cattle/*

CAREER CONNECTIONS[1]

Livestock Geneticist
Ranch Owner/Manager
Breed Organization Marketing/Management
Equipment/Facilities Engineer

[1] Careers adapted from: Beef is your future and a world of opportunities. (n.d.). Retrieved February 19, 2016 from http://beefcareers.weebly.com/.