Chariho Regional School District - Science Curriculum
September, 2016

BIOTECHNOLOGY CURRICULUM

Unit 1: What is Biotechnology

OVERVIEW

Summary

Students will be introduced to the overarching concept of biotechnology. They will research various fields of biotechnology, including pharmaceutical biotechnology, agricultural biotechnology, genomics and proteomics, bioinformatics, food innovations, and medical biotechnology. They will look at the history of biotechnology and the advancements that have been made in the field, from artificial selection of seeds to modern engineering. They will begin the laboratory component of the course with an investigation on an introductory biotechnology, for example, making cheese.

Content to Be Learned

- Defining biotechnology - what is it, what does it look like in today's society.
- Identify the domains of biotechnology and examples of products produced in each field.
- Inventory and survey the laboratory tools of a biotechnician.
- Describe examples bioengineered products.
- Create a bioengineered product, such as cheese, using basic techniques of biotechnology.

Practices

- Planning and carrying out investigations.
- Obtaining, evaluating, and communicating information.

Crosscutting Concepts

- Not applicable for this unit.

Essential Questions

- Historically, how has the field of biotechnology changed over the course of human existence?
- What are examples of products produced using various biotechnologies?

National Council for Agricultural Education Standards

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.02.02. Implement standard operating procedures for the proper maintenance, use and sterilization of equipment in a laboratory.

Unit 2: Introduction to the Regulation of Biotechnology

OVERVIEW

Summary

Students will investigate safe practices in the laboratory setting and those used in today's industries. They will understand the importance of accurately following SOPs, and will get practice at writing them for various lab techniques. Students will learn to read and interpret SDS sheets, and MSDS sheets and will look at their similarities and differences. They will understand the reasons for the transition from MSDS to SDS and will apply the information in the sheets to safe laboratory practices. Finally, they will research how the biotech industry is primarily regulated by three agencies; the FDA, the USDA and the EPA.

Content to Be Learned

- Read, write and comply with Standard Operating Procedures.
- Read and interpret SDS and MSDS sheets for chemical and laboratory safety.
- Understand how and why SDS and MSDS sheets are used in a laboratory setting.
- Research FDA, USDA and EPA regulations and their influence on the biotech industry.

Practices

- Obtaining, evaluating, and communicating information.
- Analyzing and interpreting data.

Crosscutting Concepts

- Not applicable to this unit.

Essential Questions

- What current regulations govern the biotech industry?
- Why is compliance with standard operating procedures essential for a biotechnician?
- What important information can be gained from SDS and MSDS sheets?

National Council for Agricultural Education Standards

BS.01.02. Evaluate the scope and implications of regulatory agencies on applications of biotechnology in agriculture and protection of public interests (e.g., health, safety, environmental issues, etc.).

BS.02.01. Read, document, evaluate and secure accurate laboratory records of experimental protocols, observations and results.

BS.02.03. Apply standard operating procedures for the safe handling of biological and chemical materials in a laboratory.

Unit 3: The Raw Materials of Biotechnology

OVERVIEW

Summary

Students will review important relevant content from Biology, including hierarchical organization, structure and function of macromolecules, and function subcellular structures. Students will practice their microscope skills while identifying microorganisms and their structures, focusing on microorganisms that are used regularly in the biotechnology industry. They will apply their knowledge of macromolecules to identify unknown substances.

Content to Be Learned

- The structure of DNA determines structures of proteins which carry out essential functions.
- Systems of specialized cells help perform essential functions of life.
- Prokaryote and eukaryote comparison and analysis.
- Structure of cell membrane.
- Ribosomes are the site of protein synthesis.
- Each of the four classes of macromolecules have unique structures and characteristics.
- Macromolecules can be identified by their unique characteristics.

Practices

- Develop and use models to show the hierarchical organization of interacting systems.
- Construct an explanation based on evidence for how the structure of DNA creates the structure of proteins.

Crosscutting Concepts

- Systems and system models.
- Energy and matter flow.

Essential Questions

- How does the structure of the cell membrane, and the need for cells to use diffusion to move molecules in and out of the cell, create constraints on the size of a cell?
- How is energy transferred from light to sugar to ATP, using chloroplasts and mitochondria?

Next Generation Science Standards

Students who demonstrate understanding can:

HS-LS1-2. **Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.** [Clarification Statement: Emphasis is on functions at the organism system level such as nutrient uptake, water delivery, and organism movement in response to neural stimuli. An example of an interacting system could be an artery depending on the proper function of elastic tissue and smooth muscle to regulate and deliver the proper amount of blood within the circulatory system.] [*Assessment Boundary: Assessment does not include interactions and functions at the molecular or chemical reaction level.*]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds. • Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system.	**LS1.A: Structure and Function** • Multicellular organisms have a hierarchical structural organization, in which any one system is made up of numerous parts and is itself a component of the next level.	**Systems and System Models** • Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales.

Connections to other DCIs in this grade-band: N/A

Articulation of DCIs across grade-bands:
MS.LS1.A

Common Core State Standards Connections:
ELA/Literacy -
SL.11-12.5 Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. *(HS-LS1-2)*

Students who demonstrate understanding can:

HS-LS1-6. **Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules.** [Clarification Statement: Emphasis is on using evidence from models and simulations to support explanations.] [*Assessment Boundary: Assessment does not include the details of the specific chemical reactions or identification of macromolecules.*]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.	**LS1.C: Organization for Matter and Energy Flow in Organisms** • The sugar molecules thus formed contain carbon, hydrogen, and oxygen: their hydrocarbon backbones are used to make amino acids and other carbon-based molecules that can be assembled into larger molecules (such as proteins or DNA), used for example to form new cells. • As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products.	**Energy and Matter** • Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system.

Connections to other DCIs in this grade-band:
HS.PS1.B

Articulation of DCIs across grade-bands:
MS.PS1.A ; MS.PS1.B ; MS.PS3.D ; MS.LS1.C ; MS.ESS2.E

Common Core State Standards Connections:
ELA/Literacy -

RST.11-12.1	Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-LS1-6)
WHST.9-12.2	Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-LS1-6)
WHST.9-12.5	Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. (HS-LS1-6)
WHST.9-12.9	Draw evidence from informational texts to support analysis, reflection, and research. (HS-LS1-6)

National Council for Agricultural Education Standards

BS.02.05. Examine and perform scientific procedures using microbes, DNA, RNA and proteins in a laboratory.

Unit 4: Introduction to DNA

OVERVIEW

Summary

Students will learn about the structure of DNA and how that structure allows the molecule to be self-replicating. They will practice extracting DNA from various sources, an essential step in many biotechnology experiments. They will learn about the features of bacterial and viral DNA and how the DNA of those organisms differs from that of euaryotes. They will learn how scientists can manipulate DNA from various sources. They will experiment will sterile technique and how to identify bacteria that have specific genetic traits using this technique. They will compare the different sources of genetic changes that lead to variation among individuals of a species. Finally, students will understand and demonstrate how to cut up DNA using restriction enzymes and how DNA fingerprints can be formed from these fragments.

Content to Be Learned

- Structure and replication process of DNA.
- Characteristics of eukaryotic, bacterial and viral DNA.
- Recombinant DNA is the result of fragments from various sources merged together.
- DNA fragments are created using restriction endonucleases at specific restriction sites.
- DNA fragments can have blunt or sticky ends and those with sticky ends can be used in recombinant DNA.
- Every organism creates a unique pattern of fragments called a DNA fingerprint.
- DNA fingerprints can be used for diagnostic purposes, in forensic analysis, and many other applications.

Practices

- Ask questions to clarify relationships between the role DNA and chromosomes in coding for traits.
- Use models to show how restriction endonucleases create DNA fragments.

Crosscutting Concepts

- Cause and effect.

Essential Questions

- Using specific examples, how are the genomes of a eukaryote, a bacterium and a virus similar, yet unique?
- How are restriction enzymes used to create recombinant DNA and DNA fingerprints?
- What are some common applications of DNA fingerprints?

Next Generation Science Standards

Students who demonstrate understanding can:

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.** [*Assessment Boundary: Assessment does not include the phases of meiosis or the biochemical mechanism of specific steps in the process.*]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Asking Questions and Defining Problems Asking questions and defining problems in 9-12 builds on K-8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations. • Ask questions that arise from examining models or a theory to clarify relationships.	**LS1.A: Structure and Function** • All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins. *(secondary) (Note: This Disciplinary Core Idea is also addressed by HS-LS1-1.)* **LS3.A: Inheritance of Traits** • Each chromosome consists of a single very long DNA molecule, and each gene on the chromosome is a particular segment of that DNA. The instructions for forming species' characteristics are carried in DNA. All cells in an organism have the same genetic content, but the genes used (expressed) by the cell may be regulated in different ways. Not all DNA codes for a protein; some segments of DNA are involved in regulatory or structural functions, and some have no as-yet known function.	**Cause and Effect** • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

Connections to other DCIs in this grade-band: N/A

Articulation of DCIs across grade-bands:
MS.LS3.A ; **MS.LS3.B**

Common Core State Standards Connections:
ELA/Literacy -

RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. *(HS-LS3-1)*

RST.11-12.9 Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible. *(HS-LS3-1)*

National Council for Agricultural Education Standards

BS.02.05. Examine and perform scientific procedures using microbes, DNA, RNA and proteins in a laboratory.

Unit 5: Protein Structure and Function

OVERVIEW

Summary

Students will compare the structures of DNA with RNA and create models of the process of protein synthesis. They will then explore the various uses of proteins in a cell and the body, and specifically focus on the numerous enzymes that direct cellular and physiological processes. They will create an investigation to test the effectiveness of an enzyme in various conditions.

Content to Be Learned

- DNA is chunked into segments called genes, which carries instructions for formation of proteins.
- Protein synthesis; transcription and translation.
- Some segments of DNA are involved in regulatory or structural functions
- Enzymes are a diverse category of protein with many functions.
- Enzymes act as catalysts of biological reactions and use an induced fit to bond with a substrate.

Practices

- Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins.

Crosscutting Concepts

- Structure and function.

Essential Questions

- How does the structure of DNA determine the structure of proteins?
- How does the structural organization of the chromosome allow for the expression of traits in an organism?
- How do enzymes function in living systems?
- What factors influence the effectiveness of an enzyme and how can those factors be manipulated to control the use of enzymes in a lab setting?

Next Generation Science Standards

HS-LS1-1 From Molecules to Organisms: Structures and Processes

Students who demonstrate understanding can:

HS-LS1-1. **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.** [*Assessment Boundary: Assessment does not include identification of specific cell or tissue types, whole body systems, specific protein structures and functions, or the biochemistry of protein synthesis.*]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Constructing Explanations and Designing Solutions
Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.

- Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.

Disciplinary Core Ideas

LS1.A: Structure and Function

- Systems of specialized cells within organisms help them perform the essential functions of life.
- All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins, which carry out most of the work of cells. *(Note: This Disciplinary Core Idea is also addressed by HS-LS3-1.)*

Crosscutting Concepts

Structure and Function

- Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem.

Connections to other DCIs in this grade-band:
HS.LS3.A

Articulation of DCIs across grade-bands:
MS.LS1.A ; **MS.LS3.A** ; **MS.LS3.B**

Common Core State Standards Connections:
ELA/Literacy -

RST.11-12.1	Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-LS1-1)
WHST.9-12.2	Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-LS1-1)
WHST.9-12.9	Draw evidence from informational texts to support analysis, reflection, and research. (HS-LS1-1)

* The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

National Council for Agricultural Education Standards

BS.02.05. Examine and perform scientific procedures using microbes, DNA, RNA and proteins in a laboratory.

BS.03.02. Apply biotechnology principles, techniques and processes to enhance the production of food through the use of microorganisms and enzymes.

Unit 6: Following the Production of a Biotechnology Product from Identification to Market

OVERVIEW

Summary

Students will identify natural sources of potential biotechnology products. They will investigate how antibiotics can be harvested from natural sources like fungi. They will also be introduced to the basic principles of genetic engineering and will see how bacteria can be transformed to produce a protein product from another organism. Using the insulin production model as a foundation, they will research current genetic engineering practices being used to create biological based products. Students will continue to follow the insulin production model through to completion. They will track how raw products are purified and packaged for commercial use. They will also use willow bark and salicylic acid to simulate the production of aspirin as a model for using naturally occurring sources of synthetic products. Finally, they will be exposed to good manufacturing practices and see how manufacturing regulations guide the production of biotechnology products and will practice the methodology that allows for the separation of a protein product from cell fragments for purification.

Content to Be Learned

- Sources of potential biotechnology products are found in nature and can include plant or animal species.
- Naturally occurring compounds can be synthesized using biotech techniques.
- Genetic engineering can be used to insert a gene that codes for a target compound into a model organism (typically bacteria) to then be synthesized.
- Good manufacturing practices ensure that products are created uniformly and safely.

Practices

- Ask questions, based on previous research, to determine what characteristics of a potential sources would make it a potential resource for a new biotechnology product.

Crosscutting Concepts

- Structure and function.

Essential Questions

- What characteristics of an organism make it a potential source of a new biotechnology product?
- What are good manufacturing practices and how are they applied in a laboratory setting?
- How are genes inserted into bacterial DNA?
- What conditions are necessary to stimulate bacteria to produce a foreign product?
- How can a protein product be separated from the cell that created it?

Next Generation Science Standards

Students who demonstrate understanding can:

HS-LS4-6. **Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.***
[Clarification Statement: Emphasis is on designing solutions for a proposed problem related to threatened or endangered species, or to genetic variation of organisms for multiple species.]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Using Mathematics and Computational Thinking
Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.

- Create or revise a simulation of a phenomenon, designed device, process, or system.

Disciplinary Core Ideas

LS4.C: Adaptation

- Changes in the physical environment, whether naturally occurring or human induced, have thus contributed to the expansion of some species, the emergence of new distinct species as populations diverge under different conditions, and the decline–and sometimes the extinction–of some species.

LS4.D: Biodiversity and Humans

- Humans depend on the living world for the resources and other benefits provided by biodiversity. But human activity is also having adverse impacts on biodiversity through overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change. Thus sustaining biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth. Sustaining biodiversity also aids humanity by preserving landscapes of recreational or inspirational value. *(Note: This Disciplinary Core Idea is also addressed by HS-LS2-7.)*

ETS1.B: Developing Possible Solutions

- When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. *(secondary)*
- Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs. *(secondary)*

Crosscutting Concepts

Cause and Effect

- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

Connections to other DCIs in this grade-band:
HS.ESS2.D ; HS.ESS2.E ; HS.ESS3.A ; HS.ESS3.C ; HS.ESS3.D

Articulation of DCIs across grade-bands:
MS.LS2.C ; HS.ESS3.C

Common Core State Standards Connections:
ELA/Literacy -

WHST.9-12.5 Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. *(HS-LS4-6)*

WHST.9-12.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. *(HS-LS4-6)*

National Council for Agricultural Education Standards

BS.03.01. Apply biotechnology principles, techniques and processes to create transgenic species through genetic engineering.

BS.03.02. Apply biotechnology principles, techniques and processes to enhance the production of food through the use of microorganisms and enzymes.

Unit 7: Plant and Agriculture Biotechnology

OVERVIEW

Summary

Students will begin with an overview of plant anatomy and reproduction. They will then explore the various methods of plant propagation including separation and division, cuttings, layering, grafting and tissue culturing. The students will experiment with these techniques and by selecting plant species that could be cloned using each technique and then perform those tasks. They will also be introduced to plant hormones and their control over plant growth and other functions. They will experiment with plant growth and propagation under the influence of various hormones, including, but not limited to auxins and cytokinins. Finally, students will understand the role of bioengineering while investigating how to optimize the efficiency of key enzymes that convert cellulose into biofuels.

Content to Be Learned

- Photosynthesis transforms light energy into stored chemical energy.
- The plant body is organized into tissues and organs, each with specific functions.
- Plants produce hormones, which influence all aspects of growth and development, and can be used in a laboratory to clone and grow plants.
- Plant propagation can be performed in nature and in a lab, using various techniques.
- Soil composition and nutrient availability both influence plant growth and development.
- Biofuels are an emerging area of biotechnology and can be synthesized in a lab using extracts from common organisms.

Practices

- Engaging in argument from evidence.
- Constructing explanations and designing solutions.

Crosscutting Concepts

- Energy and matter.
- System and system models.
- Cause and effect.
- Stability and change.

Essential Questions

- How do the various plant hormones influence growth and development?
- When selecting a propagation technique for a specific plant, what factors influence which technique might be the most successful at producing new organisms?
- When analyzing the various propagation techniques from a cost-benefit standpoint, what are the pros and cons of each method?
- Under what conditions can enzymes that produce biofuels be optimized? What experiments can be performed to test these conditions?

Next Generation Science Standards

HS-ESS3-2 Earth and Human Activity

Students who demonstrate understanding can:

HS-ESS3-2. Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.* [Clarification Statement: Emphasis is on the conservation, recycling, and reuse of resources (such as minerals and metals) where possible, and on minimizing impacts where it is not. Examples include developing best practices for agricultural soil use, mining (for coal, tar sands, and oil shales), and pumping (for petroleum and natural gas). Science knowledge indicates what can happen in natural systems—not what should happen.]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Engaging in Argument from Evidence
Engaging in argument from evidence in 9–12 builds on K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about natural and designed world(s). Arguments may also come from current scientific or historical episodes in science.

- Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and logical arguments regarding relevant factors (e.g. economic, societal, environmental, ethical considerations).

Disciplinary Core Ideas

ESS3.A: Natural Resources

- All forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors.

ETS1.B: Developing Possible Solutions

- When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. *(secondary)*

Crosscutting Concepts

- -

Connections to Engineering, Technology, and Applications of Science

Influence of Science, Engineering, and Technology on Society and the Natural World

- Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks.
- Analysis of costs and benefits is a critical aspect of decisions about technology.

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Connections to Nature of Science

Science Addresses Questions About the Natural and Material World

- Science and technology may raise ethical issues for which science, by itself, does not provide answers and solutions.
- Science knowledge indicates what can happen in natural systems—not what should happen. The latter involves ethics, values, and human decisions about the use of knowledge.
- Many decisions are not made using science alone, but rely on social and cultural contexts to resolve issues.

Connections to other DCIs in this grade-band:
HS.PS3.B ; HS.PS3.D ; HS.LS2.A ; HS.LS2.B ; HS.LS4.D ; HS.ESS2.A
Articulation of DCIs across grade-bands:
MS.PS3.D ; MS.LS2.A ; MS.LS2.B ; MS.LS4.D ; MS.ESS3.A ; MS.ESS3.C
Common Core State Standards Connections:
ELA/Literacy -
RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-ESS3-2)
RST.11-12.8 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-ESS3-2)
Mathematics -
MP.2 Reason abstractly and quantitatively. (HS-ESS3-2)

HS-ESS3-4 Earth and Human Activity

Students who demonstrate understanding can:

HS-ESS3-4. **Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.*** [Clarification Statement: Examples of data on the impacts of human activities could include the quantities and types of pollutants released, changes to biomass and species diversity, or areal changes in land surface use (such as for urban development, agriculture and livestock, or surface mining). Examples for limiting future impacts could range from local efforts (such as reducing, reusing, and recycling resources) to large-scale geoengineering design solutions (such as altering global temperatures by making large changes to the atmosphere or ocean).]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Constructing Explanations and Designing Solutions

Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific knowledge, principles, and theories.

- Design or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.

Disciplinary Core Ideas

ESS3.C: Human Impacts on Earth Systems

- Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude ecosystem degradation.

ETS1.B: Developing Possible Solutions

- When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. *(secondary)*

Crosscutting Concepts

Stability and Change

- Feedback (negative or positive) can stabilize or destabilize a system.

Connections to Engineering, Technology, and Applications of Science

Influence of Science, Engineering, and Technology on Society and the Natural World

- Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks.

Connections to other DCIs in this grade-band:
HS.LS2.C ; **HS.LS4.D**

Articulation of DCIs across grade-bands:
MS.LS2.C ; **MS.ESS2.A** ; **MS.ESS2.E** ; **MS.ESS3.B** ; **MS.ESS3.C** ; **MS.ESS3.D**

Common Core State Standards Connections:

ELA/Literacy -

RST.11-12.1	Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-ESS3-4)
RST.11-12.8	Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-ESS3-4)

Mathematics -

MP.2	Reason abstractly and quantitatively. *(HS-ESS3-4)*
HSN.Q.A.1	Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-ESS3-4)
HSN.Q.A.2	Define appropriate quantities for the purpose of descriptive modeling. *(HS-ESS3-4)*
HSN.Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. *(HS-ESS3-4)*

National Council for Agricultural Education Standards

BS.03.01. Apply biotechnology principles, techniques and processes to create transgenic species through genetic engineering.

Unit 8: Biotechnology in Medicine

OVERVIEW

Summary

Students will explore how biotechnology can be used in diagnosis of diseases, genetic conditions and immunities. They will map how communicable diseases are spread and perform ELISA to determine the extent of the spread of an infection and will use the data from this procedure to determine patient zero. Students will also research how new drugs are developed and use microarrays to screen for potentially useful drugs and for genetic diseases which can then be treated by these drugs. Finally, the students will learn about how vaccines were discovered and developed, and how biotechnology is used in creating current vaccines from antibodies and antigens.

Content to Be Learned

- Diseases can be passed on through various transmission pathways, and a patient zero can be detected by analyzing the spread of the disease.
- Microarrays can be used to measure the expression levels of genes.
- Microarrays use hybridization of DNA sequences to probe for specific segments of DNA and can be used to detect genetic diseases.
- The immune system produces antibodies in response to foreign particles, that are specific to that molecule and are kept in memory cells if there is a subsequent exposure to the molecule.
- Koch's postulates are criteria developed to explain the relationship between microbes and disease.

Practices

- Developing and using models.
- Use mathematics and computational thinking.
- Planning and carrying out investigations.
- Analyzing and interpreting data.
- Constructing explanations and designing solutions.

Crosscutting Concepts

- System and system models.
- Cause and effect.
- Structure and function.

Essential Questions

- How can ELSIA be used to determine the spread of an infectious disease?
- How can Koch's postulates be used to explain the relationship between microbes and disease, and how have the original postulates been refined in recent years?
- What is the process by which new drugs are created, screened and tested?

National Council for Agricultural Education Standards

BS.03.01. Apply biotechnology principles, techniques and processes to create transgenic species through genetic engineering.

Unit 9: Ethics in Genetic Engineering

OVERVIEW

Summary

Students will finish the course by investigating a topic of their choice and present a debate on the merits and ethics of that topic. Topics include, but are not limited to, the use of gene therapy for treatment of diseases and medical conditions, the use of stem cells for scientific research, the creation and use of genetically modified organisms, or the labeling of GMOs in food and other products. Students will begin by learning about the structure of a debate and agree upon the rules by which they will debate their topic. They will then research their topic and pick sides that they will argue. They will prepare arguments, counterarguments and rebuttals. Finally, the students will present their argument in a written and/or oral manner for their classmates to then reflect, respond and discuss.

Content to Be Learned

- A proper debate presents a topic in a balanced, and researched manner. It typically consists of introductions, cross examinations, rebuttals and closing arguments. The affirmative and negative sides alternate.
- Gene therapy is a technique wherein DNA is inserted into damaged cells to stimulate a change in the function of those cells.
- Stem cells are totipotent or pluripotent and have the genetic ability to differentiate into any other cell type of the organism. Stem cells can be found in embryos, umbilical cords and bone marrow of vertebrate animals and in meristems of plants.
- Genetically modified organisms refer to any organism which has had its DNA modified in some fashion. This could be do to artificial selection, or, more current technology is used to modify the organism in a laboratory setting.

Practices

- Engaging in argument from evidence.
- Constructing explanations and designing solutions.

Crosscutting Concepts

- Energy and matter.
- System and system models.
- Stability and change.
- Cause and effect.
- Scale, proportion, and quantity.

Essential Questions

- How do values impact decisions?
- Can a person effectively defend both sides of a controversial topic?
- How do the needs of a society balance out the needs of an individual?
- Why are effective argumentation skills essential to success in any career?
- How do people effectively use persuasion to get what they want?

National Council for Agricultural Education Standards

BS.01.03. Analyze the relationship and implications of bioethics, laws and public perceptions on applications of biotechnology in agriculture (e.g., ethical, legal, social, cultural issues).