ENVISION 21

DEEP LEARNING • CFSD

SCIENCE

Academic Standards
Three Dimensions of Science Learning
Learning Goals

June 2020

Applications of Biotechnology

HS

HIGH SCHOOL

APPLICATIONS OF BIOTECHNOLOGY

Note: Note: While some of the core content of the course aligns with the “essential” Physics standards, the application of the content through labs and related activities is focused on the biotechnology domain.

CATALINA FOOTHILLS SCHOOL DISTRICT

HIGH SCHOOL APPLICATIONS OF BIOTECHNOLOGY OVERVIEW

High School Applications of Biotechnology is a dual enrollment laboratory course that emphasizes the role that biotechnology plays in research and industry. Students will apply previously developed knowledge and skills in biotechnology to an industry-based laboratory setting. The course includes topics such as recombinant DNA technology, bacterial transformations, protein identification and isolation, the human genome project, genetic ethics, and laboratory techniques in an industry-based biotechnology lab. Students will also get hands-on experiences working through experimental design and critical analysis using physics-based concepts such as motion and stability, wave phenomena, energy and matter interactions, and electricity and magnetism. Students are expected to apply these concepts to real-world phenomena to gain a deeper understanding of causes, effects, and solutions for physical processes in the real world. Students will create an individual research project that will tie together the skills from the classroom with an investigation of their choosing, and will be given the opportunity to share their projects in a scientific environment. There is an emphasis on collaborative learning and industry-based laboratory skills. Optional summer internship opportunities are available for students who wish to continue performing scientific research. Students who are interested in earning college credit for UA MCB 101 must register and pay reduced tuition to the University of Arizona. Scholarships are available from Pima JTED. See course instructor for more information.

Applications of Biotechnology is a third-year science course and students will have been taught the full set of “essential” standards upon completion of the course. The “essential” standards are those that every high school student is expected to know and understand (see “coding of the standards” below). Two topics from the standards in the Earth and Space Sciences, have been integrated into the course. This is to ensure that students have been taught the full set of “essential” science standards by their third year of high school (see “coding of the standards” below). Because students have some flexibility in the pathway they select to meet the graduation requirements for science, specific “essential” standards were integrated into some of the high school science courses to meet this Arizona State Board of Education requirement.

The standards for high school Applications of Biotechnology are categorized according to the topics listed below. The list does not imply the instructional sequence or how the standards will be organized for instruction. Educators will make decisions about instructional sequence and how standards will be grouped by units for classroom instruction and assessment to best meet student needs.

High School Applications of Biotechnology Topics:

- Biotechnology
  - Industry Safety Standards
  - Bioscience Research and Ethical Conduct
  - Investigative and Laboratory Skills
  - Protein Techniques: Isolation and Analysis
  - Agricultural Biology
  - Bacteria/Microbiology
  - Nucleic Acid Techniques and Bioinformatics
  - Research Project
- Physical Science: Physics
  - Motion & Stability – Forces & Interactions, Energy & Waves
- Earth and Space Sciences
  - Weather and Climate, Earth and the Solar System, The Universe and its Stars
- Arizona Professional Skills

High school students continue the pattern from previous years by engaging in the science and engineering practices to apply their knowledge of core ideas to understand how scientists continue to build an understanding of phenomena and see how people are impacted by natural phenomena or to construct solutions. The crosscutting concepts support their understanding of patterns, cause and effect relationships, and systems thinking as students make sense of phenomena in the natural and designed worlds.

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ENVISION 21
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Navigating the Science Standards: Abbreviated Version

The standards serve as the basis for the design of instruction and assessment of the district's science curriculum.

- **Standards** are what a student needs to know, understand, and be able to do by the end of each grade or course. They build across grade levels in a progression of increasing understanding and through a range of cognitive demand levels.
- **Curriculum** refers to the resources used for teaching and learning the standards (units, lessons, texts, materials, tech apps, assessments, etc.).
- **Instruction** refers to the methods or methodologies used by teachers to teach their students. Instructional techniques are employed by individual teachers in response to the needs of students in their classes to help them progress through the curriculum to achieve the standards.

Grade Level or Course and **Topic Area** for standard.

Standard – What is Assessed
Describes what students should be able to do at the end of instruction to show what they have learned. Combines Science and Engineering Practices, Core Ideas, and Crosscutting Concepts.

Learning Goals
Indicators or evidence of learning at the end of a lesson or unit as aligned to the standard.

Life Science
Description of what students will learn for the area of science under study (K-8 only).

KINDERGARTEN

LIFE SCIENCE: LIVING AND NON-LIVING THINGS

Students develop an understanding that the world is comprised of living and non-living things. They investigate the relationship between structure and function in living things; plants and animals use specialized parts to help them meet their needs and survive.

Science Standard: K.L2U1.8 **Observe, ask questions, and explain the differences between the characteristics of living and non-living things.**

Learning Goals

I can:

- Based on prior experiences, ask questions about living and non-living things.
- Make direct or indirect observations about living and non-living things:
  - Identify traits of living and non-living things.
  - Record observations (*e.g., through pictures and/or words*).
  - Make inferences about the characteristics of living and non-living things.
- List the characteristics of living things (*i.e., move, reproduce, react to stimuli*).
- Use evidence to explain how the characteristics of living things differ from the characteristics of non-living things.

Core Ideas for Knowing and Using Science
"Understandings" or big ideas for physical, earth and space, and life sciences that build in complexity across grade levels and students develop over time.
Background Information (Content) is provided under each Core Idea.

Core Ideas

Knowing Science
L2: Organisms require a supply of energy and materials for which they often depend on, or compete with, other organisms.
- There is a wide variety of living things (organisms), including plants and animals. They are distinguished from non-living things by their ability to move, reproduce, and react to certain stimuli.

Using Science
U1: Scientists explain phenomena using evidence obtained from observations and/or scientific investigations. Evidence may lead to developing models and/or theories to make sense of phenomena. As new evidence is discovered, models and theories can be revised.
- Students ask questions to frame their exploration of living and non-living things.
- Students make observations about living and non-living things.
- Students use the evidence from their observations to make inferences about the characteristics of living and non-living things.

Three Dimensions (3-D) of Science:
The Practices, Core Ideas, and Crosscutting Concepts that were used to create the standards.

Science and Engineering Practices	Crosscutting Concepts
Asking Questions and Defining Problems • Ask questions based on observations of the natural and/or designed world. **Constructing Explanations and Designing Solutions** • Use information from direct or indirect observations to construct explanations. • Distinguish between opinions and evidence in one's own explanations.	**Patterns** • Patterns in the natural and human designed world can be observed, used to describe phenomena, and used as evidence. **Structure and Function** • The shape and stability of structures of natural and designed objects are related to their function(s). **Systems and System Models** • Objects and organisms can be described in terms of their parts.

Science and Engineering Practices
Skills and knowledge that scientists and engineers engage in to either understand the world or solve a problem.

Crosscutting Concepts
Concepts that cut across all disciplines and help students deepen their understanding of core ideas.

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BIOTECHNOLOGY

INDUSTRY SAFETY PROCEDURES

BIOSCIENCE RESEARCH AND ETHICAL CONDUCT

INVESTIGATIVE AND LABORATORY SKILLS

PROTEIN TECHNIQUES: ISOLATION AND ANALYSIS

AGRICULTURAL BIOLOGY

BACTERIA/MICROBIOLOGY

NUCLEIC ACID TECHNIQUES AND BIOINFORMATICS

RESEARCH PROJECT

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HIGH SCHOOL APPLICATIONS OF BIOTECHNOLOGY

BIOTECHNOLOGY

INDUSTRY SAFETY PROCEDURES (CTE Correlation: 1.1-1.10, 2.1, 2.2, 5.0-5.6, 6.1-6.3, 9.1, 9.2, 9.7, 11.1, 11.2, 11.3, 11.4,11.6)

Science Standards:

- Adhere to health practices and industry safety standards in the classroom and laboratory setting for personal health and safety and the health and safety of others *(i.e., SOPs for biological, biohazardous, and chemical materials, appropriate personal protective equipment [PPE] for the situation, emergency equipment).*
- Safely operate and perform care and routine maintenance of equipment *(e.g., maintain equipment log, report unsafe and nonfunctioning equipment, storage of chemicals, reagents and compounds, and maintenance of equipment).*
  - manufacturing practices pertaining to quality control (QC)
  - control inventory process for materials and supplies
- Apply compliancy procedures for state, local, and industry regulations *(e.g., OSHA [occupational safety and health administration] SDS [safety data sheets], EPA [Environmental Protection Act], FDA [Federal Drug Administration], NIH [National Institute for Health], AZDEQ [Arizona Department of Educational Quality], safety data sheets [SDSs] for chemicals).*

Learning Goals

I can:

- Comply with safety signs and symbols and utilize appropriate lab attire and protective equipment *(e.g., safety glasses, gloves).*
- Interpret safety data sheets (SDS) and apply practices for the safe use of hazardous chemicals according to standards from the Occupational Safety and Health Administration, Environmental Protection Agency, Federal Drug Administration, National Institute for Heath, and the Arizona Department of Educational Quality.
- Identify appropriate emergency contacts and perform drills for emergency protocols *(e.g., fire procedure, evacuation protocol, hazardous chemical contact).*
- Explain appropriate handling of biological and biohazardous materials and distinguish between the biosafety levels (BSL-1 to BSL-4).
- Perform and document tests for quality control *(i.e., accuracy of balances, concentration of chlorine in bleach, pH, spectrophotometry).*

Core Ideas

Knowing Science

L1: Organisms are organized on a cellular basis and have a finite life span.

L3: Genetic information is passed down from one generation of organisms to another.

- Biotechnology is defined by the US government as any technique that uses living organisms (or parts of organisms) to make or modify products, to improve plants and animals, or to develop microorganisms for specific uses.
- ADE/CTE content focus: fermentation technology, cell culturing, protein purification, biologic synthesis, assaying and testing, quality control, industrial microbiology, bioprocessing, chromatography and bio separation, genetic technology, laboratory and hazardous materials safety, computer applications, and test equipment operation and maintenance.

Using Science

U2: The knowledge produced by science is used in engineering and technologies to solve problems and/or create products.

U3: Applications of science often have both positive and negative ethical, social, economic, and/or political implications.

- Students apply scientific principles and technical skills in support of biologists and biotechnologists in research, industrial, and government settings.
- Students research and investigate the positive and negative ethical, social, economic, and political implications of bioscience/biotechnology related techniques and technologies. Some applications of biotechnology can be controversial, so it is important to evaluate claims and evidence to determine their scientific validity.

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Science and Engineering Practices	Crosscutting Concepts
Planning and Carrying Out Investigations • Design and conduct investigations and test design solutions in a safe and ethical manner including considerations of environmental, social, and personal impacts.	**Cause and Effect: Mechanism and Prediction** • Events have causes, sometimes simple, sometimes multifaceted. Deciphering causal relationships, and the mechanisms by which they are mediated, is a major activity of science and engineering.

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HIGH SCHOOL APPLICATIONS OF BIOTECHNOLOGY
BIOTECHNOLOGY
BIOSCIENCE RESEARCH AND ETHICAL CONDUCT (CTE Correlation: 4.1-4.4, 5.0-5.6, 7.2, 7.3)

Science Standards:

- Summarize findings from scientific and technical literature *(e.g., patents, peer-reviewed articles, white papers, and technical bulletins).*
  - evaluate the scientific merit and commercial viability of prior work and its relevance to experimental design
- Critically analyze the interaction between biotechnology research and society *(e.g., genetically modified foods, cloning, bioterrorism, gene therapy, stem cells, and animal research).*
  - compare and contrast attitudes about the use of biotechnology regionally, nationally, and internationally
  - differentiate between moral, ethical, and legal biotechnology issues
- Evaluate the scientific merit and commercial viability of prior work and its relevance to experimental design.
- Describe codes of ethics and protocols used by various organizations that apply to confidentiality and security.
- Adhere to standards for harassment, labor, and employment laws as well as other legal and regulatory codes *(e.g., EPA, FDA, OSHA, NIH, AZDEQ).*

Learning Goals

I can:

- Identify and access relevant scientific and technical literature, including patents, peer-reviewed articles, white papers, and technical bulletins.
- Concisely summarize findings from scientific papers using relevant terminology while taking care to prevent plagiarism.
- Determine the features of experimental design in prior scientific research that led the research to be successful.
- Explain the implications of bioethical issues for society *(e.g., GMOs and HeLa privacy issue).*
- Describe local, state, and federal standards of practice for treatment, care, and maintenance of living organisms.
- Describe practices (including negligence) that could result in liability and how these situations can be avoided *(i.e., risk management and incident reporting)*.

Core Ideas

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- It is important to examine multiple lines of empirical evidence. Not all evidence is equally valid, however, so students must evaluate the information, findings, and studies contained in the sources they explore.

Science and Engineering Practices	Crosscutting Concepts
Obtaining, Evaluating, and Communicating Information • Critically read scientific literature adapted for classroom use to determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms. • Synthesize, communicate, and evaluate the validity and reliability of claims, methods, and designs that appear in scientific and technical texts or media reports, verifying the data when possible. • Produce scientific and/or technical writing and/or oral presentations that communicate scientific ideas and/or the process of development and the design and performance of a proposed process or system.	**Cause and Effect: Mechanism and Prediction** • Events have causes, sometimes simple, sometimes multifaceted. Deciphering causal relationships, and the mechanisms by which they are mediated, is a major activity of science and engineering. **Stability and Change** • Much of science deals with constructing explanations of how things change and how they remain stable.

HIGH SCHOOL APPLICATIONS OF BIOTECHNOLOGY

BIOTECHNOLOGY

INVESTIGATIVE AND LABORATORY SKILLS (CTE Correlation: 2.2, 2.3, 3.1-3.6, 4.0-4.4, 6.1, 6.2, 6.4, 8.0-8.8, 8.11-8.14, 14.3, 14.4)

Science Standards:

- Apply industry-recognized scientific methods to develop knowledge and understanding of scientific ideas and how scientists study the natural world.
    - ask or respond to scientifically-oriented questions
    - develop a testable question or hypothesis based on evidence of scientific principles, probability and/or modeling appropriate to the scientific domain being investigated
    - identify independent and dependent variables and controls
    - select appropriate tools to collect, record, analyze, and evaluate data
    - analyze data using statistics and graphs *(e.g., Excel and other software)*
    - formulate explanations based on evidence and connect explanations to prior scientific knowledge
    - communicate results and justify explanations
- Apply standard operating procedures (SOPs) in the laboratory.
- Operate lab equipment properly and safely *(i.e., centrifuges, gel electrophoresis apparatus, autoclave, glassware, balances, micropipettes, spectrophotometer, fume hoods, incubators, hot plates, water baths, pH meter, etc.*).

Learning Goals

I can:

- Develop and test a research question (scientific process).
- Design experiments using best practices *(i.e., control groups, constants, multiple trials, adequate sample size, detailed procedure*).
- Make observations and collect data using industry-recognized methods *(i.e., contemporaneous notebook).*
- Demonstrate reproducibility from an SOPs (Standard Operating Procedures).
- Operate lab equipment properly and safely.
- Analyze data (graphs and statistical analyses) using spreadsheet software *(e.g., Excel).*
- Explain the implications of the research and how it connects with prior scientific knowledge.
- Communicate results of experiments with others using representations that include graphs, pictures, and written descriptions.

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Science and Engineering Practices	Crosscutting Concepts
Asking Questions and Defining Problems • Ask questions that arise from careful observation of phenomena, models, theory, or unexpected results. • Ask questions to determine relationships, including quantitative relationships, between independent and dependent variables. **Planning and Carrying Out Investigations** • Design and conduct investigations and test design solutions in a safe and ethical manner including considerations of environmental, social, and personal impacts. • Design and conduct an investigation individually and collaboratively, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. • Select appropriate tools to collect, record, analyze, and evaluate data. • Use investigations to gather evidence to support explanations or concepts. **Analyzing and Interpreting Data** • Use tools, technologies, and/or models (e.g., computational, mathematical) to generate and analyze data in order to make valid and reliable scientific claims or determine an optimal design solution. • Apply concepts of statistics and probability (including determining function fits to data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible. • Consider limitations (e.g., measurement error, sample selection) when analyzing and interpreting data.	**Cause and Effect: Mechanism and Prediction** • Events have causes, sometimes simple, sometimes multifaceted. Deciphering causal relationships, and the mechanisms by which they are mediated, is a major activity of science and engineering. **Scale, Proportion, and Quantity** • In considering phenomena, it is critical to recognize what is relevant at different size, time, and energy scales, and to recognize proportional relationships between different quantities as scales change.

HIGH SCHOOL APPLICATIONS OF BIOTECHNOLOGY

BIOTECHNOLOGY

PROTEIN TECHNIQUES: ISOLATION AND ANALYSIS (CTE Correlation: 10.1-10.4)

Science Standards:

- Evaluate the role of proteins within a biological system.
- Isolate and purify proteins for identification and function.
- Use SDS Gel electrophoresis to identify proteins in purified fractions.
- Create laboratory enhanced proteins using recombinant DNA methods and cultures.
- Perform a Western Blot analysis to learn immunoassays.
- Use multiple techniques to isolate protein from cell cultures including salting out and dialysis.

Learning Goals

I can:

- Use a centrifuge to physically separate a substance.
- Compare and contrast methods to detect specific proteins *(e.g., Western Blot and ELISA)*.
- Extract and precipitate proteins from cells.
- Perform protein assays and use standard curves to determine protein of interest.
- Perform column chromatography using a variety of different column materials.
- Separate and characterize proteins using chromatography and SDS-PAGE.

Core Ideas

Knowing Science

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Using Science

U2: The knowledge produced by science is used in engineering and technologies to solve problems and/or create products.

U3: Applications of science often have both positive and negative ethical, social, economic, and/or political implications.

- Students apply scientific principles and technical skills in support of biologists and biotechnologists in research, industrial, and government settings.
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Science and Engineering Practices	Crosscutting Concepts
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BIOTECHNOLOGY
AGRICULTURAL BIOLOGY (CTE Correlation: 7.1, 7.2, 7.5, 5.3)

Science Standards:

- Propagate plants used as models.
- Use hydroponics to grow plants and understand their role in food generation.
- Debate the implication of bioethical issues such as genetically modified organisms (GMOs).
- Clone cells of plants using tissue culture.
- Describe proper use and limitations of living organisms for biotechnology and determine if alternatives are available.

Learning Goals

I can:

- Use plants as a model system for growing plants *(e.g., Arabidopsis or Wisconsin Fast Plants)*.
- Describe techniques used to propagate plants *(e.g., plant cutting and grafting).*
- Grow plants using alternative methods to traditional soil systems.
- Evaluate the ethical issues related to genetically modified organisms (GMOs).
- Use a sterile technique to clone an organism.
- Describe the benefits and risks of using of living organisms in scientific research.

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HIGH SCHOOL APPLICATIONS OF BIOTECHNOLOGY
BIOTECHNOLOGY
BACTERIA/MICROBIOLOGY (CTE Correlation: 7.1-7.5, 8.7, 8.9, 8.12 9.0-9.7)

Science Standards:

- Demonstrate microbiology skills such as culturing bacteria and preparing microscopic specimens.
- Explain the differences in types of cultures *(i.e., bacterial, mammalian, tissue vs. cell).*
- Transform and maintain hosts *(e.g., E. coli).*
- Determine what types of living organisms are used in biotechnology research (model organisms, cell lines) and conduct experiments with selected organisms.
- Illustrate different types of microorganisms based on morphology, color, and edge margins.

Learning Goals

I can:

- Prepare microscopic specimens and observe using a microscope *(i.e., dissecting, compound, digital*).
- Maintain lab equipment and practice appropriate hygiene (aseptic technique) in the lab environment.
- Identify, prepare, sterilize, dispense, and store media.
- Identify, propagate, and quantify microorganisms and cells.
- Identify techniques for short and long-term cultures *(e.g., stabs, slants, liquid nitrogen, glycerol stocks).*
- Isolate, maintain, and store pure cultures.
- Perform transformation of bacteria.
- Compare and contrast mammalian cell culture, bacterial cell culture, and culture of tissues.
- Determine the best cell lines and/or model organism for experiments and the proper use and limitation of living organisms.

Core Ideas

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HIGH SCHOOL APPLICATIONS OF BIOTECHNOLOGY
BIOTECHNOLOGY
NUCLEIC ACID TECHNIQUES AND BIOINFORMATICS (CTE Correlation: 8.15-8.16, 12.0-12.9, 13.0-13.11)

Science Standards:

- Access bioinformatics databases and tools to analyze DNA and proteins (e.g., NCBI, BLAST, FlyBase, geno.org, DNA subway, MEGA, RCSB PDB).
- Perform basic molecular biology techniques (i.e., nucleic acid isolation, transformation, optimized protein production, polymerase chain reaction (PCR), vertical and horizontal gel electrophoresis).
- Explain gene regulation (e.g., lac operon or trp operon, introns and exons, alternative splicing).
- Design PCR primers for use with recombinant DNA strategies.

Learning Goals

I can:

- Interpret gene and genome maps (FlyBase, NCBI, geno.org) and predict the origin and function of unknown sequences (NCBI).
- Determine relationships among multiple sequences (DNA subway, MEGA).
- Explain the types of BLAST searches, compare homologous sequences using BLAST, and interpret E-values and scores.
- Utilize protein data bank (RCSB PDB) for protein structure analysis *(e.g., structure data for Cn3D, RCSB).*
- Identify sources of genetic variation (e.g., SNP, inversion, translocation, copy number variant).
- Isolate nucleic acids and explain the structure of DNA.
- Perform PCR in the lab using a thermocycler *(i.e., design primers, optimize and perform protocols)*.
- Compare and contrast PCR to the cellular process of DNA replication.
- Perform and explain the process of vertical and horizontal gel electrophoresis.
- Prepare a standard curve based on a DNA or protein ladder to estimate DNA length or protein size.
- Identify and troubleshoot common gel electrophoresis errors from a gel image.
- Describe DNA sequencing methods, including basic and next-generation, and compare and contrast the advantages and disadvantages of each method.
- Explain gene regulation in prokaryotes and eukaryotes.

Core Ideas

Knowing Science

L1: Organisms are organized on a cellular basis and have a finite life span.

L3: Genetic information is passed down from one generation of organisms to another.

- Biotechnology is defined by the US government as any technique that uses living organisms (or parts of organisms) to make or modify products, to improve plants and animals, or to develop microorganisms for specific uses.
- ADE/CTE content focus: fermentation technology, cell culturing, protein purification, biologic synthesis, assaying and testing, quality control, industrial microbiology, bioprocessing, chromatography and bio separation, genetic technology, laboratory and hazardous materials safety, computer applications, and test equipment operation and maintenance.

Using Science

U2: The knowledge produced by science is used in engineering and technologies to solve problems and/or create products.

Note: Note: While some of the core content of the course aligns with the “essential” Physics standards, the application of the content through labs and related activities is focused on the biotechnology domain.

U3: Applications of science often have both positive and negative ethical, social, economic, and/or political implications.

- Students apply scientific principles and technical skills in support of biologists and biotechnologists in research, industrial, and government settings.
- Students research and investigate the positive and negative ethical, social, economic, and political implications of bioscience/biotechnology related techniques and technologies. Some applications of biotechnology can be controversial, so it is important to evaluate claims and evidence to determine their scientific validity.
- It is important to examine multiple lines of empirical evidence. Not all evidence is equally valid, however, so students must evaluate the information, findings, and studies contained in the sources they explore.

Science and Engineering Practices	Crosscutting Concepts
Planning and Carrying Out Investigations • Design and conduct investigations and test design solutions in a safe and ethical manner including considerations of environmental, social, and personal impacts. • Design and conduct an investigation individually and collaboratively, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. • Select appropriate tools to collect, record, analyze, and evaluate data. • Use investigations to gather evidence to support explanations or concepts.	**Patterns** • Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them. **Cause and Effect: Mechanism and Prediction** • Events have causes, sometimes simple, sometimes multifaceted. Deciphering causal relationships, and the mechanisms by which they are mediated, is a major activity of science and engineering. **Structure and Function** • The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs.

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HIGH SCHOOL APPLICATIONS OF BIOTECHNOLOGY

BIOTECHNOLOGY

RESEARCH PROJECT (CTE Correlation: 3.2, 3.3, 3.4, 3.5, 3.6, 4.1-4.4,14.1-14.4)

Science Standards:

- Design and carry out a research project related to biotechnology.
- Synthesize scientific literature to produce a literature review.
  - Evaluate the scientific merit and viability of prior work and its relevance to science.
- Present the research project with other scientists at a conference or other appropriate science venue *(e.g., SARSEF, school science fair).*

Learning Goals

I can:

- Identify a research project.
- Find and analyze scientific literature.
- Produce a credible literature review that is appropriately cited.
- Develop a research question to formulate testable conditions.
- Design experiments using best practices *(e.g., control groups, constants, multiple trials, adequate sample size, detailed procedure).*
- Collect data and make observations using industry recognized methods.
- Analyze the data and explain the implications of the research and how it connects with prior scientific knowledge.
- Maintain a scientific notebook of research that shows how legal and ethical guidelines are utilized.
- Create a plan to share the research in a formal setting.
- Present my research at a scientific conference or venue.

Core Ideas

Knowing Science

L1: Organisms are organized on a cellular basis and have a finite life span.
L2: Organisms require a supply of energy and materials for which they often depend on, or compete with, other organisms.
L3: Genetic information is passed down from one generation of organisms to another.

- Biotechnology is defined by the US government as any technique that uses living organisms (or parts of organisms) to make or modify products, to improve plants and animals, or to develop microorganisms for specific uses.
- ADE/CTE content focus: fermentation technology, cell culturing, protein purification, biologic synthesis, assaying and testing, quality control, industrial microbiology, bioprocessing, chromatography and bio separation, genetic technology, laboratory and hazardous materials safety, computer applications, and test equipment operation and maintenance.

Using Science

U2: The knowledge produced by science is used in engineering and technologies to solve problems and/or create products.
U3: Applications of science often have both positive and negative ethical, social, economic, and/or political implications.

- Students apply scientific principles and technical skills in support of biologists and biotechnologists in research, industrial, and government settings.

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- Students research and investigate the positive and negative ethical, social, economic, and political implications of bioscience/biotechnology related techniques and technologies. Some applications of biotechnology can be controversial, so it is important to evaluate claims and evidence to determine their scientific validity.
- It is important to examine multiple lines of empirical evidence. Not all evidence is equally valid, however, so students must evaluate the information, findings, and studies contained in the sources they explore.

Science and Engineering Practices	Crosscutting Concepts
Asking Questions and Defining Problems • Ask questions that arise from careful observation of phenomena, models, theory, or unexpected results. • Ask questions to determine relationships, including quantitative relationships, between independent and dependent variables. **Planning and Carrying Out Investigations** • Design and conduct investigations and test design solutions in a safe and ethical manner including considerations of environmental, social, and personal impacts. • Design and conduct an investigation individually and collaboratively, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. • Select appropriate tools to collect, record, analyze, and evaluate data. • Use investigations to gather evidence to support explanations or concepts. **Analyzing and Interpreting Data** • Use tools, technologies, and/or models (e.g., computational, mathematical) to generate and analyze data in order to make valid and reliable scientific claims or determine an optimal design solution. • Apply concepts of statistics and probability (including determining function fits to data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible. • Consider limitations (e.g., measurement error, sample selection) when analyzing and interpreting data.	**Patterns** • Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them. **Cause and Effect: Mechanism and Prediction** • Events have causes, sometimes simple, sometimes multifaceted. Deciphering causal relationships, and the mechanisms by which they are mediated, is a major activity of science and engineering. **Structure and Function** • The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs.

PHYSICAL SCIENCE: PHYSICS

MOTION & STABILITY – FORCES & INTERACTIONS

ENERGY & WAVES

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HIGH SCHOOL APPLICATIONS OF BIOTECHNOLOGY	
PHYSICAL SCIENCE	
MOTION & STABILITY – FORCES & INTERACTIONS	

Science Standard: **Essential HS.P2U1.5 Construct an explanation for a field's strength and influence on an object (electric, gravitational, magnetic).**
 	
Learning Goals
I can:
• Construct an explanation based on evidence to explain observations of electric, gravitational, and magnetic field phenomena:
  ○ Explain the structure of fields and how they allow forces to act at a distance.
  ○ Quantitatively determine the strength of various fields (gravitational, electric, or magnetic) based on the relationships between variables *(i.e., distance, mass, charge, etc.)*.
  ○ Apply scientific knowledge to predict how objects *(e.g., orbiting bodies, electrons, and magnets)* are influenced by an external field.
  ○ Revise explanations based on evidence obtained from a variety of sources and peer review.	

Core Ideas	
Knowing Science P2: Objects can affect other objects at a distance. • Newton's law of universal gravitation and Coulomb's law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects. • Forces at a distance are explained by fields (gravitational, electric, magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields. • When two objects interacting through a field change relative position, the energy stored in the field is changed. **Using Science** U1: Scientists explain phenomena using evidence obtained from observations and / or scientific investigations. Evidence may lead to developing models and / or theories to make sense of phenomena. As new evidence is discovered, models, and theories can be revised. • Students examine evidence from a variety of sources and then select appropriate scientific evidence to explain the influence of electric, gravitational, and magnetic fields.	
Science and Engineering Practices	Crosscutting Concepts
Constructing Explanations and Designing Solutions • Make quantitative and qualitative claims regarding the relationship between dependent and independent and variables. • Construct and revise explanations based on evidence obtained from a variety of sources (e.g., scientific principles, models, theories, simulations) and peer review. • Using Mathematics and Computational Thinking • Use mathematical or algorithmic representations of phenomena or design solutions to describe and support claims and explanations, and create computational models or simulations.	**Stability and Change** • Much of science deals with constructing explanations of how things change and how they remain stable. **Cause and Effect: Mechanism and Prediction** • Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms with the system.

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HIGH SCHOOL APPLICATIONS OF BIOTECHNOLOGY
PHYSICAL SCIENCE
MOTION & STABILITY – FORCES & INTERACTIONS

Science Standard: Essential HS.P3U1.6 Collect, analyze, and interpret data regarding the change in motion of an object or system in one dimension, to construct an explanation using Newton's Laws.

Learning Goals

I can:

- Collect data *(e.g., from investigations, demonstrations, scientific texts, data sets, simulations, etc.)* regarding the change in motion of an object or system in one dimension:
    - Ask questions to frame data collection, analysis, and interpretation.
    - Decide on types, how much, and accuracy of data needed to construct an explanation using Newton's Laws.
    - Select appropriate tools to collect and record data.
- Use tools, technologies, and models to analyze and interpret data measuring changes to an object's motion in relation to mass and forces:
    - Identify and describe patterns in data.
    - Compare and contrast various types of data sets to *(e.g., self-generated, archival)* to examine observations about the change in motion of an object or system in one dimension.
    - Interpret data, applying concepts of statistics and probability, to describe how forces can change the motion of objects, as predicted by Newton's Laws of Motion.
- Construct an explanation using Newton's Laws:
    - Construct or adapt an explanation of changes to an object's motion using momentum and the Law of Conservation of Momentum.
    - Use data to make claims regarding the motion of objects in terms of kinematic variables such as position, velocity, and acceleration.

Core Ideas

Knowing Science

P3: Changing the movement of an object requires a net force to be acting on it.

- Newton's second law accurately predicts changes in the motion of macroscopic objects, but it requires revision for subatomic scales or for speeds close to the speed of light. Momentum is defined for a particular frame of reference; it is the mass times the velocity of the object.

Using Science

U1: Scientists explain phenomena using evidence obtained from observations and/or scientific investigations. Evidence may lead to developing models and/or theories to make sense of phenomena. As new evidence is discovered, models and theories can be revised.

- Students interpret data to explore change in motion of objects to build an understanding of Newton's Laws. Tools and procedures for data collection and analysis must be carefully selected in order to ensure that the data are valid. Students apply their analysis and interpretations of data as well as their understanding of Newton's Laws to explain changes in motion of objects or systems.

Science and Engineering Practices	Crosscutting Concepts
Asking Questions and Defining Problems • Ask questions that arise from careful observation of phenomena, models, theory, or unexpected results.	**Patterns**

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• Ask questions that require relevant empirical evidence to answer. • Ask questions to determine relationships, including quantitative relationships, between independent and dependent variables. **Constructing Explanations and Designing Solutions** • Construct and revise explanations based on evidence obtained from a variety of sources (e.g., scientific principles, models, theories, simulations) and peer review. **Analyzing and Interpreting Data** • Use tools, technologies, and/or models (e.g., computational, mathematical) to generate and analyze data in order to make valid and reliable scientific claims or determine an optimal design solution. • Consider limitations (e.g., measurement error, sample selection) when analyzing and interpreting data. • Apply concepts of statistics and probability (including determining function fits to data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible. • Compare and contrast various types of data sets (e.g., self-generated, archival) to examine consistency of measurements and observations.	• Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. **Systems and Systems Models** • Systems can be designed to do specific tasks. **Stability and Change** • Much of science deals with constructing explanations of how things change and how they remain stable.

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HIGH SCHOOL APPLICATIONS OF BIOTECHNOLOGY

PHYSICAL SCIENCE

MOTION & STABILITY – FORCES & INTERACTIONS

Science Standard: Essential HS.P3U2.7 Construct an explanation to demonstrate how Newton's laws are used in engineering and technologies to create products to serve human ends.

Learning Goals

I can:

- Construct explanations based on evidence *(e.g., scientific principles, models, theories, simulations)* to describe how Newton's laws are used in engineering and technologies to create products and solutions that meet human needs:
  - Apply scientific knowledge and evidence to explain how Newton's laws have provided engineers with physical, mathematical, and computer models to use in the construction of products.
  - Evaluate designs and models based on their environmental and societal impacts.
  - Revise explanations based on evidence obtained from a variety of sources and peer review.

Core Ideas

Knowing Science

P3: Changing the movement of an object requires a net force to be acting on it.

- The application of science in making new materials is an example of how scientific knowledge has led advances in technology and provided engineers with a wider choice in designing constructions.
- At the same time technological advances have helped scientific developments by improving instruments for observation and measuring, automating processes that might otherwise be too dangerous or time consuming to undertake, and particularly through the provision of computers. Thus, technology aids scientific advances which in turn can be used in designing and making things for people to use.

Using Science

U2: The knowledge produced by science is used in engineering and technologies to solve problems and/or create products.

- Students examine how technology aids scientific advances, which in turn, can be used in designing and making things for people to use.

Science and Engineering Practices

Constructing Explanations and Designing Solutions

- Apply scientific knowledge and evidence to explain phenomena and solve design problems, taking into account possible unanticipated effects.
- Construct and revise explanations based on evidence obtained from a variety of sources (e.g., scientific principles, models, theories, simulations) and peer review.

Crosscutting Concepts

Systems and Systems Models

- Systems can be designed to do specific tasks.
- 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.

Cause and Effect: Mechanism and Prediction

- Systems can be designed to cause a desired effect.

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HIGH SCHOOL APPLICATIONS OF BIOTECHNOLOGY
PHYSICAL SCIENCE

ENERGY & WAVES

Science Standard: Essential HS.P4U1.8 Engage in argument from evidence that the net change of energy in a system is always equal to the total energy exchanged between the system and the surroundings.

Learning Goals

I can:

- Construct, use, and present oral and written arguments regarding the law of conservation of energy:
    - Make and defend a claim about the law of conservation of energy.
    - Use quantitative and qualitative scientific evidence to develop and support the claim.
    - Describe the transfer of energy between different parts of a system, including its surroundings.

Core Ideas

Knowing Science

P4: The total amount of energy in a closed system is always the same but can be transferred from one energy store to another during an event.

- Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms.
- Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system. Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems.

Using Science

U1: Scientists explain phenomena using evidence obtained from observations and/or scientific investigations. Evidence may lead to developing models and/or theories to make sense of phenomena. As new evidence is discovered, models and theories can be revised.

- Students evaluate, develop, and defend arguments using scientific evidence from texts, observations, and investigations. As they weigh evidence regarding the conservation of energy, students will refine their understanding of the role of energy within a system.

Science and Engineering Practices	Crosscutting Concepts
Engaging in Argument from Evidence • Critique and evaluate competing arguments, models, and/or design solutions in light of new evidence, limitations (e.g., trade-offs), constraints, and ethical issues • Evaluate the claims, evidence, and reasoning behind currently accepted explanations or solutions to determine the merits of arguments. • Construct a counter-argument that is based on data and evidence that challenges another proposed argument. • Make and defend a claim about the natural world or the effectiveness of a design solution that reflects scientific knowledge, and student-generated evidence.	**Energy and Matter: Flows, Cycles, and Conservation** • The total amount of energy and matter in closed systems is conserved. • 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. • Energy cannot be created or destroyed—only moves between one place and another place, between objects and/or fields, or between systems. **Stability and Change** • Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible.

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HIGH SCHOOL APPLICATIONS OF BIOTECHNOLOGY	
PHYSICAL SCIENCE	
ENERGY & WAVES	

Science Standard: **Essential HS.P4U3.9 Engage in argument from evidence regarding the ethical, social, economic, and/or political benefits and liabilities of energy usage and transfer.**
 	
Learning Goals
I can:
• Evaluate arguments regarding the ethical, social, economic, and/or political benefits and liabilities of energy usage and transfer:
  ○ Evaluate the claims, evidence, and reasoning of oral and/or written arguments to determine merits of arguments and elicit elaboration from peers.
  ○ Evaluate ethical, social, economic, and/or political perspectives of energy use and transfer.
  ○ Critique and evaluate competing arguments about the benefits and liabilities of energy usage and transfer.
  ○ Evaluate the evidence and reasoning behind currently accepted methods of energy usage and transfer.
• Construct, use, and present oral and written arguments regarding the ethical, social, economic, and/or political benefits and liabilities of energy usage and transfer:
  ○ Make and defend a claim about the benefits and liabilities of energy usage and transfer.
  ○ Develop and support a claim with analysis of the positive and negative economic, social, and/or political implications of the demand for energy usage.
  ○ Construct a counter-argument that is based on data and evidence that challenges another proposed argument.
  ○ Use scientific evidence to develop and support the claim.
  ○ Describe the transfer of energy between different parts of a system, including its surroundings.	

Core Ideas	
Knowing Science P4: The total amount of energy in a closed system is always the same but can be transferred from one energy store to another during an event. • The availability of energy limits what can occur in any system. • Across the world, the demand for energy increases as human populations grow and because modern lifestyles require more energy, particularly in the convenient form of electrical energy. • Fossil fuels, frequently used in power stations and generators, are a limited resource and their combustion contributes to global warming and climate change. Therefore, other ways of generating electricity have to be sought, whilst reducing demand and improving the efficiency of the processes in which we use it. **Using Science** U1: Scientists explain phenomena using evidence obtained from observations and/or scientific investigations. Evidence may lead to developing models and/or theories to make sense of phenomena. As new evidence is discovered, models and theories can be revised. • Students evaluate, develop, and defend arguments using scientific evidence from texts, observations, and investigations. As they weigh evidence regarding the conservation of energy, students will refine their understanding of the role of energy within a system.	
Science and Engineering Practices	Crosscutting Concepts
Engaging in Argument from Evidence	**Energy and Matter: Flows, Cycles, and Conservation**

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• Critique and evaluate competing arguments, models, and/or design solutions in light of new evidence, limitations (e.g., trade-offs), constraints, and ethical issues • Evaluate the claims, evidence, and reasoning behind currently accepted explanations or solutions to determine the merits of arguments. • Construct a counter-argument that is based on data and evidence that challenges another proposed argument. • Make and defend a claim about the natural world or the effectiveness of a design solution that reflects scientific knowledge, and student-generated evidence.	• 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. • Energy cannot be created or destroyed—only moves between one place and another place, between objects and/or fields, or between systems. • Energy drives the cycling of matter within and between systems. **Stability and Change** • Change and rates of change Systems can be designed for greater or lesser stability. **Scale, Proportion, and Quantity** • The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs.

HIGH SCHOOL APPLICATIONS OF BIOTECHNOLOGY	
PHYSICAL SCIENCE	
ENERGY & WAVES	

Science Standard: Essential HS.P4U1.10 Construct an explanation about the relationships among the frequency, wavelength, and speed of waves traveling in various media, and their applications to modern technology.

Learning Goals

I can:

- Construct explanations based on evidence obtained from a variety of sources *(e.g., scientific principles, models, theories, simulations)*:
  - Apply scientific reasoning, theory, and models to compare the processes by which waves *(i.e., light, sound, vibration, etc.)* propagate through various media.
  - Draw connections between observed properties and associated quantities of a wave. *(e.g., how color is associated by the wavelength of a light wave or pitch is associated with the frequency of a sound wave).*
  - Explain how changes in a wave's medium and/or speed will affect its properties or direction *(e.g., refraction, reflection, the Doppler effect, redshifts, talking through helium or sulfur hexafluoride).*
  - Apply scientific knowledge and evidence to explain how waves are used in applications of modern technology to meet human needs.
  - Revise explanations based on evidence obtained from a variety of sources and peer review.

Core Ideas

Knowing Science

P4: The total amount of energy in a closed system is always the same but can be transferred from one energy store to another during an event.

- The wavelength and frequency of a wave are related to one another by the speed of travel of the wave, which depends on the type of wave and the medium through which it is passing. The reflection, refraction, and transmission of waves at an interface between two media can be modeled on the basis of these properties.
- Combining waves of different frequencies can make a wide variety of patterns and thereby encode and transmit information. Information can be digitized (e.g., a picture stored as the values of an array of pixels); in this form, it can be stored reliably in computer memory and sent over long distances as a series of wave pulses.
- All electromagnetic radiation travels through a vacuum at the same speed, called the speed of light. Its speed in any other given medium depends on its wavelength and the properties of that medium.
- Multiple technologies based on the understanding of waves and their interactions with matter are part of everyday experiences in the modern world (e.g., medical imaging, communications, scanners) and in scientific research. They are essential tools for producing, transmitting, and capturing signals and for storing and interpreting the information contained in them. Knowledge of quantum physics enabled the development of semiconductors, computer chips, and lasers, all of which are now essential components of modern imaging, communications, and information technologies.

Using Science

U1: Scientists explain phenomena using evidence obtained from observations and/or scientific investigations. Evidence may lead to developing models and/or theories to make sense of phenomena. As new evidence is discovered, models and theories can be revised.

- Students examine a variety of evidence to better understand the role of waves in media and modern technology. They then select evidence to support a scientific explanation of the relationships among frequency, wavelength, and speed of waves.

Science and Engineering Practices	Crosscutting Concepts

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Constructing Explanations and Designing Solutions • Make quantitative and qualitative claims regarding the relationship between dependent and independent variables. • Apply scientific reasoning, theory, and models to link evidence to claims to assess the extent to which the reasoning and data support the explanation or conclusion. Construct and revise explanations based on evidence obtained from a variety of sources (e.g., scientific principles, models, theories, simulations) and peer review.	**Cause and Effect: Mechanism and Prediction** • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. • Systems can be designed to cause a desired effect. **Energy and Matter: Cycles, Flows, and Conservation** • Energy cannot be created or destroyed—only moves between one place and another place, between objects and/or fields, or between systems.

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EARTH AND SPACE SCIENCES

WEATHER AND CLIMATE

EARTH AND THE SOLAR SYSTEM

THE UNIVERSE AND ITS STARS

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HIGH SCHOOL APPLICATIONS OF BIOTECHNOLOGY	
EARTH & SPACES SCIENCES	
WEATHER AND CLIMATE	

Science Standard: **Essential HS.E1U1.11 Develop and use models to explain how energy from the Sun affects weather patterns and climate.**
 	
Learning Goals
I can:
• Develop a model to explain how energy from the Sun affects weather patterns and climate:
  ○ Use design criteria to create representations of weather patterns and climate based on energy from the Sun.
  ○ Evaluate the merits and limitations of model types in order to select or revise a model that best fits the evidence or design criteria.
  ○ Design a test of a model to ascertain its reliability.
• Revise models based on results of tests and design criteria to more appropriately represent weather patterns and climate based on energy from the Sun.	

Core Ideas	
Knowing Science E1: The composition of the Earth and its atmosphere and the natural and human processes occurring within them shape the Earth's surface and its climate. • Weather, which varies from day to day and seasonally throughout the year, is the condition of the atmosphere at a given place and time. Climate is longer term and location sensitive; it is the range of a region's weather over 1 year or many years, and, because it depends on latitude and geography, it varies from place to place. • The foundation for Earth's global climate system is the electromagnetic radiation from the sun as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems and this energy's reradiation into space. • Climate change can occur when certain parts of Earth's systems are altered. Geological evidence indicates that past climate changes were either sudden changes caused by alterations in the atmosphere; longer term changes *(e.g., ice ages)* due to variations in solar output, Earth's orbit, or the orientation of its axis; or even more gradual atmospheric changes due to plants and other organisms that captured carbon dioxide and released oxygen. The time scales of these changes varied from a few to millions of years. **Using Science** U1: Scientists explain phenomena using evidence obtained from observations and/or scientific investigations. Evidence may lead to developing models and/or theories to make sense of phenomena. As new evidence is discovered, models and theories can be revised. • Students use data from various sources to make sense of the cause and effect relationships between the Sun's energy and weather patterns and climate.	
Science and Engineering Practices	Crosscutting Concepts
Developing and Using Models • Develop, revise, and use models to predict and support explanations of relationships between systems or between components of a system. • Use models (including mathematical and computational) to generate data to support explanations and predict phenomena, analyze systems, and solve problems.	**Patterns** • Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. • Empirical evidence is needed to identify patterns. **Energy and Matter: Cycles, Flows, and Conservation** • 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.

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	• Energy drives the cycling of matter within and between systems. **Cause and Effect: Mechanism and Prediction** • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. • Changes in systems may have various causes that may not have equal effects.

HIGH SCHOOL APPLICATIONS OF BIOTECHNOLOGY

EARTH & SPACES SCIENCES

EARTH AND THE SOLAR SYSTEM

Science Standard: Essential HS.E2U1.16 Construct an explanation of how gravitational forces impact the evolution of planetary motion, structure, surfaces, atmospheres, moons, and rings.

Learning Goals

I can:

- Construct explanations based on evidence obtained from a variety of sources *(e.g., scientific principles, models, theories, simulations)*:
  - Apply scientific reasoning to explain how Kepler's Laws show the formation and evolution of planetary motion.
  - Apply scientific reasoning to explain how Newton's Law of Universal Gravity predicts the formation of planetary structure, moons, and rings.
  - Apply scientific reasoning to explain how Newton's Law of Universal Gravity predicts the evolution of planetary surfaces and atmospheres.
  - Revise explanations based on evidence obtained from a variety of sources and peer review.

Core Ideas

Knowing Science

E2: The Earth and our solar system are a very small part of one of many galaxies within the Universe.

- Earth and the moon, sun, and planets have predictable patterns of movement. These patterns, which are explainable by gravitational forces and conservation laws, in turn explain many large-scale phenomena observed on Earth.
- Planetary motions around the sun can be predicted using Kepler's three empirical laws, which can be explained based on Newton's theory of gravity. Kepler's laws describe common features of the motions of orbiting objects, including their elliptical paths around the sun. (Note: application of the laws should be emphasized rather than memorization).

Using Science

U1: Scientists explain phenomena using evidence obtained from observations and/or scientific investigations. Evidence may lead to developing models and/or theories to make sense of phenomena. As new evidence is discovered, models and theories can be revised.

- Students examine multiple sources of evidence to better understand gravitational forces in space. They use evidence and Kepler's laws to construct scientific explanations.

Science and Engineering Practices

Constructing Explanations and Designing Solutions

- Apply scientific reasoning, theory, and models to link evidence to claims to assess the extent to which the reasoning and data support the explanation or conclusion.
- Construct and revise explanations based on evidence obtained from a variety of sources (e.g., scientific principles, models, theories, simulations) and peer review.
- Base causal explanations on valid and reliable empirical evidence from multiple sources and the assumption that natural laws operate today as they did in the past and will continue to do so in the future.

Crosscutting Concepts

Structure and Function

- The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials.

Cause and Effect: Mechanism and Prediction

- Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system.

Note: Note: While some of the core content of the course aligns with the "essential" Physics standards, the application of the content through labs and related activities is focused on the biotechnology domain.

HIGH SCHOOL APPLICATIONS OF BIOTECHNOLOGY

EARTH & SPACES SCIENCES

THE UNIVERSE AND ITS STARS

Science Standard: Essential HS.E2U1.17 Construct an explanation of the origin, expansion, and scale of the universe based on astronomical evidence.

Learning Goals

I can:

- Construct explanations based on astronomical evidence obtained from a variety of sources *(e.g., scientific principles, models, theories, simulations)*:
  - Apply scientific reasoning to explain the origin and expansion of the universe.
  - Apply scientific reasoning to explain distances between planets, stars, moons, and other bodies in the universe (*e.g., next nearest star, furthest planet of Neptune*) using different scales (*e.g., lightyears*).
  - Use valid and reliable empirical evidence to quantify and estimate the scale and size of the universe.
  - Assess the extent to which the reasoning and evidence about the origin and expansion of the universe support the explanations.

Core Ideas

Knowing Science

E2: The Earth and our solar system are a very small part of one of many galaxies within the Universe.

- There are billions of galaxies in the universe, almost unimaginably vast distances apart and perceived as moving rapidly away from each other. This apparent movement of galaxies indicates that the universe is expanding from an event called a 'big bang', about 13.7 billion years ago.
- The next nearest star [from the Sun] is much further away than the distance of the furthest planet, Neptune. The distances between and within galaxies are so great that they are measured in 'light years', the distance that light can travel in a year.

Using Science

U1: Scientists explain phenomena using evidence obtained from observations and/or scientific investigations. Evidence may lead to developing models and/or theories to make sense of phenomena. As new evidence is discovered, models and theories can be revised.

- Students examine evidence from a variety of sources to develop their understanding of the universe. They then use astronomical evidence to support scientific explanations of the origin, expansion, and scale of the universe.

Science and Engineering Practices	Crosscutting Concepts
Constructing Explanations and Designing Solutions • Apply scientific reasoning, theory, and models to link evidence to claims to assess the extent to which the reasoning and data support the explanation or conclusion. • Make quantitative and qualitative claims regarding the relationship between dependent and independent variables. • Construct and revise explanations based on evidence obtained from a variety of sources (e.g., scientific principles, models, theories, simulations) and peer review.	**Scale, Proportion, and Quantity** • Some systems can only be studied indirectly as they are too small, too large, too fast, or too slow to observe directly. • Patterns observable at one scale may not be observable or exist at other scales. **Energy and Matter: Cycles, Flows, and Conservation** • Energy cannot be created or destroyed—only moves between one place and another place, between objects and/or fields, or between systems.

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• Base causal explanations on valid and reliable empirical evidence from multiple sources and the assumption that natural laws operate today as they did in the past and will continue to do so in the future. • Apply scientific knowledge and evidence to explain phenomena and solve design problems, taking into account possible unanticipated effects.	

ARIZONA PROFESSIONAL SKILLS

CAREER AND TECHNICAL EDUCATION

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HIGH SCHOOL APPLICATIONS OF BIOTECHNOLOGY
BIOTECHNOLOGY
PROFESSIONAL SKILLS: PROFESSIONALISM & ORGANIZATIONAL CULTURE (CTE Correlation: 4A – 4F, 6B, 7.A - 7.C)
Conducts oneself in a professional manner appropriate to organizational expectations.

Professional Skills Standards:

- Demonstrate professionalism in the workplace (being on time, proper dress, courteousness).
- Represent the school [organization] in a positive manner, demonstrating the school's [or organization's] mission and core values.
- Demonstrate respect for personal and professional boundaries (distinguish between personal and work-related matters).
- Interact respectfully with others; act with integrity.
- Produce high quality work that reflects professional pride and contributes to organizational success.
- Take initiative to develop skills and improve work performance.

Learning Goals

I can:

- Communicate the mission and core values of the school [or organization].
- Follow protocol(s) related to behavior, appearance, and other expectations.
- Perform my work with a positive attitude.
- Explain the importance of "dress for success."
- Demonstrate proper etiquette for introductions with clients.
- Create work products in a timely manner that are high quality and positively represent the organization.
- Identify and apply strategies to improve my performance.

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HIGH SCHOOL APPLICATIONS OF BIOTECHNOLOGY
BIOTECHNOLOGY
PROFESSIONAL SKILLS: COMPLEX COMMUNICATION (TRADITIONAL AND DIGITAL) (CTE Correlation: 1A – 1D, 6A, 6C)
Employs complex communication skills in a manner that adds to organizational productivity. Complex Communication refers to the need to combine traditional communication skills with technical workplace content transmitted via rapidly evolving technologies to increasingly diverse audiences.

Professional Skills Standards:

- Communicate effectively in a diverse work environment *(i.e., style, format, and medium appropriate to audience/culture/generation, purpose and context; accuracy; use of appropriate technical/industry language; to resolve conflicts; address intergenerational differences/challenges; persuade others).*
- Use documentation (for example: itineraries and schedules) to plan and meet client needs.
- Use appropriate technologies and social media to enhance or clarify communication.
- Use a variety of interpersonal skills, including tone of voice and appropriate physical gestures *(e.g., eye contact, facing the speaker, active listening)* during conversations and discussions to build positive rapport with others.
- Pose and respond to questions, building upon others' ideas in order to enhance the discussion; clarify, verify, or challenge ideas and conclusions with diplomacy.

Learning Goals

I can:

- Use appropriate verbal and nonverbal modes of communication.
- Proof and edit all communications based on [organizational] standards.
- Verify the accuracy of information and authority of sources.
- Respond in a timely manner to communications.
- Address communications in a style that is appropriate to the audience and situation.
- Use professional etiquette and follow applicable laws and regulations for web-, email-, and social media-based communications.
- Demonstrate appropriate active listening skills.
- Ask questions to obtain accurate information.

HIGH SCHOOL APPLICATIONS OF BIOTECHNOLOGY
BIOTECHNOLOGY
PROFESSIONAL SKILLS: INITIATIVE AND SELF-DIRECTION (CTE Correlation: 5A-5E, 7C)
Exercises initiative and self-direction in the workplace.

Professional Skills Standards:

- Apply the skills and mindset of self-direction/self-regulation to accomplish a project.
- Adapt to organizational changes and expectations while maintaining productive and cooperative relationships with colleagues.
- Select and use appropriate technologies to increase productivity.
- Employ leadership skills that build respectful relationships and advance the organization *(e.g., recognize and engage individual strengths, plan for unanticipated changes, pursue solutions/improvements).*

Learning Goals

I can:

- Establish priorities and set challenging, achievable goals.
- Create a plan with specific timelines for completion to achieve the goals.
- Take initiative to select strategies, resources and/or learning opportunities to accomplish the task(s) in the plan.
- Identify the success criteria/metrics to determine the effectiveness of the outcome for each goal.
- Monitor my progress/productivity and self-correct during the learning process.
- Persist when faced with obstacles or challenges.
- Reflect upon my learning (strengths and weaknesses) and use feedback to modify work or improve performance.
- Use appropriate technology tools and resources to create and deliver a product.

HIGH SCHOOL APPLICATIONS OF BIOTECHNOLOGY
BIOTECHNOLOGY
PROFESSIONAL SKILLS: CRITICAL THINKING AND INNOVATION (CTE Correlation: 3A-3E)
Integrates expertise in technical knowledge and skills with thinking and reasoning strategies to create, innovate, and devise solutions.
Professional Skills Standards: • Identify problems and use strategies and resources to innovate and/or devise plausible solutions. • Take action or make decisions supported by evidence and reasoning. • Transfer knowledge/skills from one situation/context to another. **Learning Goals** I can: • Use relevant criteria to eliminate ineffective solutions or approaches and select those that are plausible; put selected alternatives through trials to determine their helpfulness or benefit. • Evaluate sources of evidence, the accuracy and relevance of information, and the strengths of arguments. • Demonstrate ethical reasoning and judgment by clearly sharing multiple perspectives on why the proposed course of action is ethically the best decision. • Identify factors that affect one's objectivity or rationality *(e.g., prejudices, disposition, etc.).* • Apply my knowledge and skills in new contexts.

HIGH SCHOOL APPLICATIONS OF BIOTECHNOLOGY
BIOTECHNOLOGY
PROFESSIONAL SKILLS: COLLABORATION (CTE Correlation: 2A-2C)
Collaborates, in person and virtually, to complete tasks aimed at organizational goals.
Professional Skills Standards: • Take responsibility for any role on a team and accurately describe and perform the duties of each role, including leadership. • Integrate diverse ideas, opinions, and perspectives of the team and negotiate to reach workable solutions. • Prioritize and monitor individual and team progress toward goals, making sufficient corrections and adjustments when needed. • Submit high-quality products that meet the specifications for the assigned task. • Utilize technologies that promote collaboration and productivity, as appropriate. **Learning Goals** I can: • Assess project needs and work with a team in a positive manner to create a final project. • Contribute personal strengths to a project. • Respect contributions of others. • Build team relationships. • Proactively solicit feedback; accept and show appreciation for constructive feedback. • Act upon feedback to achieve team goals. • Critique and reflect on individual and collaborative strengths and weaknesses. • Develop a plan for improving individual participation and group productivity.

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