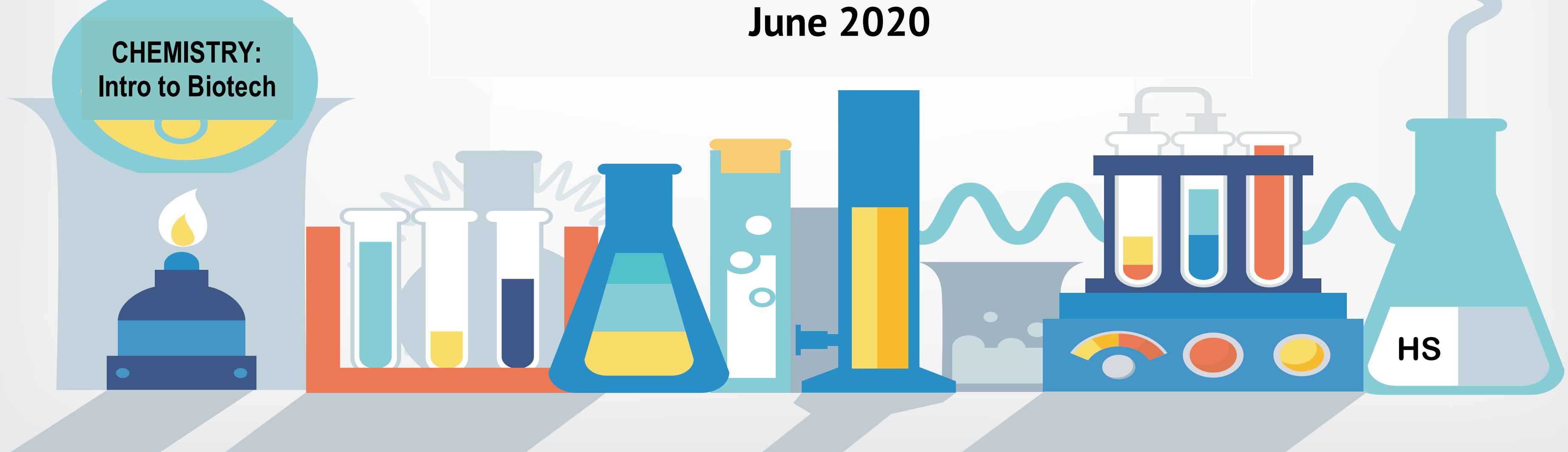
ENVISION 21

DEEP LEARNING • CFSD

SCIENCE

Academic Standards
Three Dimensions of Science Learning
Learning Goals

June 2020



CHEMISTRY: INTRO TO BIOTECHNOLOGY

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

CATALINA FOOTHILLS SCHOOL DISTRICT

HIGH SCHOOL CHEMISTRY: INTRODUCTION TO BIOTECHNOLOGY OVERVIEW

High School Chemistry: Intro to Biotechnology is a laboratory course that emphasizes essential chemistry concepts in an industry-based lab setting. Students gain an understanding of the physical and chemical sub-processes that occur within systems at both the micro and macro levels. 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. They will explore topics such as the structure of matter, bonding, chemical reactions, molar relationships, and periodicity, by exploring biological phenomenon using extensive laboratory techniques. Students will be engaged in activities that promote critical analysis, experimental design, and the development of higher-level thinking skills. This course is a combination of guided instruction, collaborative learning, and laboratory design with practical applications.

The standards for Chemistry: Intro to Biotechnology are grouped into four categories: Biotechnology, Physical Science – Chemistry, Earth and Space Sciences, and Professional Skills. The Chemistry and Earth and Space Science standards are designated as "essential" and "plus" standards. Essential standards are those that every high school student is expected to know and understand. Plus standards in chemistry are designed to extend the concepts learned in the essential standards to prepare students for entry level college courses. 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 science courses to meet this Arizona State Board of Education requirement.

The list of high school Chemistry: Intro to Biotechnology topics below does not indicate 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 Chemistry: Intro to Biotechnology Topics:

- Biotechnology
  - Industry Safety Standards
  - Bioscience Research and Ethical Conduct
  - Investigative and Laboratory Skills
- Physical Science: Chemistry
  - Structures and Properties of Matter
  - Chemical Reactions
  - Nuclear Processes and Applications of Chemistry
- Earth and Space Sciences
  - Earth's Systems
  - Earth's Place in the Universe
- 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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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.

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

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.

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.

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

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

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

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

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.

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.

BIOTECHNOLOGY

INDUSTRY SAFETY PROCEDURES

BIOSCIENCE RESEARCH AND ETHICAL CONDUCT

INVESTIGATIVE AND LABORATORY SKILLS

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

HIGH SCHOOL CHEMISTRY: INTRO TO 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 U.S. government as any technique that uses living organisms (or parts of organisms) to make or modify products, to improve plants and animal, 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.

Science and Engineering Practices	Crosscutting Concepts

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Planning and Carrying Out Investigations	Cause and Effect: Mechanism and Prediction
• Design and conduct investigations and test design solutions in a safe and ethical manner including considerations of environmental, social, and personal impacts.	• 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 CHEMISTRY: INTRO TO BIOTECHNOLOGY

BIOTECHNOLOGY

BIOSCIENCE RESEARCH AND ETHICAL CONDUCT (CTE Correlation: 2.2, 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
- 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 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).*

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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.

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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.

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HIGH SCHOOL CHEMISTRY: INTRO TO BIOTECHNOLOGY

BIOTECHNOLOGY

INVESTIGATIVE AND LABORATORY SKILLS (CTE Correlation: 2.2, 4.1-4.4, 5.0-5.6, 7.2, 7.3)

Science Standards:

- Apply industry-recognized scientific methods and inquiry 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
  - analyze data using statistics and graphs *(e.g., Excel and other software)*
  - utilize appropriate SI (International System of Units) base units and prefixes for all measurements *(e.g., milli, micro, nano)*
  - perform biomath calculations and use scientific notation, as appropriate
  - 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 *(i.e., centrifuges, gel electrophoresis apparatus, autoclave, glassware, balances, micropipettes, spectrophotometer, fume hoods, incubators, hot plates, water baths, pH meter, etc.),* and store solutions and buffers *(e.g., initials, dates, concentration, lots, storage conditions, sterility, hazards, special directions)* properly and safely.

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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- 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.	**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.

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PHYSICAL SCIENCE: CHEMISTRY

STRUCTURES AND PROPERTIES OF MATTER

CHEMICAL REACTIONS

NUCLEAR PROCESSES AND APPLICATIONS OF CHEMISTRY

HIGH SCHOOL CHEMISTRY: INTRO TO BIOTECHNOLOGY
PHYSICAL SCIENCE
STRUCTURES AND PROPERTIES OF MATTER (CTE Correlation: 8.17)

Science Standard: Essential HS.P1U1.1 Develop and use models to explain the relationship of the structure of atoms to patterns and properties observed within the Periodic Table and describe how these models are revised with new evidence.

Learning Goals

I can:

- Develop models (*e.g., in the form of diagrams, drawings, physical replicas, mathematical representations, analogies, and/or computer simulations*) to represent the relationships of the structure of atoms and patterns and properties observed within the Periodic Table:
  - Use design criteria to create models to represent the relationships of the structure of atoms and patterns and properties observed within the periodic table.
  - Use multiple types of models to represent the relationships of the structure of atoms and patterns and properties observed within the periodic table.
  - Develop models based on evidence to illustrate the relationships between the structure of an atom and the way that an atom behaves.
  - Use multiple types of models to represent the relationships of the structure of atoms and patterns and properties observed within the periodic table.
  - Evaluate the merits and limitations of model types in order to select or revise a model that best fits the evidence or design criteria.
- Use models to explain the relationship of the structure of atoms to patterns and properties observed within the periodic table:
  - Use multiple types of models to support explanations of why various atoms on the periodic table interact.
  - Use models to describe patterns and properties observed in the periodic table.
  - Use models to identify and predict patterns in properties that determine how the periodic table is organized based on subatomic particles and element properties.
- Describe how models are revised with new evidence:
  - Evaluate limitations of multiple models on predicting relationships between atoms on the periodic table.
  - Describe how the periodic table was created using patterns and how the patterns determine how to add new elements.
  - Describe how and why the atomic model has been changed/revised over time.

Core Ideas

Knowing Science

P1: All matter in the Universe is made of very small particles.

- The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states.

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.

- Atomic structures are too small to be studied directly; therefore, students use models to better understand the relationships between patterns, structures, and properties. They also explore how models are adjusted over time in response to new evidence.

Science and Engineering Practices	Crosscutting Concepts
Developing and Using Models • Develop, revise, and use models to predict and support explanations of relationships	**Patterns** • Mathematical representations are needed to identify some patterns.

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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.	• Empirical evidence is needed to identify patterns. **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. • 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.

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HIGH SCHOOL CHEMISTRY: INTRO TO BIOTECHNOLOGY
PHYSICAL SCIENCE
STRUCTURES AND PROPERTIES OF MATTER

Science Standard: Plus HS+C.P1U1.1 Plan and conduct an investigation to demonstrate how changes in the number of subatomic particles (protons, neutrons, electrons) affect the identity, reactivity, and properties of the element.

Learning Goals

I can:

- Plan investigations to test the identity, properties, and stabilities (reactivities) of elements:
  - Ask testable questions regarding the properties, and stabilities (reactivities) of elements.
  - Frame a hypothesis in response to the testable question based on a model or theory.
  - Select appropriate variables and controls.
  - Evaluate the investigation's design to ensure variables are controlled.
  - Determine the data *(e.g., types, amount, and accuracy*) needed to produce reliable measurements of the outcomes.
  - Select appropriate tools to collect, record, and analyze the data.
  - Consider limitations on the precision of the data (*e.g., number of trials, cost, risk, time*), and refine the design accordingly.
- Conduct investigations individually and/or collaboratively to test the investigative question:
  - Conduct investigations in a safe and ethical manner including considerations of environmental, social, and personal impacts.
  - Gather evidence to support explanations about identity, properties, and stabilities (reactivity) of elements.
  - Use data from the investigation to evaluate hypotheses about identity, properties, and stabilities (reactivity) of elements.
  - Make quantitative and qualitative claims regarding identity, properties, and stabilities (reactivity) of elements.

Core Ideas

Knowing Science

P1: All matter in the Universe is made of very small particles.

- The repeating patterns of the Periodic Table reflect patterns of outer electron states. The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms. Stable forms of matter are those in which the electric and magnetic field energy is minimized.

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.

- Because subatomic particles are too small to be observed directly, students use models to better understand cause and effect relationships between the particles and an element's identity, stability, and properties.

Science and Engineering Practices	Crosscutting Concepts
Asking Questions and Defining Problems • Ask questions that require relevant empirical evidence to answer. • Ask questions to determine relationships, including quantitative relationships,	**Patterns** • Mathematical representations are needed to identify some patterns. • Empirical evidence is needed to identify patterns.

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between independent and dependent variables. **Planning and Carrying Out Investigations** • 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. • Design and conduct investigations and test design solutions in a safe and ethical manner including considerations of environmental, social, and personal impacts. • Select appropriate tools to collect, record, analyze, and evaluate data.	**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. **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. • 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.

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HIGH SCHOOL CHEMISTRY: INTRO TO BIOTECHNOLOGY	
PHYSICAL SCIENCE	
STRUCTURES AND PROPERTIES OF MATTER (CTE Correlation: 8.5, 8.6)	

Science Standard: Plus HS+C.P1U1.2 Obtain, evaluate, and communicate the qualitative evidence supporting claims about how atoms absorb and emit energy in the form of electromagnetic radiation.
 	
Learning Goals
I can:
• Obtain qualitative evidence supporting claims about electromagnetic radiation:
  ○ Ask questions to frame the collection of evidence.
  ○ Gather information from a variety of sources *(e.g., texts, investigations, media, data sets, models, etc.)* in response to the investigative questions.
  ○ Determine the central ideas or conclusions of a complex scientific text.
  ○ Summarize and paraphrase complex concepts, processes, or information about electromagnetic radiation in simpler, but still accurate terms.
• Evaluate qualitative evidence supporting claims about electromagnetic radiation:
  ○ Evaluate the validity and reliability of qualitative evidence supporting claims about how atoms absorb and emit energy in the form of electromagnetic radiation.
  ○ Verify data across texts.
• Communicate qualitative evidence supporting claims about electromagnetic radiation:
  ○ Produce scientific/technical writing and/or oral presentations (*e.g., blog post, newspaper column, position paper, Socratic Seminar)* that present qualitative evidence supporting claims about electromagnetic radiation - how atoms absorb and emit energy in the form of electromagnetic radiation, and how electromagnetic radiation is either absorbed or emitted by different elements.
  ○ Compare, integrate, and evaluate multiple sources of information presented in different media or formats *(e.g., visually, quantitatively)* in order to present claims about the link between light and electromagnetic radiation.
  ○ Explain the relationship between the absorbance and emittance of energy in an atom.
  ○ Explain the relationship between the Bohr model of the atom and electromagnetic radiation.	

Core Ideas	
Knowing Science: P1: All matter in the Universe is made of very small particles. • Stable forms of matter are those in which the electric and magnetic field energy is minimized. • Atoms of each element emit and absorb characteristic frequencies of light, and nuclear transitions have distinctive gamma ray wavelengths. These characteristics allow identification of the presence of an element, even in microscopic quantities. **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 multiple sources of evidence to explore phenomena pertaining to energy in atoms.	
Science and Engineering Practices	**Crosscutting Concepts**
Asking Questions and Defining Problems	**Systems and System Models**

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• Ask questions that arise from careful observation of phenomena, models, theory, or unexpected results. • Ask questions that require relevant empirical evidence to answer. • Ask questions to determine relationships, including quantitative relationships, between independent and dependent variables. **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. • 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. **Engaging in Argument from Evidence** • Evaluate the claims, evidence, and reasoning behind currently accepted explanations or solutions to determine the merits of arguments.	• Some systems can only be studied indirectly as they are too small, too large, too fast, or too slow to observe directly. **Stability and Change** • Much of science deals with constructing explanations of how things change and how they remain stable. **Energy and Matter: Flows, Cycles, 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. • 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.

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

HIGH SCHOOL CHEMISTRY: INTRO TO BIOTECHNOLOGY

PHYSICAL SCIENCE

STRUCTURES AND PROPERTIES OF MATTER

Science Standard: Plus HS+C.P1U1.3 Analyze and interpret data to develop and support an explanation for the relationships between kinetic molecular theory and gas laws.

Learning Goals

I can:

- Use tools, technologies, and models to analyze and interpret data (*e.g., from investigations, demonstrations, texts, data sets, simulations, etc.*) related to the kinetic molecular theory and gas laws:
  - Ask questions to frame the data analysis and interpretation.
  - Use tools to generate data that illustrates the relationship between pressure, volume and temperature.
  - Use tools to generate data that proves the validity of kinetic molecular theory.
    - Construct representations of the data (*e.g., graphs, data sets, etc.*) to identify patterns and relationships associated with the gas laws.
    - Use the data to analyze the limitations of the kinetic molecular theory and the ideal gas law (PV=nRT).
- Use data to develop and support an explanation of the relationships between kinetic molecular theory and gas laws:
  - Apply scientific knowledge and evidence to explain how the kinetic molecular theory explains the gas laws.
  - Base causal explanations on valid and reliable empirical evidence from multiple sources and the assumption that gas laws operate today as they did in the past and will continue to do so in the future.
  - Construct and revise explanations based on evidence obtained from a variety of sources *(e.g., scientific principles, models, theories, simulations)* and peer review.

Core Ideas

Knowing Science

P1: All matter in the Universe is made of very small particles.

- Whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, that are matched by changes in kinetic energy.
- Within matter, atoms and their constituents are constantly in motion. The arrangement and motion of atoms vary in characteristic ways, depending on the substance and its current state. Specifically, atoms in a gaseous state have characteristics and behaviors that vary greatly from the same atoms in a liquid or solid state. Temperature and pressure affect such arrangements and motions of particles, as well as the ways in which they interact.

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 explore a variety of data sources to identify and make meaning of patterns and relationships between kinetic molecular theory and gas laws. They use this data to develop scientific explanations.

Science and Engineering Practices	Crosscutting Concepts
Asking Questions and Defining Problems • Ask questions that arise from careful observation of phenomena, models, theory, or	**Patterns** • Empirical evidence is needed to identify patterns.

unexpected results. • Ask questions that require relevant empirical evidence to answer. • Ask and evaluate questions that challenge the premise of an argument, the interpretation of a data set, or the suitability of a design. **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. **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. • 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.	• Mathematical representations are needed to identify some patterns. **Systems and System Models** • Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models. **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.

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

ENVISION21
DEEP LEARNING • CFSD

HIGH SCHOOL CHEMISTRY: INTRO TO BIOTECHNOLOGY
PHYSICAL SCIENCE
CHEMICAL REACTIONS (CTE Correlation: 8.1, 14.1 14.2, 14.3, 14.4)

Science Standard: Essential HS.P1U1.2 Develop and use models for the transfer or sharing of electrons to predict the formation of ions, molecules, and compounds in both natural and synthetic processes.

Learning Goals

I can:

- Develop models (*e.g., in the form of diagrams, drawings, physical replicas, mathematical representations, analogies, and/or computer simulations*) to represent the transfer or sharing of electrons:
  - Use design criteria to create models to represent the transfer or sharing of electrons.
  - Use multiple types of models to represent the transfer or sharing of electrons.
  - Develop models to show the movement of electrons from one atom to another based on electronegativity changes.
  - Develop models to show the differences between ionic and covalent bonding using the sharing/transfer of electrons between molecules.
  - Evaluate the merits and limitations of model types in order to select or revise a model that best fits the evidence or design criteria.
- Use models to predict the formation of ions, molecules, and compounds in both natural and synthetic processes:
  - Use models to describe the differences between natural and synthetic processes of ion formation.
  - Use models to predict and explain which atoms will form which types of ions.

Core Ideas

Knowing Science

P1: All matter in the Universe is made of very small particles.

- The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms. Stable forms of matter are those in which the electric and magnetic field energy is minimized.
- Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, that are matched by changes in kinetic energy.

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.

- Because subatomic and molecular structures are too small to be observed directly, students use models to better understand and predict formation of ions, molecules, and compounds.

Science and Engineering Practices	Crosscutting Concepts
Developing and Using Models • Use multiple types of models to represent and support explanations of phenomena, and move flexibly between model types based on merits and limitations. • Develop, revise, and use models to predict and support explanations of relationships between systems or between components of a system.	**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. **Systems and System Models**

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

	• 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. • Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models.

HIGH SCHOOL CHEMISTRY: INTRO TO BIOTECHNOLOGY
PHYSICAL SCIENCE
CHEMICAL REACTIONS (CTE Correlation: 11.1, 11.2, 11.3, 11.4)

Science Standard: Essential HS.P1U1.3 Ask questions, plan, and carry out investigations to explore the cause and effect relationship between reaction rate factors.

Learning Goals

I can:

- Ask questions to explore the cause and effect relationship between reaction rate factors
  - Ask questions that arise from careful observation of reaction rate phenomena.
  - Ask questions that require relevant empirical evidence to answer.
  - Ask and evaluate questions to identify the factors that affect the speed at which a reaction proceeds.
- Plan investigations individually and/or collaboratively to explore the cause and effect relationship between reaction rate factors:
  - Ask testable questions regarding relationships between independent and dependent variables.
  - Select appropriate variables to illustrate the importance of temperature, surface area, volume, concentration, and/or catalysts on the rates of reactions.
  - Consider possible confounding variables or effects and evaluate the investigation's design to ensure variables are controlled.
  - Determine the data (*e.g., types, amount, and accuracy*) needed to produce reliable measurements of the relationship between reaction rate factors.
  - Select appropriate tools to collect, record, analyze, and evaluate data about reaction rate factors.
  - Consider limitations on the precision of the data (*e.g., number of trials, cost, risk, time*), and refine the design accordingly.
- Conduct investigations individually and collaboratively to explore the cause and effect relationship between reaction rate factors:
  - Conduct investigations in a safe and ethical manner including considerations of environmental, social, and personal impacts.
  - Use data from the investigation to identify and analyze cause and effect relationships between reaction rate factors.
  - Use evidence from the investigation to describe the significance of reaction rates in chemical processes.
  - Make quantitative and qualitative claims regarding the relationship between reaction rate factors.
  - Explain how reaction mechanisms affect the rate of a reaction.

Core Ideas

Knowing Science

P1: All matter in the Universe is made of very small particles.

- The Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, that are matched by changes in kinetic energy.
- In many situations, a dynamic and condition-dependent balance between a reaction and the reverse reaction determines the numbers of all types of molecules present. The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions.

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 explore cause and effect relationships through scientific investigations. The design of the investigations and the ways in which the procedures are carried out will have a significant impact on the quality of the evidence produced.

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

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 that require relevant empirical evidence to answer. **Planning and Carrying Out Investigations** • 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.	**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. **Energy and Matter: Flows, Cycles, 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. • Energy drives the cycling of matter within and 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.

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

HIGH SCHOOL CHEMISTRY: INTRO TO BIOTECHNOLOGY

PHYSICAL SCIENCE

CHEMICAL REACTIONS (CTE Correlation: 14.3, 14.4)

Science Standard: Plus HS+C.P1U1.4 Develop and use models to predict and explain forces within and between molecules.

Learning Goals

I can:

- Develop models (*e.g., in the form of diagrams, drawings, physical replicas, mathematical representations, analogies, and/or computer simulations*) to represent forces within and between molecules:
  - Use design criteria to create models to represent intermolecular forces.
  - Use multiple types of models to represent intermolecular forces.
  - Evaluate the merits and limitations of chemical models for looking at intramolecular forces.
  - Compare the strength of forces within molecules using bond energy.
- Use evidence from models to predict and explain forces within and between molecules:
  - Use models to generate data to predict the relative strength between types of intermolecular forces using macroscopic properties.
  - Use models to predict the intermolecular forces expected within molecules using models of bonding and geometries of molecules.
  - Use models to explain the relationship between intermolecular force strength and physical properties.
  - Use models to explain the relationship between intermolecular force strength, molecular shape, and physical properties.

Core Ideas

Knowing Science

P1: All matter in the Universe is made of very small particles.

- The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms. Stable forms of matter are those in which the electric and magnetic field energy is minimized.
- Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, that are matched by changes in kinetic energy.

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.

- Because molecular forces are too small to be observed directly, students engage in modeling to make meaning and form predictions about these forces. Students use evidence from models to construct scientific explanations of molecular forces.

Science and Engineering Practices	Crosscutting Concepts
Developing and Using Models • Use multiple types of models to represent and support explanations of phenomena, and move flexibly between model types based on merits and limitations. • Develop, revise, and use models to predict and support explanations of relationships	**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.

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

between systems or between components of a system. **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.	**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. • Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models. **Stability and Change** • Much of science deals with constructing explanations of how things change and how they remain stable.

HIGH SCHOOL CHEMISTRY: INTRO TO BIOTECHNOLOGY
PHYSICAL SCIENCE
CHEMICAL REACTIONS (CTE Correlation: 11.4, 14.1, 14.2, 14.3)

Science Standard: Plus HS+C.P1U1.5 Plan and carry out investigations to test predictions of the outcomes of various reactions, based on patterns of physical and chemical properties.

Learning Goals

I can:

- Plan investigations to test predictions of the outcomes *(e.g., energy, pH, solubility, products, precipitate, color change, gas formation, oxidation/reduction*) of various reactions based on physical states of matter:
    - Ask testable questions regarding the outcomes of various types of chemical reactions.
    - Frame a hypothesis in response to the testable question based on a model or theory.
    - Select appropriate variables and controls.
    - Consider possible confounding variables or effects and evaluate the investigation's design to ensure variables are controlled.
    - Determine the data *(e.g., types, amount, and accuracy)* needed to produce reliable observations in order to determine the type of chemical reaction.
    - Select appropriate tools to collect, record, and analyze the products created in various types of chemical reactions.
- Conduct investigations individually and collaboratively to test predictions of the outcomes of various reactions:
    - Conduct investigations in a safe and ethical manner including considerations of environmental, social, and personal impacts.
    - Gather evidence to support explanations about why certain products are created in reactions.
    - Use data from the investigation to identify and analyze the outcomes *(e.g., energy, pH, solubility, products, precipitate, color change, gas formation, oxidation/reduction)* of various reactions.
    - Use data from the investigation to evaluate hypotheses about properties of chemicals.
    - Make quantitative and qualitative claims regarding outcomes of various reactions, based on patterns of physical and chemical properties.
    - Determine if a chemical reaction is endothermic or exothermic based on data analysis.

Core Ideas

Knowing Science

P1: All matter in the Universe is made of very small particles.

- Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the rearrangements of atoms into new molecules.
- In many situations, a dynamic and condition-dependent balance between a reaction and the reverse reaction determines the numbers of all types of molecules present. The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions.

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 explore cause and effect relationships through scientific investigations. The design of the investigations and the ways in which the procedures are carried out will have a significant impact on the quality of the evidence produced.

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 that require relevant empirical evidence to answer. • Ask questions to determine relationships, including quantitative relationships, between independent and dependent variables. **Planning and Carrying Out Investigations** • Design an investigation individually and collaboratively and test designs as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems. Consider possible confounding variables or effects and evaluate the investigation's design to ensure variables are controlled. • 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.	**Patterns** • Classifications or explanations used at one scale may fail or need revision when information from smaller or larger scales is introduced; thus requiring improved investigations and experiments. • Patterns of performance of designed systems can be analyzed and interpreted to reengineer and improve the system. **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. • Systems can be designed for greater or lesser stability. **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.

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

HIGH SCHOOL CHEMISTRY: INTRO TO BIOTECHNOLOGY	
PHYSICAL SCIENCE	
CHEMICAL REACTIONS (CTE Correlation: 4.1, 4.2, 4.4)	
Science Standard: Plus HS+C.P1U1.6 Construct an explanation, design a solution, or refine the design of a chemical system in equilibrium to maximize production. **Learning Goals** I can: • Construct explanations based on evidence obtained from a variety of sources *(e.g., scientific principles, models, theories, simulations)* of a chemical system in equilibrium: ○ Use calculations of the equilibrium constant for reactions to explain equilibrium in a chemical system. ○ Use evidence to explain the factors (concentration, temperature, pressure) that can shift equilibrium. ○ Use Le Chatelier's principle and evidence to explain shifts in equilibrium in multiple directions. ○ Revise explanations based on data *(e.g., collected in experiments)* or peer review about shifting equilibrium. • Design a solution to maximize production of a chemical system in equilibrium: ○ Define the design problem, identifying the complexity of the system, criteria for success, and constraints that may include social, technical and/or environmental considerations. ○ Determine the best method to shift equilibrium given a specific reaction to maximize products. ○ Communicate designs through sketches, drawings, or physical models. • Refine the design of a chemical system in equilibrium to maximize production: ○ Ask and evaluate questions that challenge the suitability of the design. ○ Test the design *(e.g., using criteria or simulations)* to identify failure points or improve performance relative to criteria for success. ○ Use peer feedback, design criteria, and constraints to make refinements to the designed system to increase the amount of product and describe the reasoning behind design decisions.	
Core Ideas	
Knowing Science P1: All matter in the Universe is made of very small particles. • In many situations, a dynamic and condition-dependent balance between a reaction and the reverse reaction determines the numbers of all types of molecules present. The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions. **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. • The goal of science is the construction of theories that provide explanatory accounts of the world, and the goal of engineering design is to find a systematic solution to problems. Students construct explanations and solutions using evidence and scientific knowledge of chemical systems, and they refine these explanations and solutions in response to additional evidence, peer feedback, and criteria.	
Science and Engineering Practices	**Crosscutting Concepts**
Constructing Explanations and Designing Solutions	**Cause and Effect: Mechanism and Prediction**

• Make quantitative and qualitative claims regarding the relationship between dependent and independent variables. • 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. • Design, evaluate, and refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade off considerations.	• Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects • 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. • Changes in systems may have various causes that may not have equal effects. **Scale, Proportion, and Quantity** • The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. • Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth). **Stability and Change** • Much of science deals with constructing explanations of how things change and how they remain stable. • Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible. • Feedback (negative or positive) can stabilize or destabilize a system. • Systems can be designed for greater or lesser stability.

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

HIGH SCHOOL CHEMISTRY: INTRO TO BIOTECHNOLOGY	
PHYSICAL SCIENCE	
CHEMICAL REACTIONS (CTE Correlation: 8.14, 11.1, 11.2, 11.3, 11.4, 14.2)	
Science Standard: Plus HS+C.P1U1.7 Use mathematical models and computational thinking to determine stoichiometric relationships between reactants and products in chemical reactions. Learning Goals I can: • Use models to balance a chemical reaction using proper coefficients and subscripts. • Model the ratios between chemical reactions and the conservation of mass. • Calculate in moles the amount of each reactant that was used up. • Calculate in moles the amount of product that was produced. • Make qualitative and quantitative claims regarding the relationship between reactants and products. • Use a model to describe the concept of a limiting reactant and how it affects the amount of product produced in a reaction. • Use computational thinking to explain theoretical and actual yield. • Use computational thinking to predict grams of product given grams of reactant. • Create a model to analyze relationship between units (moles, mass, and volume).	
Core Ideas	
Knowing Science P1: All matter in the Universe is made of very small particles. • In many situations, a dynamic and condition-dependent balance between a reaction and the reverse reaction determines the numbers of all types of molecules present. The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions. **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 apply mathematics and computational thinking to make meaning of chemical reactions. They combine quantitative and qualitative thinking to better understand the relationships involved in chemical reactions.	
Science and Engineering Practices	**Crosscutting Concepts**
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. • Apply techniques of algebra and functions to represent and solve scientific and engineering problems.	**Stability and Change** • Much of science deals with constructing explanations of how things change and how they remain stable. • Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible. **Scale, Proportion, and Quantity**

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

• Create a simple computational model or simulation of a designed device, process, or system.	• The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. • Some systems can only be studied indirectly as they are too small, too large, too fast, or too slow to observe directly. **Energy and Matter: Flows, Cycles, and Conservation** • The total amount of energy and matter in closed systems is conserved.

HIGH SCHOOL CHEMISTRY: INTRO TO BIOTECHNOLOGY	
PHYSICAL SCIENCE	
NUCLEAR PROCESSES AND APPLICATIONS OF CHEMISTRY (CTE Correlation: 8.5)	

Science Standard: Essential HS.P1U3.4 Obtain, evaluate, and communicate information about how the use of chemistry related technologies have had positive and negative ethical, social, economic, and/or political implications.
 	
Learning Goals
I can:
• Obtain information about the positive and negative implications (*i.e., ethical, social, economic, and/or political*) of the use of chemistry related technologies:
  ○ Ask questions to frame the collection of information.
  ○ Gather information from a variety of sources (*e.g., texts, investigations, media, data sets, models, etc.*) in response to the investigative questions.
  ○ Determine the central ideas or conclusions of a complex scientific text.
  ○ Summarize and paraphrase complex concepts, processes, or information about the implications of the use of chemistry-related technologies.
• Evaluate information about the positive and negative implications (*i.e., ethical, social, economic, and/or political*) of the use of chemistry related technologies:
  ○ Verify data across texts.
  ○ Use scientific reasoning to evaluate the validity and reliability of information regarding positive and negative implications of the use of chemistry related technologies.
• Communicate information about the positive and negative implications (*i.e., ethical, social, economic, and/or political*) of the use of chemistry related technologies:
  ○ Produce scientific/technical writing and/or oral presentations (*e.g., blog post, newspaper column, position paper, poster, Socratic Seminar*) that communicate the cause and effect relationships between chemistry related technologies and their ethical, social, economic, and/or political implications.
  ○ Compare, integrate, and evaluate multiple sources of information presented in different media or formats (*e.g., visually, quantitatively*) in order to describe the positive and negative implications of the use of chemistry related technologies.	

Core Ideas	
Knowing Science P1: All matter in the Universe is made of very small particles. • Scientific understanding can help to identify implications of certain applications but decisions about whether certain actions should be taken will require ethical and moral judgements which are not provided by knowledge of science. • There is an important difference between the understanding that science provides about, for example, the need to preserve biodiversity, the factors leading to climate change and the adverse effects of harmful substances and lifestyles, and the actions that may or may not be taken in relation to these issues. Opinions may vary about what action to take but arguments based on scientific evidence should not be a matter of opinion. **Using Science** U3: Applications of science often have both positive and negative ethical, social, economic, and/or political implications. • Students explore the positive and negative ethical, social, economic, and political implications of chemistry related technologies. Applications of chemical technology can be controversial, so it is important to evaluate claims and evidence to determine their scientific validity.	
Science and Engineering Practices	**Crosscutting Concepts**
Asking Questions and Defining Problems	**Cause and Effect: Mechanism and Prediction**

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

• Ask questions that arise from careful observation of phenomena, models, theory, or unexpected results. **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. • 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. • Compare, integrate and evaluate multiple sources of information presented in different media or formats (e.g., visually, quantitatively) in order to address a scientific question or solve a problem.	• Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. • 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. • Changes in systems may have various causes that may not have equal effects.

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

HIGH SCHOOL CHEMISTRY: INTRO TO BIOTECHNOLOGY
PHYSICAL SCIENCE
NUCLEAR PROCESSES AND APPLICATIONS OF CHEMISTRY (CTE Correlation: 8.5)

Science Standard: Plus HS+C.P1U3.8 Engage in argument from evidence regarding the ethical, social, economic, and/or political benefits and liabilities of fission, fusion, and radioactive decay.

Learning Goals

I can:

- Evaluate arguments regarding the ethical, social, economic, and/or political benefits and liabilities of fission, fusion, and radioactive decay:
  - Critique and evaluate competing arguments about the benefits and liabilities of fission, fusion, and radioactive decay.
  - 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 fission, fusion, and radioactive decay.
  - Evaluate the evidence and reasoning behind current applications of fission, fusion, and radioactive decay.
- Construct, use, and present oral and written arguments regarding the ethical, social, economic, and/or political benefits and liabilities of fission, fusion, and radioactive decay:
  - Make and defend a claim about the benefits and liabilities of fission, fusion, and radioactive decay.
  - Develop and support the claim with analysis of ethical, social, economic, and/or political perspectives of fission, fusion, and radioactive decay.
  - 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.

Core Ideas

Knowing Science

P1: All matter in the Universe is made of very small particles.

- The total number of neutrons plus protons does not change in any nuclear process. Strong and weak nuclear interactions determine nuclear stability and processes.
- Spontaneous radioactive decays follow a characteristic exponential decay law. Nuclear lifetimes allow radiometric dating to be used to determine the ages of rocks and other materials from the isotope ratios present.
- Scientific understanding can help to identify implications of certain applications but decisions about whether certain actions should be taken will require ethical and moral judgements which are not provided by knowledge of science. Opinions may vary about what action to take but arguments based on scientific evidence should not be a matter of opinion.

Using Science

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

- Students evaluate, develop, and defend arguments using scientific evidence from texts, observations, and investigations. As they weigh evidence regarding fission, fusion, and radioactive decay, students will need to evaluate sources and claims from various perspectives.

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.	**Energy and Matter** • 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.

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• 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. • Evaluate a claim for a design solution to a real-world problem based on scientific knowledge, empirical evidence, and logical arguments regarding relevant factors (e.g., economic, societal, environmental, ethical considerations).	• In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved. **Structure and Function** • The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. • Some systems can only be studied indirectly as they are too small, too large, too fast, or too slow to observe directly. **Stability and Change** • Much of science deals with constructing explanations of how things change and how they remain stable.

EARTH AND SPACE SCIENCES

EARTH'S SYSTEMS

EARTH'S PLACE IN THE UNIVERSE

HIGH SCHOOL CHEMISTRY: INTRO TO BIOTECHNOLOGY

EARTH AND SPACE SCIENCES

EARTH'S SYSTEMS

Science Standard: ESSENTIAL HS.E1U1.13 Evaluate explanations and theories about the role of energy and matter in geologic changes over time.

Learning Goals

I can:

- Apply scientific reasoning, theory, and models to evaluate explanations and theories about the role of energy and matter in geologic changes over time:
  - Identify and explain examples of evidence that support scientific theories that Earth has evolved over geologic time due to natural processes.
  - Explain the mechanisms of heat transfer *(i.e., convection, conduction, radiation)* in a chemical system and then correlate it to the Earth's core and mantle, and why heat transfer is important for the layers of the Earth.
  - Connect Bowen's Reaction Series to the chemical evolution of the continental and oceanic crust composition.
  - Compare and evaluate scientific information and theories to explain the relationships between the different forms of carbon and how they are related.
  - Base causal explanations on valid and reliable empirical evidence from multiple sources that geologic processes that happened in the past can be explained by those same processes that are happening today (uniformitarianism) (*e.g., Japanese war balloon situation).*

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.

- Evidence from deep probes and seismic waves, reconstructions of historical changes in Earth's surface and its magnetic field, and an understanding of physical and chemical processes lead to a model of Earth with a hot but solid inner core, a liquid outer core, a solid mantle and crust. Motions of the mantle and its plates occur primarily through thermal convection, which involves the cycling of matter due to the outward flow of energy from Earth's interior and the gravitational movement of denser materials toward the interior.
- Active geological processes, such as plate tectonics and erosion, have destroyed or altered most of the very early rock records on Earth. Radioactive decay lifetimes and isotopic content in rocks provide a way of dating rock formations and thereby fixing the scale of geological time.

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 pertaining to geologic change over time. Not all explanations are equally valid, so students must compare and evaluate the claims, methods, theories, and conclusions presented in order to better understand the role of energy and matter in geologic changes over time.

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. • 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.	**Stability and Change** • Much of science deals with constructing explanations of how things change and how they remain stable. • Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible. **Energy and Matter: Flows, Cycles, and Conservation**

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• Evaluate a claim for a design solution to a real-world problem based on scientific knowledge, empirical evidence, and logical arguments regarding relevant factors (e.g., economic, societal, environmental, ethical considerations).	• Energy drives the cycling of matter within and between systems.

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HIGH SCHOOL CHEMISTRY: INTRO TO BIOTECHNOLOGY

EARTH AND SPACE SCIENCES

EARTH'S PLACE IN THE UNIVERSE

Science Standard: ESSENTIAL HS.E2U1.15 Construct an explanation based on evidence to illustrate the role of nuclear fusion in the life cycle of a star.

Learning Goals

I can:

- Construct explanations based on evidence obtained from a variety of sources *(e.g., scientific principles, models, theories, simulations)* about the role of nuclear fusion in the life cycle of a star:
    - Apply scientific knowledge and evidence to illustrate and/or model the life cycle of a star *(e.g., nebula, protostar, main sequence, etc.).*
    - Apply scientific knowledge and evidence to describe the role of nuclear fusion in the star's core to release energy.
    - 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.

- Our Sun is one of many stars that make up the Universe, essentially made of hydrogen. The source of energy that the Sun and all stars radiate comes from nuclear reactions in their central cores.
- Nuclear fusion within stars produces all atomic nuclei lighter than and including iron, and the process releases the energy seen as starlight. Heavier elements are produced when certain massive stars achieve a supernova stage and explode. Elements other than these remnants of the Big Bang continue to form within the cores of stars.

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 sources to better understand the role of nuclear fusion in the life cycle of a star. They then select valid, scientific evidence to construct their explanation.

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.
- 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.
- Evaluate a claim for a design solution to a real-world problem based on scientific knowledge, empirical evidence, and logical arguments regarding relevant factors (e.g., economic, societal, environmental, ethical considerations).

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.

Energy and Matter: Flows, Cycles, and Conservation

- In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved.

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ARIZONA PROFESSIONAL SKILLS

CAREER AND TECHNICAL EDUCATION

HIGH SCHOOL CHEMISTRY: INTRO TO 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 CHEMISTRY: INTRO TO 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 *(e.g., 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 (for example: 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.

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HIGH SCHOOL CHEMISTRY: INTRO TO 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.

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HIGH SCHOOL CHEMISTRY: INTRO TO 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.

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HIGH SCHOOL CHEMISTRY: INTRO TO 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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