Washington Office of Superintendent of
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CTE

Statewide Framework Document for: 261202

Biotechnology

Standards may be added to this document prior to submission but may not be removed from the framework to meet state credit equivalency requirements. Performance assessments may be developed at the local level. In order to earn state approval, performance assessments must be submitted within this framework. **This course is eligible for 1 credit of Lab, science.** The Washington State Science Standards performance expectations for high school blend core ideas (Disciplinary Core Ideas, or DCIs) with scientific and engineering practices (SEPs) and crosscutting concepts (CCCs) to support students in developing usable knowledge that can be applied across the science disciplines. These courses are to be taught in a three-dimensional manner. The details about each performance expectation can be found at Next Generation Science Standards, and the supporting evidence statements can be found under Resources.

School District Name		
Course Title: Biotechnology		**Total Framework Hours:** 180
CIP Code: 261202	☐ Exploratory ☒ Preparatory	**Date Last Modified:** October 30, 2020
Career Cluster: Health Science		**Cluster Pathway:** Biotechnology Research and Development
Course Summary: A program that focuses on the application of biological sciences, biochemistry, and genetics to health care. Includes instruction bioinformatics, gene identification, biochemistry, DNA sequencing, genetic engineering, industrial microbiology, drug and biologic developments, patent law, biotechnology management, marketing and ethic, and applicable regulations.		
Eligible for Equivalent Credit in: Science		**Total Number of Units:** 6

Unit 1: Introduction to Biotechnology	**Total Learning Hours for Unit:** 20

Unit Summary:
This unit introduces students to the field of biotechnology and the nature of science.

Performance Assessments: (Districts to complete for each unit)
Example assessments for this unit include:

- Research and communicate how scientific knowledge develop over time and plays an important role in society, citing specific evidence.
- Create a timeline of biotechnology inventions and innovations and justify the order of importance of the top ten.
- Use Career Bridge (WorkForce Career Website) to investigate 3 career opportunities in biotechnology fields. They will make pictographs showing the job forecast, the potential earnings in their county, the necessary education and potential entry level jobs skills.
- Create, following a model, a professional laboratory journal documenting their scientific work in detail

Leadership Alignment: (Districts to complete for each unit)
Leadership alignment must include a unit specific project/activity that aligns with the 21st Century Leadership Skills.
Examples:

- Students manage goals and time when they research a biotechnology invention or innovation and develop a visual display to present their research, citing evidence, to a group.
- Students collaborate with others as they create a timeline of biotechnology inventions and innovations in small groups. They will justify the order of importance of the top ten inventions/innovations as well.
- Students analyze media when they use Career Bridge to investigate several career options in biotechnology fields.
- Students produce a result and communicate clearly as they create a professional laboratory journal documenting their scientific work in detail.

Industry Standards and/or Competencies:
Common Career Technical Core Standards for Health Science Career Cluster (HL); Biotechnology Research and Development Pathway (BRD)

CCTC Standard HL-BRD 1: Summarize the goals of biotechnology research and development within legal and ethical protocols.

CCTC Standard HL-BRD 3.2: Identify trends in the field of biotechnology.

Competencies:

- Articulate and demonstrate the values of scientific research, including but not limited to curiosity, skepticism, collaboration, integrity, and perseverance.
- Develop a model of the science and engineering practice as a nonlinear process.
- Differentiate between basic research, applied research, and translational research.
- Create a professional laboratory journal which documents their scientific work in detail, including but not limited to questions, procedures, data, observations, and claims based on evidence about experiments.
- Communicate the difference between invention and innovation.
- Create a historical timeline of the biotechnology industries development and how it has influenced one of the fourteen biotechnology areas and society.

● Investigate the career opportunities within several of the diverse fields of biotechnology.

Aligned Washington State Academic Standards	
Science	Washington Science Standards (Next Generation Science Standards): **ETS2.A: Interdependence of Science, Engineering, and Technology** The fields of science and engineering are mutually supportive, and scientists and engineers often work together in teams, especially in fields at the borders of science and engineering. Advances in science offer new capabilities, new materials, or new understanding of processes that can be applied through engineering to produce advances in technology. Advances in technology, in turn, provide scientists with new capabilities to probe the natural world at larger or smaller scales; to record, manage, and analyze data; and to model ever more complex systems with greater precision. In addition, engineers' efforts to develop or improve technologies often raise new questions for scientists' investigation. **ETS2.B: Influence of Engineering, Technology, and Science on Society and the Natural World** Modern civilization depends on major technological systems, including those related to agriculture, health, water, energy, transportation, manufacturing, construction, and communications. Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks. Widespread adoption of technological innovations often depends on market forces or other societal demands, but it may also be subject to evaluation by scientists and engineers and to eventual government regulation. New technologies can have deep impacts on society and the environment, including some that were not anticipated or that may build up over time to a level that requires attention or mitigation. Analysis of costs, environmental impacts, and risks, as well as of expected benefits, is a critical aspect of decisions about technology use.

	Disciplinary Core Idea	**Crosscutting Concept**
Develop and Use Models Obtain, Evaluate, and Communicate Information		*Connections to Engineering, Technology, and Application of Science* ETS2.A: Interdependence of Science, Engineering, and Technology ETS2.B: Influence of Engineering, Technology, and Science on Society and the Natural World

Unit 2: Biotechnology Laboratory Basic Skills and Safety	**Total Learning Hours for Unit:** 30
Unit Summary: This unit introduces students to basic biotechnology skills and laboratory safety protocols used in industry setting.	

Performance Assessments: (Districts to complete for each unit)
Example assessments for this unit include:

- Select and use the appropriate personal protective (PPE) and emergency equipment necessary in a student-designed investigation
- Demonstrate the ability to pipet with accuracy and precision.
- Demonstrate consistent use of sterile techniques and knowledge of contamination control.
- Demonstrate ability to calculate and prepare solutions and dilutions.

Leadership Alignment: (Districts to complete for each unit)
Leadership alignment must include a unit specific project/activity that aligns with the 21st Century Leadership Skills.
Example:

- Students make judgments and decisions as they correctly and consistently use personal protective equipment to implement infection control and reduce exposures to hazardous chemicals according to industry standards.
- Working independently, students demonstrate the ability to pipet with accuracy and precision, the use of sterile technique, the knowledge of contamination control and the ability to calculate and prepare solutions/dilutions. These skills are necessary to master as they are essential to each student's success in biotechnology.

Industry Standards and/or Competencies:
Common Career Technical Core Standards for Health Science Career Cluster (HL); Biotechnology Research and Development Pathway (BRD)

CCTC Standard HL-BRD 4: Demonstrate the principles of solution preparation, sterile techniques, contamination control, and measurement and calibration of instruments used in biotechnology research.
CCTC Standard HL-BRD 2.1: Apply mathematical concepts to the field of biotechnology.
CCTC Standard HL-BRD 6.2: Apply institutional protocols to biotech research.
Mowery, Jeannette, and John Carrese. "Core Skill Standards for Bioscience Technicians." *Bio-Link*, edited by Lisa Huffman, U.S. Department of Labor, 2016, bio-link.org/home2/sites/default/files/Core%20Skills%20Booklet_low_res.pdf. Accessed 1 Apr. 2017.

- Maintain a safe and productive work environment
    - Recognize unsafe conditions and take corrective and/or preventative action(s).
    - Follow relevant safety procedures, guidelines, and regulations (e.g. company, OSHA, EPA, CDC).
    - Access and use SDS and other safety information sources.
    - Maintain a safe, clean, contamination-free, and clutter-free environment, as appropriate.
    - Select appropriate PPE to use to protect self from biological, chemical, and/or physical hazards.
- Comply with applicable regulations and standards
    - Follow established policies and procedures
    - Record information according to established procedures
    - Exercise proper document control
    - Participate in required training
- Perform mathematical manipulations
    - Perform calculations relating to work function

- Perform data analysis

Competencies:

- Maintain a sanitary, safe and hazard free laboratory environment while following universal precautions.
- Identify the emergency lab response and biosafety protocols for chemical spills, sharps disposal, fire, and biological agent exposure.
- Identify and report conditions presenting a threat to health and safety in the laboratory.
- Recognize and report non-hazardous problems in equipment and supplies.
- Use proper precautions and disposal methods when working with microorganisms.
- Identify chemical hazards and follow the rules for safe use and disposal of all chemicals.
- Safely operate biotechnology laboratory equipment according to standard operating procedures (SOPs).
- Understand and explain SDS for chemicals and follow chemical safety guidelines for chemical labeling.
- Identify the parts of a micropipette and use the micropipette to accurately and precisely measure small volumes of liquid.
- Demonstrate the ability to adjust and focus a microscope to clearly visualize specimens.
- Prepare laboratory solutions such as Mass/volume, % mass/volume, molarity, dilutions, and buffers correctly.
- Demonstrate collaboration as a member of a team, using oral and written communication skills to generate data and solve problems.

Aligned Washington State Academic Standards

Science	ETS2.A: Interdependence of Science, Engineering, and Technology The fields of science and engineering are mutually supportive, and scientists and engineers often work together in teams, especially in fields at the borders of science and engineering. Advances in science offer new capabilities, new materials, or new understanding of processes that can be applied through engineering to produce advances in technology. Advances in technology, in turn, provide scientists with new capabilities to probe the natural world at larger or smaller scales; to record, manage, and analyze data; and to model ever more complex systems with greater precision. In addition, engineers' efforts to develop or improve technologies often raise new questions for scientists' investigation.

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Ask questions and defining problems Analyzing and Interpreting Data Using Mathematics and Computational Thinking Obtaining, evaluating and communicating information	HS-PS1 Matter and Interactions HS-LS1 From Molecules to Organisms: Structures and Processes HS-LS2B Cycles of Matter and Energy Transfer in Ecosystems	Cause and Effect Structure and Function *Connections to Engineering, Technology, and Applications of Science* ETS2.A: Interdependence of Science, Engineering, and Technology

Unit 3: DNA and DNA Analysis	**Total Learning Hours for Unit:** 40
Unit Summary:	

This unit reviews DNA structure and function, introduces basic methods of DNA manipulation and analysis, and has students apply these techniques to real world questions

Performance Assessments: (Districts to complete for each unit)

Example assessments for this unit include:

- Construct a model that explains how the process of electrophoresis technology separates molecules.
- Apply the process of gel electrophoresis and scientific inquiry to generate evidence to solve a problem.
- Model the fragments that would be produced by specific restriction enzymes on a molecule of DNA.
- Analyze a DNA Fingerprint to construct a claim supported by evidence and reasoning.
- Use the process of PCR, gel electrophoresis, and scientific inquiry to generate evidence to solve a problem.
- Reason effectively and use systems thinking to troubleshoot lab challenges with PCR and or electrophoresis
- Use a model to develop and communicate an explanation and applications of the process of Polymerase Chain Reaction (PCR).

Leadership Alignment: (Districts to complete for each unit)

Leadership alignment must include a unit specific project/activity that aligns with the 21st Century Leadership Skills.

Example:

- Students use systems thinking as they construct a model that explains how the process of electrophoresis technology separates molecules.
- Students manage projects as they apply the process of gel electrophoresis and scientific inquiry to generate evidence to solve a problem.
- Students analyze, refine, and apply decision-making skills as they perform gel electrophoresis techniques in the classroom laboratory to answer biological questions.
- Students interact effectively with others when they model the fragments that would be produced by specific restriction enzymes on a molecule of DNA.
- Students reason effectively when they analyze a DNA fingerprint to construct a claim supported by evidence and reasoning.
- In a team, students solve a problem as they use the process of PCR, gel electrophoresis, and scientific inquiry to generate evidence.
- In a team, students are responsible to others as they use a model to develop and communicate an explanation of the process and applications of Polymerase Chain Reaction (PCR).
- Students apply technology as they research and present how current technologies, e.g. PCR and gel electrophoresis, are used in society today and discover what possible career options may be available.

Industry Standards and/or Competencies:

Common Career Technical Core Standards for Health Science Career Cluster (HL); Biotechnology Research and Development Pathway (BRD)

CCTC Standard HL-BRD 2.4: Apply principles of organic chemistry to biotechnology.

- Structure (including bonding) and function of DNA and the process of DNA replication.

CCTC Standard HL-BRD 2.6: Apply principles of cell biology to biotechnology.

- Amplify DNA fragments using the PCR process.
- Use restriction enzymes to conduct a DNA Fingerprint.

CCTC Standard HL-BRD 2.7: Apply principles of molecular biology to biotechnology

- Structure and function of DNA and the process of DNA replication.

- Construct an explanation of how the central dogma of molecular biology impacts biotechnology research and development.

CCTC Standard HL-BRD 3: *Demonstrate basic knowledge of* recombinant DNA, *genetic engineering*, bioprocessing, monoclonal antibody production, nanotechnology, *bioinformatics, genomics*, *proteomics,* and transcriptomics to conduct biotechnology research and development.

- Use the process of gel electrophoresis to separate and analyze mixtures of molecules.
- Compare and contrast the different types of electrophoresis and their application in biotechnology.
- Understand the purpose of different biological stains and how they apply to the studies of cells and/or molecules.
- Explain the job of restriction enzymes and their source.
- Explore how DNA differs between individuals within and between a species (using bioinformatics, cladograms, SNPS - evolutionary origins, paternity)
- Explain the process of PCR
  Mowery, Jeannette, and John Carrese. "Core Skill Standards for Bioscience Technicians." *Bio-Link*, edited by Lisa Huffman, U.S. Department of Labor, 2016, https://bio-link.org/home2/sites/default/files/Core%20Skills%20Booklet_low_res.pdf. Accessed 1 Apr. 2017.
- Perform measurements/tests/assays
  - Collect samples according to established procedures and applicable sampling plans
  - Prepare samples according to established procedures
  - Follow appropriate test procedures/instructions
  - Document data & results according to established procedures
  - Interpret and/or analyze data & results as appropriate
- Master fundamental lab skills involving DNA extraction from various organisms.

Aligned Washington State Academic Standards

Science	**Washington Science Standards (Next Generation Science Standards):** HS-PS1 Matter and Interactions HS-PS1-2 Construct and revise an explanation for the outcome of a chemical reaction based on the outermost electron states of atoms, trends in periodic table, and knowledge of the patterns of chemical properties. HS-PS1-3 Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between the particles. HS-PS1-5 Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles. HS-LS1 From Molecules to Organisms Structures and Processes HS-LS1-1 Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins which carry out the essential functions of life through systems of specialize cells. HS-LS1-3 Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis HS-LS3 Heredity: Inheritance and Variation of Traits.

	HS-LS3-1. Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristics traits passed from parents to offspring. HS-LS3-2. Make and defend a claim based on evidence that inheritable genetic variations may result from (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors. HS-LS3-3 Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Ask questions and defining problems Developing and Using Models Analyzing and Interpreting Data Engaging in Argument from Evidence	*HS-LS1 From Molecules to Organisms: Structures and Processes* HS-LS1.A Structure and Function *HS-LS3 Heredity: Inheritance and Variations of Traits* HS-LS3.A: Inheritance of Traits HS-LS3.B Variations of Traits *HS-PS1 Matter and Interactions* HS-PS1.A Structure and Properties of Matter HS-PS1.B Chemical Reactions	Cause and Effect Structure and Function Scale, Proportion and Quantity *Connections to Nature of Science:* Science is a Human Endeavor

Unit 4: Genetic Engineering	**Total Learning Hours for Unit:** 40

Unit Summary:
This unit introduces recombinant DNA and the current technologies of genetic engineering and their applications in today's world.

Performance Assessments: (Districts to complete for each unit)
Example assessments for this unit include:

- Research an explanation of how restriction enzymes are used to build plasmids in recombinant DNA technologies and construct a paper model of a plasmid that could be used in a bacterial transformation.
- As a team perform a bacterial transformation to successfully genetically engineer a bacterial cell and formulate conclusions from the experimental data.
- Use mathematical reasoning to determine efficiency of transformation.
- Based on prior data and self-reflection, redesign and perform the experiment to increase transformation efficiency.

Leadership Alignment: (Districts to complete for each unit)
Leadership alignment must include a unit specific project/activity that aligns with the 21st Century Leadership Skills.
Example:

- Student produce results as they construct a paper model of a plasmid that could be used in a bacterial transformation, as they research an explanation of how restriction enzymes are used to build plasmids in recombinant DNA technologies.
- Students guide and lead others as they perform a team bacterial transformation to successfully genetically engineer a bacterial cell and formulate conclusions from the experimental data.
- Students solve a problem using mathematical reasoning to determine the efficiency of transformation.
- Students think creatively, implement innovations and be self-directed learners as they redesign their transformation experiments to increase transformation efficiency.
- Carry out a bacteria transformation experiment and articulate thoughts and ideas effectively using written communication skills by generating a formal lab report.

Industry Standards and/or Competencies:
Common Career Technical Core Standards for Health Science Career Cluster (HL); Biotechnology Research and Development Pathway (BRD)

CCTC Standard HL-BRD 2.8: Apply principles of microbiology to biotechnology.

- Prepare and utilize appropriate bacterial culture media to grow pure cultures of bacterial strains.
- Accurately pick a colony of bacteria and transfer to a new media without contamination.
- Model and explain plasmid design and development for use in bacterial transformation.

CCTC Standard HL-BRD.3 Demonstrate basic knowledge of recombinant DNA, genetic engineering, bioinformatics, genomics, proteomics

- Outline the process of a genetic engineering procedure.
- Communicate the role of plasmids in nature (i.e. plasmids role in developing antibiotic resistance in nature and why society should be concerned)
- Identify applications of recombinant DNA and give examples of protein products made utilizing recombinant DNA. (i.e. insulin)

Aligned Washington State Academic Standards

Science	**Washington Science Standards (Next Generation Science Standards):** HS-PS1 Matter and Interactions HS-PS1-2 Construct and revise an explanation for the outcome of a chemical reaction based on the outermost electron states of atoms, trends in periodic table, and knowledge of the patterns of chemical properties. HS-PS1-5 Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles. HS-LS1 From Molecules to Organisms Structures and Processes HS-LS1-1Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins which carry out the essential functions of life through systems of specialize cells. HS-LS1-3 Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis

	HS-LS3 Heredity: Inheritance and Variation of Traits. HS-LS3-1. Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristics traits passed from parents to offspring. HS-LS3-2. Make and defend a claim based on evidence that inheritable genetic variations may result from (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors. HS-LS3-3 Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population HS-ESS Earth and Human Activity HS-ESS3-3. Create a computational simulation to illustrate the relationship among the management of natural resources, sustainability of human populations, and biodiversity. HS-ESS3-6. Use a computational representation to illustrate the relationships among Earth systems and how these relationships are being modified due to human activity.

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Ask questions and defining problems Developing and Using Models Planning and carrying out investigations Analyzing and interpreting data Using mathematic and computational thinking Constructing explanation and designing solutions Engaging in argument from evidence Obtaining, evaluating and communicating information	*HS-LS1 From Molecules to Organisms: Structures and Processes* HS-LS1.A Structure and Function *HS-LS3 Heredity: Inheritance and Variations of Traits* HS-LS3.A Inheritance of Traits HS-LS3.B Variation of Traits *HS-PS1 Matter and Interactions* HS-PS1.B Chemical Reactions *HS-ESS3 Earth and Human Activity* HS-ESS3.C Human Impacts on Earth Systems	Cause and Effect Systems and Systems Model Patterns *Connections to Nature of Science* Science is a Human Endeavor *Connection to Engineering, Technology, and Applications of Science* ETS2.B Influence of Engineering, Technology, and Science on Society and the Natural World.

Unit 5: Immunology and Epidemiology	**Total Learning Hours for Unit:** 30
Unit Summary: This unit introduces the basics of the human immune system. It also introduces antigens and antibodies as related to ELISA testing and how this technique applies to disease diagnosis, spread, and control	
Performance Assessments: (Districts to complete for each unit) *Example assessments for this unit include:* • Perform an ELISA to solve an epidemiology problem and explain the implications of the results using an evidence based argument.	

- Teams of students use a CDC data set to research an outbreak and use mathematics to communicate trends of the outbreak/spread of the disease and consequences of vaccination choices of the affected populations.
- Teams of students create a model that will communicate the role of antigens and antibodies in the human immune systems.
- Compile information from multiple sources and create an infographic to address a current trend in biotechnology (proteomics, rapid response drug testing, biomarkers, P4 medicine, ELISA).

Leadership Alignment: (Districts to complete for each unit)
Leadership alignment must include a unit specific project/activity that aligns with the 21st Century Leadership Skills.
Example:

- Students work effectively in diverse teams accessing and evaluating information while performing an ELISA to solve an epidemiology problem and explain the implications of the results using an evidence-based argument.
- Teams of students reason effectively and access and evaluate information using a CDC data set to research an outbreak and use mathematics to communicate trends of the outbreak/spread of the disease and consequences of vaccination choices of the affected populations.
- Students work creatively with others to create a model that will communicate the role of antigens and antibodies in the human immune systems.
- Working independently, students create media products as they compile information from multiple sources and create an infographic to address a current trend in biotechnology (proteomics, rapid response drug testing, biomarkers, P4 medicine, ELISA).

Industry Standards and/or Competencies:
Common Career Technical Core Standards for Health Science Career Cluster (HL); Biotechnology Research and Development Pathway (BRD)

CCTC Standard HL-BRD 2.1: Apply mathematical concepts to the field of biotechnology.

- Model the role of the CDC in identifying the origin and transmission of an outbreak
- Analyze and communicate the impact of vaccines using data using mean and standard deviation

CCTC Standard HL-BRD 2.6: Apply principles of cell biology to biotechnology

- Communicate the role of viruses and microorganisms in infection and disease, pandemics and epidemics of the past and how understanding these inform current prevention practices today.
- Obtain, evaluate and communicate the role of antigens and antibodies in immune systems.

CCTC Standard HL-BRD 3.1: Identify techniques used in biotechnology.

- Use models to communicate how current technology analyzes and detects agents of infection and or disease (ELISA, dip sticks/rapid response testing, HIV/AIDS, pregnancy testing, and in the food industry when detecting potential food allergens)

CCTC Standard HL-BRD 3.2: Identify trends in the field of biotechnology.

- Mowery, Jeannette, and John Carrese. "Core Skill Standards for Bioscience Technicians." *Bio-Link*, edited by Lisa Huffman, U.S. Department of Labor, 2016, https://bio-link.org/home2/sites/default/files/Core%20Skills%20Booklet_low_res.pdf. Accessed 1 Apr. 2017.
- Perform measurements/tests/assays
    - Follow appropriate test procedures/instructions

- Document data & results according to established procedures
- Interpret and/or analyze data & results as appropriate

Aligned Washington State Academic Standards	
Science	HS-PS1 Matter and Interactions. HS-PS1-2 Construct and revise an explanation for the outcome of a chemical reaction based on the outermost electron states of atoms, trends in periodic table, and knowledge of the patterns of chemical properties. HS-PS1-5 Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs. HS-LS1 From Molecules to Organisms Structures and Processes. HS-LS1-1 Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins which carry out the essential functions of life through systems of specialized cells. HS-LS1-3 Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis. HS-LS3 Heredity: Inheritance and Variation of Traits. HS-LS3-2 Make and defend a claim based on evidence that inheritable genetic variations may result from (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors. HS-LS3-3 Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.

Science and Engineering Practice	**Disciplinary Core Idea**	**Crosscutting Concept**
Ask questions and defining problems Developing and Using Models Planning and carrying out investigations Analyzing and interpreting data Using mathematic and computational thinking Constructing explanation and designing solutions Engaging in argument from evidence Obtaining, evaluating and communicating information	HS-LS1 From Molecules to Organisms: Structures and Processes HS-LS1.A Structure and Function HS-LS3 Heredity: Inheritance and Variations of Traits HS-LS3.B: Variation of Traits HS-PS1 Matter and Interactions PS1.A Structure and Properties of Matter PS1.B Chemical Reactions HS-PS1-2 Construct and revise and explanation for the outcome of a chemical reaction. HS-PS1-5 Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting principles.	Structure and Function Patterns Cause and effect Scale, proportion and quantity Systems and system models Stability and change

Unit 6: Bioethics	**Total Learning Hours for Unit:** 20

Unit Summary:
This unit introduces bioethical principles and how they apply to an ethical dilemma, the role of cellular and animal models in research, and the role of human clinical trials in product development.

Performance Assessments: (Districts to complete for each unit)
Example assessments for this unit include:

- Engage in argument from evidence to analyze an ethical dilemma justifying a position using knowledge of ethical principles, stakeholder perspectives and scientific facts.
- Analyze and communicate their understanding of the 3 Rs (replace, reduce, refine) in an example of scientific animal research.
- Using a sample product, model the process of design to production including the ethical constraints and limitations.
- Using current news and/or articles, students will obtain, evaluate and communicate information about a large ethical, moral or legal issue related to biotechnology research, product development, and use in society.

Leadership Alignment: (Districts to complete for each unit)
Leadership alignment must include a unit specific project/activity that aligns with the 21st Century Leadership Skills.
Example:

- Students make judgements and decisions and communicate clearly as they engage in argument from evidence to analyze an ethical dilemma justifying a position using knowledge of ethical principles, stakeholder perspectives and scientific facts and analyze and communicate their understanding of the 3 Rs (replace, reduce, refine) in an example of scientific animal research.
- Students use systems thinking as they use a sample product to model the process of design to production, including the ethical constraints and limitations.
- Students create media products as they use current news and/or articles to obtain, evaluate and communicate information about a large ethical, moral or legal issue related to biotechnology research, product development, and use in society.
- Respect cultural differences and work effectively with people from a range of social and cultural backgrounds to identify possible solutions to bioethical dilemmas.

Industry Standards and/or Competencies:
Common Career Technical Core Standards for Health Science Career Cluster (HL); Biotechnology Research and Development Pathway (BRD)

CCTC Standard HL-BRD.1 Summarize the goals of biotechnology research and development within legal and ethical protocols.

- Differentiate between morals and ethics
- Identify the four bioethical principles of maximizing benefits (beneficence), minimizing harms (non-maleficence), fairness (justice), and respect for persons (autonomy).
- Explain that an ethical dilemma does not have a right or wrong/legal or illegal solution.
- Identify the 3 Rs (replace, reduce, and refine) used to analyze the appropriate use of animals in research.

CCTC Standard HL-BRD.1.21 Assess a current biotechnology-related ethical issue in the news and how it may affect the quality of life.

- Discuss bioethical issues related to biotechnology products, e.g. HeLa cells, recombinant products (agr, enviro, medical)
- Analyze a current biotechnology technique or issue from the perspective of morality and ethics
- Explain why using cellular and animal models are essential for answering scientific questions.

CCTC Standard HL-BRD.5 Determine processes for product design and production and how that work contributes to an understanding of the biotechnology product development process.

- Identify the components of human clinical trials and how they relate to ethics

CCTC Standard HL-BRD.5.12 Analyze the role of pre-clinical and clinical trials in biotechnology product development.

- Explain how informed consent is essential to the process of human clinical trials.
- Communicate clearly the role of human clinical trials in biotechnology product development.

CCTC Standard HL-BRD.6 Summarize and explain the larger ethical, moral, and legal issues related to biotechnology research, product development, and use in society.

Aligned Washington State Academic Standards	
Science	HS-ESS Earth and Human Activity HS-ESS3-3. Create a computational simulation to illustrate the relationship among the management of natural resources, sustainability of human populations, and biodiversity. HS-ETS1 Engineering Design HS-ETS1-3 Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts. HS-ETS1-4 Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Ask questions and defining problems Developing and Using Models Constructing explanation and designing solutions Engaging in argument from evidence Obtaining, evaluating and communicating information	*HS-ESS3 Earth and Human Activity* HS-ESS3.C: Human Impacts of Earth Systems *HS-ETS1 Engineering Design* HS-ETS1.B Developing Possible Solutions	Cause and effect Stability and change