



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](http://nextgenscience.org/three-dimensions). The details about each performance expectation can be found at [Next Generation Science Standards](http://nextgenscience.org/next-generation-science-standards), and the supporting evidence statements can be found under [Resources](http://nextgenscience.org/ngss-high-school-evidence-statements).

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| **School District Name** | | |
| **Course Title:** Biotechnology | | **Total Framework Hours:** 180 |
| **CIP Code:** 261202 | ExploratoryPreparatory | **Date Last Modified:** October 30, 2020, June 25, 2025 |
| **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.  **Units:**  Unit 1: Introduction to Biotechnology (20)  Unit 2: Biotechnology Laboratory Basic Skills and Safety (30)  Unit 3: DNA and DNA Analysis. (40)  Unit 4: Genetic Engineering (40)  Unit 5: Immunology and Epidemiology (30)  Unit 6: Bioethics (20) | | |
| **Eligible for Equivalent Credit in:** Science | | **Total Number of Units:** 6 |
| **Course Resources:**   * [Oregon Career and Technical Education Frameworks: Health Science Career Cluster Resource Guide](https://www.oregon.gov/ode/learning-options/CTE/resources/Documents/Resource%20Guide_Health%20Sciences.pdf)   + Oregon Department of Education (2024)   + Update and revalidation of the knowledge and skills and indicators used to define the Health Science Career Cluster   + Updated [Health Science Common Career and Technical Core Standards: Biotechnology Research and Development Pathway](https://careertech.org/career-clusters/archive/) in 2020 framework * [Core Skill Standards for Bioscience Technicians](https://innovatebio.org/publication/core-skill-standards-for-bioscience-technicians) * [Competency Model Clearinghouse: Bioscience Competency Model](https://www.careeronestop.org/competencymodel/competency-models/bioscience.aspx) ‘ * Biotility - [Biotechnology Aptitude and Competency Exam (BACE)](https://biotility.research.ufl.edu/what-is-the-bace/)   + [Detail of Exam Competencies](https://biotility.research.ufl.edu/bace/exam-site-resources/documentation/) * [DESE (Massachusetts Department of Elementary and Secondary Education) Biotechnology Standards and Skills](https://macte.ns4ed.com/biotechnology-standards-and-skills/) | | |

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| **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:*   * *S*tudents manage goals and time (8.A.1, 8.A.3) 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 (3.B1. 3.B.3) 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 (5.A.2) when they use Career Bridge to investigate several career options in biotechnology fields. * Students produce a result [10.B.1 (a-h)] and communicate clearly (3.A.1, 3.A.3) 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)  **Oregon Health Science Career Cluster Knowledge and Skill Statements with Suggested Performance Indicators**  CC-HS01 Explain the history, trends, and career pathways within the healthcare system.   * Identify historical and current trends in healthcare and how they impact the system and society. * Explain current and potential uses of biotechnology within healthcare (e.g., vaccine development, genetically tailored health care) * Describe the different types of healthcare careers. * Identify the certification, licensing, and regulatory requirements associated with different healthcare pathways. * Describe the importance of major healthcare contributors and developments, linking them with modern innovations and practices.   **DESE Biotechnology Standards and Skills**  Standard 2 Role of Biotechnology Professionals in Society: Students will examine the role of biotechnology professionals in society, analyze the evolution of biotechnology and its technological advances, and evaluate the impact of biotechnology on environmental awareness and sustainability.  a. Describe the contributions of biotechnology professionals in various sectors such as healthcare, agriculture, environmental science, and industry.  b. Trace the historical development of biotechnology, including significant milestone and breakthroughs, e.g., discovery of DNA, the first recombinant DNA molecule, and the development of the Polymerase Chain Reaction (PCR).  Standard 3 Fundamentals of Biotechnology: Students will apply fundamental biotechnology concepts, explore key techniques and principles, and assess their practical applications and ethical implications.  a. Identify and explain the main fields of biotechnology and their products, including medical applications, e.g., gene therapies, biopharmaceuticals, mRNA technologies, vaccines, agricultural biotechnology, e.g., GMOs, biopesticides, environmental biotechnology, e.g., bioremediation, and industrial technology, e.g., biofuels, bioplastics.  c. Explain how new discoveries in biotechnology, such as breakthroughs in gene editing, influence decision-making in scientific research, product development, and ethical considerations.  j. Examine the basics of scientific research, including how to ask research questions, develop hypotheses, and design experiments to test them in the context of biotechnology.  Standard 6: Laboratory Management: Students will demonstrate safe laboratory work habits that ensure personal and others; safety and employ effective laboratory management techniques that meet industry standards.  c. Maintain accurate laboratory records of experiments, equipment usage, and safety inspections.  d. Utilize various documentation methods, including logbooks, computer systems, and forms, to document lab support functions and equipment operations, such as those for autoclaves, pH meters, incubators, and freezers.  **Oregon Health Science Career Cluster - Biotechnology Knowledge and Skill Statements with Suggested Performance Indicators**  FA-BIOT01 (CCTC Standard HL-BRD 1) Summarize the goals of biotechnology research and development within legal and ethical protocols.   * Use data to explain biotechnology’s contributions to quality of life * Recognize the role of innovation in the creation of emerging biotechnology careers.   FA-BIOT10 (CCTC Standard HL-BRD 3.2) Identify techniques, trends, and current areas of research in biotechnology.   * Predict how artificial intelligence, nanotechnology. Bioinformatics, proteomics, genomics, and transcriptomics will create new career opportunities and impact healthcare environments.   FA-BIOT013 (CCTC Standard HL-BRD 6.1) Understand the ethical, moral, legal, and cultural issues related to the use of biotechnology research and product development   * Understand the critical need for ethical policies and procedures for institutions engaged in biotechnology research and product development.   **BACE - Biotechnology Aptitude and Competency Exam - Practical Categories**   * Experimental Design and Data Analysis involves understanding how to design experiments, analyze data, and communicate findings effectively. It covers the use of controls, maintaining a laboratory notebook, applying statistical methods, and adhering to the principles of Responsible Conduct of Research (RCR). The focus is on ensuring that experiments are well-designed, data is accurately interpreted, and results are clearly communicated.   + Read, interpret, and draw conclusions from technical material, test records, and specification sheets   + Explain how to maintain a laboratory notebook.   + Understand and apply the principles of RCR.   + Effectively communicate scientific findings.   **Bioscience Competency Model**   * **Tier 4 Industry-Wide Technical Competencies** * 4.1 Bioscience Fundamentals: The bioscience industry and its interactions with society * Critical Work Functions   4.1.1 Understand the major application areas of bioscience  4.1.2 Describe the major technologies and historical development of bioscience  4.1.4 Research emerging and future applications of bioscience  4.1.5 Understand the social impact of bioscience  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 | |

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| **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 (2.C.1, 2.C.4) 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 (8.B.1), 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)  **Oregon Health Science Career Cluster - Biotechnology Knowledge and Skill Statements with Suggested Performance Indicators**  FA-BIOT11 (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.   * Apply biosafety protocols in the laboratory environment * Describe the criticality of the requirements of sterile techniques.   FA-BIOT02 (CCTC Standard HL-BRD 2.1) Apply mathematical concepts to the field of biotechnology.   * Prepare solutions based on both percent and weight composition to demonstrate proficiency in use of mechanical and digital microbalances. * Calculate and prepare solutions of various molarity, calculate and prepare buffers of various pH, and prepare serial dilutions. * Explain scientific notations.   **DESE Biotechnology Standards and Skills**  Standard 1 Students will demonstrate the skills necessary to maintain a safe and healthy working environment in biotechnology settings, understanding regulatory requirements, recognizing potential hazards, and implementing appropriate safety protocols and health practices.  a. Identify, describe, and demonstrate the effective use of Safety Data Sheets (SDS) to meet documentation requirements.  b. Locate emergency equipment, including the first aid kit, emergency action and response plan, and essential items such as eyewash stations, shower facilities, sinks, fire extinguishers, fire blankets, telephones, master power switches, and emergency exits, ensuring that all labels and signage comply with the OSHA Hazard Communication Program (HAZCOM)  c. Develop an emergency contact list, identifying appropriate health and safety agencies and resources.  d. Describe procedures used to manage emergency situations, defensive measures, and accidents, including identification, reporting, response, evacuation plans, and follow-up procedures.  e. Read and interpret chemical, product, and equipment labels to determine appropriate health and safety considerations.  f. Identify and describe fire protection precautions and response procedures.  h. Demonstrate safe handling, storing, disposing of, and recycling hazardous, flammable, and combustible materials, according to Environmental Protection Agency (EPA), OSHA, and product specifications.  i. Identify, describe, and apply EPS and other environmental protection regulations that apply to specific tasks and jobs in the specific occupational area.  j. Demonstrate proper use of personal protective equipment (PPE) and ergonomic practices, including gloves, safety goggles, masks, ear plugs, eye protection, breathing apparatus, appropriate footwear, wrist rests, and adjustable workstations depending on the tasks and hazards present.  k. Demonstrate the safe use, storage, and maintenance of equipment in the lab, shop, and classroom, e.g., the OSHA Lockout/Tagout Program (LOTO)  l. Demonstrate appropriate safe body mechanics, including appropriate lifting techniques and ergonomics.  m. Demonstrate the ability to perform first aid, utilize an Automated External Defibrillator (AED), and administer Cardiopulmonary Resuscitation (CPR) according to current guidelines and best practices.  n. Identify and describe potential consequences for non-compliance with appropriate health and safety regulations.  Standard 6: Laboratory Management: Students will demonstrate safe laboratory work habits that ensure personal and others; safety and employ effective laboratory management techniques that meet industry standards.  a. Apply 5S components (Sort, Set in Order, Shine, Standardize, Sustain) in laboratory setting to enhance organization, safety, and productivity.  b. Demonstrate basic lab management skills, including inventorying supplies, ordering required materials, and scheduling work functions.  g. Understand biosafety levels (BSL) and their requirements.  h. Demonstrate aseptic techniques and proper handling of biological materials using a biological safety cabinet and explain the principles of maintaining sterility in laboratory environments.  i. Describe procedures for dealing with biological spills and contamination.  k. Identify various methods used in clean room sterilization and their applications.  l. Demonstrate the operation of an autoclave and explain its role in maintaining sterile technique.  m. Demonstrate sterilizing reagents, solutions and media properly according to established procedures.  n. Demonstrate cleaning and sterilizing glassware and counters to meet laboratory procedures.  o. Demonstrate cleaning and maintenance of equipment according to manufacturer’s specifications.  p. Identify, use, and store laboratory equipment, e.g., pipettes, centrifuges, autoclaves.  Standard 7: Solution Preparation, Instrumentation, and Lab Assays: Students will accurately prepare and analyze solutions, perform precise calculations related to measurements, reagent formations, and data analysis, and effectively use instrumentation for lab assays.  a. Accurately calculate measurements, including unit conversions and molarity, and prepare various types of solutions.  b. Determine correct amounts of reagents and media for formulations and dilutions  c. Formulate solutions with precise percent, molar, and molal concentrations.  d. Conduct dilutions and calculate the concentrations of the resulting solutions.  e. Execute serial dilutions and determine the final concentrations.  g. Label and store reagents, solutions, and media according to established protocols.  j. Perform accurate and precise measurements of volume, pH levels, and temperature.  k. Achieve accurate and precise weight measurements.  Standard 8: Basics of Microscopes: Students will demonstrate the use and care of various types of microscopes and perform laboratory procedures related to microscopy.  a. Identify, describe, and use the components of a microscope.  b. Differentiate between the different types of microscopes and describe their uses, including compound, inverted, scanning electron, fluorescent, and stereo.  c. Demonstrate proper cleaning technique for the microscope and lenses to maintain functionality and prevent damage.  **BACE - Biotechnology Aptitude and Competency Exam -**  **Knowledge Categories**   * Technical Skills & Applications covers the foundational techniques used in biotechnology workplace settings. It includes understanding and applying methods such as aseptic technique, cell culture, DNA isolation, and various assays. The focus is on both the theoretical principles and the practical application of these techniques, including the use of advanced equipment and procedures such as polymerase chain reaction (PCR), gel electrophoresis, and chromatography.   + Describe the proper use of microscopes.   + Discuss the differences between sterilization, decontamination, and disinfection. * Safety & Workplace Culture emphasizes the importance of safety, ethics, and proper behavior in the biotechnology workplace. It includes understanding and following safety protocols, using personal protective equipment (PPE), handling hazardous materials, and responding to emergencies. It also covers the ethical considerations in biotechnology, workplace behaviors, and compliance with regulations enforced by agencies such as the Occupational Safety and Health Administration. (OSHA)   + Describe appropriate workplace behaviors   + Identify proper workplace safety behaviors   + Identify safety symbols   + Identify and explain proper use of safety equipment   + Identify and properly use PPE   + Exercise proper safety protocols   + Describe proper handling of biological and hazardous waste   + Explain the importance of posting and complying with signage   + Describe procedures for safe handling and storage of chemicals   + Derive information from safety data sheets (SDS)   + Discuss key OSHA regulations applicate to biotechnology workplaces.   + Describe proper lockout/tagout procedures for machinery and equipment   + Describe emergency response procedures for fires, chemical spills, or other incidents   + Discuss the process for reporting safety concerns and hazards, including near misses   + Discuss the importance of proactive safety communication   + Understand the importance of comprehensive training and safety training in biotechnology workplaces   + Properly label items, including solutions, buffers, Petri plates, samples, and products   **Practical Categories**   * Biotechnology Skills centers on technical skills essential for quality work. It includes accurately measuring liquids and solids, preparing solutions, performing serial dilutions, and using standard equipment such as centrifuges, spectrophotometers, and biosafety cabinets. The focus is on mastering these practical skills to ensure precise and reliable outcomes.   + Properly prepare solutions and buffers   + Properly measure and adjust the pH of a solution.   + Properly perform a serial dilution   + Demonstrate proper aseptic/sterile technique   + Describe the use and maintenance of biological safety cabinets (BSC) * Applied Mathematics covers the mathematical skills needed to perform common bioscience workplace calculations and data analysis. It includes scientific notations, significant digits, metric conversions, making dilutions, calculating weight and volume measurements for buffer and media prep, graphing data, and performing statistical analyses. These skills are crucial for designing experiments, preparing reagents and solutions, and interpreting results.   + Use scientific notation correctly   + Use significant digits correctly   + Understand and use mathematical symbols   + Understand and use fractions   + Use metric measurements and perform metric conversions   + Perform calculations for serial dilutions   + Perform calculations using dilution factors     - Solve Dilution Factor calculations     - Solve Molarity solution calculations     - Solve Volume/Volume (V/V) solution calculations     - Solve Weight/Volume (W/V) solution calculations * Standard equipment focuses on the proper identification, use, and maintenance of standard equipment. It includes understanding the safe operations of micro and macro pipettes, balances, pH meters, centrifuges, and other essential tools. Mastery ensures an aptitude for the accurate and safe handling of equipment, and critical parameters such as calibration, maintenance, and validation.   + Demonstrate proper and safe use of     - Micropipettes & serological pipets     - Microscopes   Mowery, Jeannette, and John Carrese. "Core Skill Standards for Bioscience Technicians." *Bio-Link*, edited by Lisa Huffman, U.S. Department of Labor, 2016, <https://innovatebio.org/publication/core-skill-standards-for-bioscience-technicians>   * 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 | | |

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| **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 (2.B.1) as they construct a model that explains how the process of electrophoresis technology separates molecules. * Students manage projects (10.A.2) as they apply the process of gel electrophoresis and scientific inquiry to generate evidence to solve a problem. * Students make judgments and decisions (2.C.1, 2.C.4) as they 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 (9.A.1, 9.A.2) when they model the fragments that would be produced by specific restriction enzymes on a molecule of DNA. * Students reason effectively (2.A.1) when they analyze a DNA fingerprint to construct a claim supported by evidence and reasoning. * In a team, students solve a problem (2.D.2) as they use the process of PCR, gel electrophoresis, and scientific inquiry to generate evidence. * In a team, students are responsible to others (11.B.1) as they use a model to develop and communicate an explanation of the process and applications of Polymerase Chain Reaction (PCR). * Students apply technology (6.A.1, 6.A.3) 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)  **Oregon Health Science Career Cluster - Biotechnology Knowledge and Skill Statements with Suggested Performance Indicators**  FA-BIOT05 (CCTC Standard HL-BRD 2.4): Use standard operating procedure (SOP) when performing systematic and methodical application of general and organic chemistry principles.   * Contrast covalent, ionic, and hydrogen bonding. * Structure (including bonding) and function of DNA and the process of DNA replication.   FA-BIOT07 (CCTC Standard HL-BRD 2.6) Recognize basic concepts in cell biology and become familiar with the laboratory tools used for their analysis   * Describe the basic structures and functions of cells and how this knowledge is used in biotechnology. * Describe conditions that promote cell growth under aseptic conditions in the laboratory and workplace * Use various methods to monitor the growth of cell cultures. * Explain the basic concepts of cell growth and reproduction, DNA replication, mitosis, meiosis, and protein synthesis. * Amplify DNA fragments using the PCR process. * Use restriction enzymes to conduct a DNA Fingerprint.   FA-BIOT08 (CCTC Standard HL-BRD 2.7) Understand the fundamental principles of molecular cell biology   * Construct an explanation of the central dogma of molecular biology and how understanding this process impacts biotechnology research and development. * Define and describe the structure and function of DNA ribonucleic acid (RNA) and proteins, and explain the consequences of DNA mutations on proteins * Use standard techniques of DNA extraction, purification, restriction digests, bacterial cell culture, and agarose gel electrophoresis and document and evaluate results. * Demonstrate and document and evaluate results of standard protein techniques, including antibody production, enzyme assays, spectrophotometry, gel electrophoresis, and chromatography. * Demonstrate DNA replication graphically and its importance to biotechnology product development.   FA-BIOT10 (CCTC Standard HL-BRD 3) Identify techniques, trends, and current areas of research in biotechnology   * Describe and identify uses of the following techniques: recombinant DNA, genetic engineering, monoclonal antibody production, separation, and purification of biotechnology and bioprocessing   **DESE Biotechnology Standards and Skills**  Standard 3: Fundamentals of Biotechnology: Students will apply fundamental biotechnology concepts, explore key techniques and principles, and assess their practical applications and ethical implications  d. Demonstrate the use of scientific methods and techniques, such as PCR, genetic engineering, and cell culture, to solve problems and explain their application in real-world biotechnology contexts.  j. Examine the basics of scientific research, including how to ask research questions, develop hypotheses, and design experiments to test them in context of biotechnology.  Standard 9: Standard Lab Assays and Techniques: Students will demonstrate a variety of standard laboratory assays and techniques, including proper documentation, aseptic techniques, protein purification methods, and techniques for separation, detection, and quantification of proteins.  a. Demonstrate the ability to isolate DNA from a variety of samples, including bacterial, plant, and animal, using appropriate protocols.  i. Conduct DNA fingerprinting for genetic analysis and comparison.  s. Use electrophoresis systems, such as SDS-PAGE for protein separation and agarose gel electrophoresis for nucleic acid (DNA/RNA) separation  v. Culture and isolate bacterial colonies, perform Gram staining and basic biochemical tests, and use DNA analysis methods, e.g., PCR or 165rRNA sequencing, to identify bacterial species.  **BACE - Biotechnology Aptitude and Competency Exam -**  **Knowledge Categories**   * Technical Skills & Applications covers the foundational techniques used in biotechnology workplace settings. It includes understanding and applying methods such as aseptic technique, cell culture, DNA isolation, and various assays. The focus is on both the theoretical principles and the practical application of these techniques, including the use of advanced equipment and procedures such as polymerase chain reaction (PCR), gel electrophoresis, and chromatography.   + Discuss cell staining, and distinguish between gram-positive/negative cell * Discuss methods of chromosomal and plasmid DNA isolation, purification, and quantification. * Discuss gel electrophoresis techniques, including agarose and polyacrylamide gel electrophoresis (PAGE) * Understand how restriction enzymes are used. * Describe the mechanism of PCR, including the theory and practical use of conventional and real-time PCR (qPCR) thermal cyclers. * Biochemistry & Molecular Biology focuses on the molecular and biochemical principles that underpin biotechnology. It includes understanding DNA structure and function, gene expression, protein synthesis, enzyme activity, and cell biology. It also covers processes and techniques related to molecular biology and protein expression, such as monoclonal antibody production, immunotherapy, and the role of mRNA in therapeutics.   + Understand the chemistry of molecules and macromolecules.   + Describe DNA structure and function   + Understand the general physiology of cells   **Practical Categories**   * Biotechnology Skills centers on technical skills essential for quality work. It includes accurately measuring liquids and solids, preparing solutions, performing serial dilutions, and using standard equipment such as centrifuges, spectrophotometers, and biosafety cabinets. The focus is on mastering these practical skills to ensure precise and reliable outcomes. * Describe the proper use of electrophoresis equipment. * Standard equipment focuses on the proper identification, use, and maintenance of standard equipment. It includes understanding the safe operations of micro and macro pipettes, balances, pH meters, centrifuges, and other essential tools. Mastery ensures an aptitude for the accurate and safe handling of equipment, and critical parameters such as calibration, maintenance, and validation.   + Demonstrate proper and safe use of electrophoresis equipment * 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://innovatebio.org/publication/core-skill-standards-for-bioscience-technicians>   * 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 | | |

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| **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 [10.b.1 (a-h)] 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 (11.A.1, 11.A.2) 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 (2.D.1) using mathematical reasoning to determine the efficiency of transformation. * Students think creatively (1.A.1, 1.A.2) implement innovations (1.C.1) and be self-directed learners (8.C.1, 8.C.2) as they redesign their transformation experiments to increase transformation efficiency. * Carry out a bacteria transformation experiment and communicate clearly (3.A.1) as they 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)  **Oregon Health Science Career Cluster - Biotechnology Knowledge and Skill Statements with Suggested Performance Indicators**  FA-BIOT09 (CCTC Standard HL-BRD 2.8) Describe the morphology and process of reproduction of microorganisms important to clinical disease and biotechnology applications.   * Compare and contrast use of plasmids in bacterial transformations and the process of plasmid DNA isolation and production decisions. * 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.   FA-BIOT10 (CCTC Standard HL-BRD.3) Identify techniques, trends, and current areas of research in biotechnology.   * Describe and identify uses of the following techniques, recombinant DNA, genetic engineering, monoclonal antibody production, separation, and purification of biotechnology products and bioprocessing. * 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)   **DESE Biotechnology Standards and Skills**  Standard 3: Fundamentals of Biotechnology: Students will apply fundamental biotechnology concepts, explore key techniques and principles, and assess their practical applications and ethical implications.  d. Demonstrate the use of scientific methods and techniques, such as PCR, genetic engineering, and cell culture, to solve problems and explain their application in real-world biotechnology contexts.  Standard 9: Standard Lab Assays and Techniques: Students will demonstrate a variety of standard laboratory assays and techniques, including proper documentation, aseptic techniques, protein purification methods, and techniques for the separation, detection, and quantification of proteins.  e. Demonstrate the ability to isolate DNA from a variety of samples, including bacterial, plant and animal, using appropriate protocols.  v. Culture and isolate bacterial colonies, perform Gram staining and basic biochemical tests, and use DNA analysis methods, e.g., PCR or 16S rRNA sequencing, to identify bacterial species  w. Perform bacterial transformation with plasmids and explain transformation with plasmids and explain transformation protocols for plant and mammalian cells, including key differences between prokaryotic and eukaryotic transformation methods.  **BACE - Biotechnology Aptitude and Competency Exam -**  **Knowledge Categories**   * Technical Skills & Applications covers the foundational techniques used in biotechnology workplace settings. It includes understanding and applying methods such as aseptic technique, cell culture, DNA isolation, and various assays. The focus is on both the theoretical principles and the practical application of these techniques, including the use of advanced equipment and procedures such as polymerase chain reaction (PCR), gel electrophoresis, and chromatography. * Discuss methods of chromosomal and plasmid DNA isolation, purification, and quantification * Understand how restriction enzymes are used * Describe recombinant DNA and cloning techniques * Discuss transformation and transfection of model organisms * Biochemistry & Molecular Biology focuses on the molecular and biochemical principles that underpin biotechnology. It includes understanding DNA structure and function, gene expression, protein synthesis, enzyme activity, and cell biology. It also covers processes and techniques related to molecular biology and protein expression, such as monoclonal antibody production, immunotherapy, and the role of mRNA in therapeutics.   + Describe transcription   + Describe translation and gene expression   + Understand the genetics of model organisms   **Practical Categories**   * Applied Mathematics covers the mathematical skills needed to perform common bioscience workplace calculations and data analysis. It includes scientific notations, significant digits, metric conversions, making dilutions, calculating weight and volume measurements for buffer and media prep, graphing data, and performing statistical analyses. These skills are crucial for designing experiments, preparing reagents and solutions, and interpreting results   + Apply basic statistical techniques such as mean, median, mode, and standard deviation to analyze data. * Experimental Design & Data Analysis   + Discuss good experimental design, including the proper use of controls.   + Analyze and interpret data, including the use of statistical analysis. | | | | |
| **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-SHSESS 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. | | |

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| **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 ((9.B.1, 9.B.2) 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 (2.A.1) and access and evaluate information (4.A.1, 4.A.2) 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 (1.A.1, 1.A.2, 1.A.3) with others to create a model that will communicate the role of antigens and antibodies in the human immune systems. * Working independently,(8.B.1) students create media products (5.B.1) 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)  **Oregon Health Science Career Cluster - Biotechnology Knowledge and Skill Statements with Suggested Performance Indicators**  FA-BIOT01 (CCTC Standard HL-BRD.1) Summarize the goals of biotechnology research and development within legal and ethical protocols.   * Propose a biological or industrial enzyme that could be used for treating disease and contribute to the quality of life.   FA-BIOT02 (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   FA-BIOT03: Use statistical data when conducting biotechnology research and development.   * Graphically illustrate a set of biotechnology data so that a layperson would understand it.   FA-BIOT07 (CCTC Standard HL-BRD 2.6): Recognize basic concepts in cell biology and become familiar with the laboratory tools used for analysis.   * Describe the basic structures and functions of cells and how this knowledge is used in biotechnology. * Describe the conditions that promote cell growth under aseptic conditions in the laboratory and workplace. * Use various methods to monitor the growth of cells. * 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.   FA-BIOT09 Describe the morphology and process of reproduction of microorganisms important in clinical disease and biotechnology applications.   * Explain microbial taxonomy and classification systems and use them to identify microbial organisms. * Describe the structure of viruses and differentiate between types.   FA-BIOT10 (CCTC Standard HL-BRD 3.1) (CCTC Standard HL-BRD 3.2): Identify techniques, trends, and current areas of research in biotechnology.   * Predict how artificial intelligence, nanotechnology, bioinformatics, proteomics, genomics, and transcriptomics will create new career opportunities and impact healthcare environments. * 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)   **DESE Biotechnology Standards and Skills**  Standard 9: Standard Lab Assays and Techniques: Students will demonstrate a variety of standard laboratory assays and techniques, including proper documentation, aseptic techniques, protein purification methods, and techniques for the separation, detection, and quantification of proteins.  g. Conduct enzyme-linked immunosorbent assays (ELISA) to detect and quantify proteins or antibodies.  Standard 10: Clinical Laboratory Techniques: Students will acquire foundational clinical laboratory skills essential for biotechnology, including aseptic techniques, cell culture, and media preparation, while understanding their application in the development of biotechnological products such as biopharmaceuticals and vaccines.  k. Understand and explain the basics of mRNA technology, including how mRNA vaccines work and the role of mRNA in treating diseases.  l. Understand the general steps in vaccine production, including the use of cell cultures or bacterial systems to produce antigens for vaccine development.  **BACE - Biotechnology Aptitude and Competency Exam -**  **Knowledge Categories**   * Technical Skills & Applications covers the foundational techniques used in biotechnology workplace settings. It includes understanding and applying methods such as aseptic technique, cell culture, DNA isolation, and various assays. The focus is on both the theoretical principles and the practical application of these techniques, including the use of advanced equipment and procedures such as polymerase chain reaction (PCR), gel electrophoresis, and chromatography. * Understand the principles of enzyme-linked immunosorbent assay (ELISA) and other immunoassays. * Biochemistry & Molecular Biology focuses on the molecular and biochemical principles that underpin biotechnology. It includes understanding DNA structure and function, gene expression, protein synthesis, enzyme activity, and cell biology. It also covers processes and techniques related to molecular biology and protein expression, such as monoclonal antibody production, immunotherapy, and the role of mRNA in therapeutics. * Explain how enzymes function and affect reaction rates * Discuss monoclonal antibody (mAb) production and applications * Understand the role of mRNA in cellular function and therapeutics * Discuss immunotherapy types and applications, such as chimeric antigen receptor T-cell (CAR-T) and mAb   **Practical Categories**   * Applied Mathematics covers the mathematical skills needed to perform common bioscience workplace calculations and data analysis. It includes scientific notations, significant digits, metric conversions, making dilutions, calculating weight and volume measurements for buffer and media prep, graphing data, and performing statistical analyses. These skills are crucial for designing experiments, preparing reagents and solutions, and interpreting results   + Generate a graph using collected data     - Properly plot data     - Interpret data     - Generate a standard curve   Mowery, Jeannette, and John Carrese. "Core Skill Standards for Bioscience Technicians." *Bio-Link*, edited by Lisa Huffman, U.S. Department of Labor, 2016, <https://innovatebio.org/publication/core-skill-standards-for-bioscience-technicians>   * 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 | | |

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| **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 (2.C.1, 2.C.2, 2.C.4) and communicate clearly (3.A.1, 3.A.2, 3.A.3) 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 (2.B.1) as they use a sample product to model the process of design to production, including the ethical constraints and limitations. * Students create media products (5.B.1) 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 in diverse teams (9.B.1, 9.B.2, 9.B.3) 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)  **Oregon Health Science Career Cluster - Biotechnology Knowledge and Skill Statements with Suggested Performance Indicators**  FA-BIOT01 (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. * Assess legal and ethical considerations associated with using biotechnology. (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.   FA-BIOT12 (CCTC Standard HL-BRD.5) Understand the biotechnology product development processes and regulations that affect those processes. Determine processes for product design and production and how that work contributes to an understanding of the biotechnology product development process.   * Analyze the role of pre-clinical and clinical trials in biotechnology product development. (CCTC Standard HL-BRD.5.12) * Identify the components of human clinical trials and how they relate to ethics * 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. * Examine the role of a quality assurance person in the process * Describe the role of agencies in promoting patient safety, quality control, and entrepreneurship * Define current good manufacturing practices (CGMP) and why they are important in biotechnology production. * Diagram the process involved in making one biotechnology product in an industrial setting.   FA-BIOT13 (CCTC Standard HL-BRD.6) Understand the ethical, moral, legal and cultural issues related to the use of biotechnology research and product development.   * Differentiate between morality and ethics and the relationship of each to biotechnology health care product development * Articulate issues of ethical concern, including plagiarism, copyrights, trademarks, and patents and use online data resources and searchable databases to investigate a copyright, trademark or patent. * Understand the critical need for ethical policies and procedures for institutions engaged in biotechnology research and development.   **DESE Biotechnology Standards and Skills**  Standard 3: Fundamentals of Biotechnology: Students will apply fundamental biotechnology concepts, explore key techniques and principles, and assess their practical applications and ethical implications.  g. Explain the processes and criteria for evaluating the efficacy of biotechnology products.  h. Examine the social, legal, and ethical challenges that impact the use and development of biotechnological applications.  i. Evaluate the broader ethical concerns, such as patient consent and data privacy in the clinical setting.  **BACE - Biotechnology Aptitude and Competency Exam -**  **Knowledge Categories**   * Regulation & Quality involves understanding the regulatory environment and quality practices association with the development, manufacture, and testing of biotechnology-based products and processes. It covers the roles of current Good Laboratory Practices (CGLP), current Good Manufacturing Practices (CGMP), Good Documentation Practices (GDocP), and regulatory agencies such as the Food and Drug Administration (FDA). It also includes knowledge of the processes involved in product development, regulatory approval, departmental roles, and maintaining data integrity and security.   **Bioscience Competency Model**   * **Tier 4 Industry-Wide Technical Competencies** * 4.1 Bioscience Fundamentals: The bioscience industry and its interactions with society   + - Critical Work Functions   4.1.3 Explain legal and ethical issues affecting the application of bioscience.   * + - Technical Content Areas   4.1.9 Legal Issues and Ethics  4.1.9.1 Intellectual Property  4.1.9.2 Documentation  4.1.9.3 Patents  4.1.9.4 Confidentiality  4.1.9.5 Genetic ethics  4.1.9.6 Scientific Accountability   * + 4.2 Research & Development - Investments toward the creation or discovery of new bioscience processes, methods, products and services.     - Critical Work Functions   4.2.1 Set up and conduct tests/assays: chemical, biological, clinical, environmental, robotic, or mechanical  4.2.2 Evaluate, document, and report results of experiments and tests  4.2.3 Prepare documents including experimental protocols, technical reports, and numerical analyses  4.2.4 Understand the role of pre-clinical and clinical trials in bioscience product development  4.2.5 Isolate, identify, and prepare specimens for examination  4.2.6 Clean, sterilize, troubleshoot, calibrate, operate, and maintain lab instruments and equipment  4.2.7 Participate in care, use, and inventory of research plants and animals  4.2.8 Understand and utilize good control and inventory standards. | | | | |
| **Aligned Washington State Academic Standards** | | | | |
| **Science** | HS-SHSESS 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 | | |