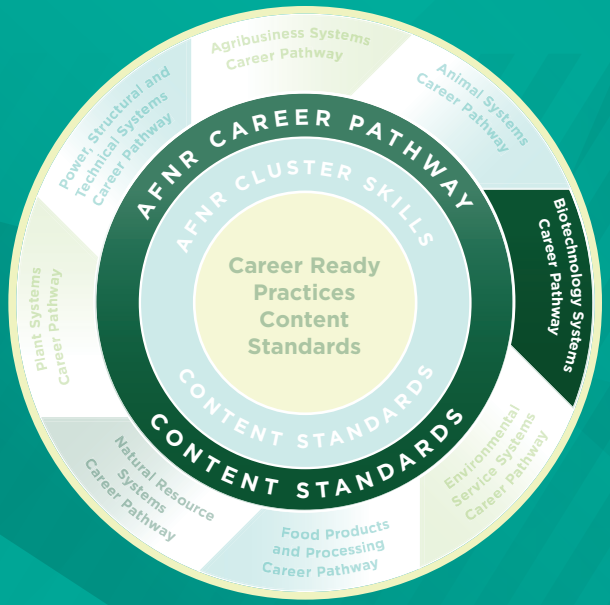



# BIOTECHNOLOGY SYSTEMS CAREER PATHWAY

# Agriculture, Food and Natural Resources Content Standards

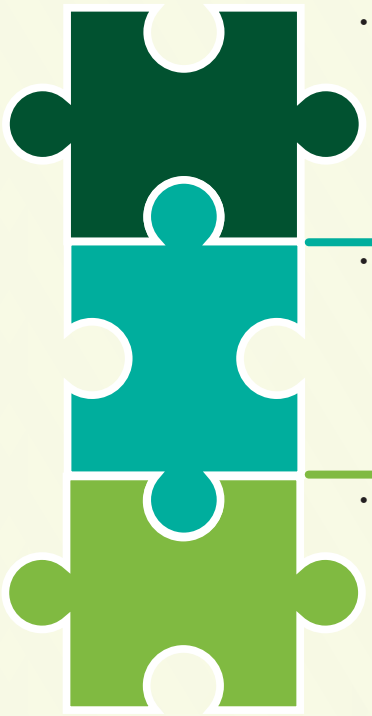
## Biotechnology Systems Career Pathway Content Standards

**PURPOSE:** The career pathway content standards outline technical knowledge and skills required for future success within this discipline. The content standards are intended to provide state agricultural education leaders and educators with a forward-thinking guide for what students should know and be able to do after completing a program of study in this career pathway. State leaders and local educators are encouraged to use the standards as a basis for the development of well-planned curriculum and assessments for Agriculture, Food and Natural Resource (AFNR)-related Career and Technical Education (CTE) programs. Adoption and use of these standards is voluntary; states and local entities are encouraged to adapt the standards to meet local needs.

**SCOPE:** The Biotechnology Systems (BS) Career Pathway encompasses the study of using data and scientific techniques to solve problems concerning living organisms with an emphasis on applications to agriculture, food and natural resource systems. Students completing a program of study in this pathway will demonstrate competence in the application of principles and techniques for the development, application and management of biotechnology in the context of AFNR.

**SAMPLE CAREERS:** Geneticist, Microbiologist, Biochemist, Lab Technician, Animal Scientist, Plant Scientist, Food Scientist

**DEFINITIONS:** Within each pathway, the standards are organized as follows:



- **National Council for Agricultural Education (NCAE) Standard*** – These are the standards set forth by the National Council for Agricultural Education for Biotechnology Systems. They define what students should know and be able to do after completing instruction in a program of study focused on applying biotechnology to AFNR systems.
- **Performance Indicators** – These statements distill each performance element into more discrete indicators of the knowledge and skills students should attain through a program of study in this pathway. Attainment of the knowledge and skills outlined in the performance indicators is intended to demonstrate an acceptable level of proficiency with the related performance element at the conclusion of a program of study in this area.
- **Sample Measurements** – The statements are ***sample*** measureable activities that students might carry out to indicate attainment of each performance indicator at three levels of proficiency – awareness (a), intermediate (b), and advanced (c). This is not intended to be an all-encompassing list; the sample measurements are provided as examples to demonstrate a logical progression of knowledge and skill development pertaining to one or more content areas related to the performance indicator. State and local entities may determine the most appropriate timing for attainment of each level of proficiency based upon local CTE program structures.

**NOTE:** * State leaders and local educators are encouraged to also refer to the standards set forth for Health Sciences: Biotechnology Research and Development (HL-BRD) from the 2012 version of the Common Career and Technical Core Standards, by the National Association of State Directors of Career and Technical Education/National career Technical Education Foundation. The NCAE Standards provide guidance for development of a contextualized program of study for the HL-BRD career pathway, but do not cover all of the content areas outlined in the CCTC standards for HL-BRD. The following table provides guidance for individuals interested in using the NCAE Standards to develop a HL-BRD pathway contextualized to AFNR.

# Agriculture, Food and Natural Resources Content Standards

## Biotechnology Systems Career Pathway Content Standards

| Relationship Between NCAE Standards for Biotechnology Systems and CCTC Standards for Health Sciences: Biotechnology Research and Development |
|---|
| **NCAE Standard – BS.01:** Assess factors that have influenced the evolution of biotechnology in agriculture (e.g., historical events, societal trends, ethical and legal implications, etc.).<br>• *Provides contextualized content standards related to:*<br>o **CCTC Standard – HL-BRD.1:** Summarize the goals of biotechnology research and development within legal and ethical protocols.<br>o **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. |
| **NCAE Standard – BS.02:** Demonstrate proficiency by safely applying appropriate laboratory skills to complete tasks in a biotechnology research and development environment (e.g., standard operating procedures, record keeping, aseptic technique, equipment maintenance, etc.).<br>• *Provides contextualized content standards related to:*<br>o **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.<br>o **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. |
| **NCAE Standard – BS.03:** Demonstrate the application of biotechnology to solve problems in Agriculture, Food and Natural Resources (AFNR) systems (e.g., bioengineering, food processing, waste management, etc.).<br>• *Provides contextualized content standards related to:*<br>o **CCTC Standard – HL-BRD.2:** Apply the fundamentals of biochemistry, cell biology, genetics, mathematical concepts, microbiology, molecular biology, organic chemistry and statistics to conduct effective biotechnology research and development of products.<br>o **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. |

**CONNECTIONS TO OTHER PATHWAYS:**
For additional content standards on the topic of media related to plant growth, see Plant Systems PS.01.
For additional content standards on the topic of genetics, see Animal Systems AS.04.
For additional content standards on the topic of microorganisms, see Environmental Service Systems ESS.03.

## BS.01. NCAE Standard: Assess factors that have influenced the evolution of biotechnology in agriculture (e.g., historical events, societal trends, ethical and legal implications, etc.).

### BS.01.01. Investigate and explain the relationship between past, current and emerging applications of biotechnology in agriculture (e.g., major innovators, historical developments, potential applications of biotechnology, etc.).

Sample Measurement: The following sample measurement strands are provided to guide the development of measurable activities (at different levels of proficiency) to assess students' attainment of knowledge and skills related to the above performance indicator. The topics represented by each strand are not all-encompassing.

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| **BS.01.01.01.a.** Research and summarize the evolution of biotechnology in agriculture. | **BS.01.01.01.b.** Analyze the developmental progression of biotechnology and the evolution of scientific knowledge. | **BS.01.01.01.c.** Evaluate and explain how scientists use the scientific method to build upon previous findings in current and emerging research. |
| **BS.01.01.02.a.** Examine and categorize current applications and gains achieved in applying biotechnology to agriculture. | **BS.01.01.02.b.** Assess and summarize current work in biotechnology being done to add value to agricultural and society. | **BS.01.01.02.c.** Evaluate the outcomes and impacts of biotechnology on the globalization of agriculture. |
| **BS.01.01.03.a.** Distinguish between current and emerging applications of biotechnology in agriculture. | **BS.01.01.03.b.** Analyze and document emerging problems and issues associated with agricultural biotechnology. | **BS.01.01.03.c.** Design a potential application of biotechnology to meet emerging agricultural and societal needs. |
| **BS.01.01.04.a.** Compare and contrast the benefits and risks of biotechnology compared with alternative approaches to improving agriculture. | **BS.01.01.04.b.** Assess the benefits and risks associated with using biotechnology to improve agriculture. | **BS.01.01.04.c.** Evaluate the short-term and long-term benefits and risks of applying biotechnology to agriculture. |

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

Sample Measurement: The following sample measurement strands are provided to guide the development of measurable activities (at different levels of proficiency) to assess students' attainment of knowledge and skills related to the above performance indicator. The topics represented by each strand are not all-encompassing.

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| **BS.01.02.01.a.** Compare and contrast differences between regulatory systems worldwide. | **BS.01.02.01.b.** Assess and summarize the role and scope of agencies that regulate biotechnology. | **BS.01.02.01.c.** Explain and critique a decision made by a major agency that regulates agricultural biotechnology. |

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| **BS.01.02.02.a.** Research and document major regulatory issues related to biotechnology in agriculture. | **BS.01.02.02.b.** Analyze the impact major regulatory issues have on public acceptance of biotechnology in agriculture. | **BS.01.02.02.c.** Critique and propose a solution for a major regulatory issue pertaining to biotechnology in agriculture. |
| **BS.01.02.03.a.** Explain the relationship between regulatory agencies and the protection of public interests such as health, safety and the environment. | **BS.01.02.03.b.** Research and summarize factors and data that regulatory agencies use to evaluate the potential risks a new application of biotechnology may pose to health, safety and the environment. | **BS.01.02.03.c.** Evaluate data to determine if new technologies present a major regulatory issue to health, safety and/or the environment. |
|  **BS.01.03. Analyze the relationship and implications of bioethics, laws and public perceptions on applications of biotechnology in agriculture (e.g., ethical, legal, social, cultural issues).** | | |
|  Sample Measurement: The following sample measurement strands are provided to guide the development of measurable activities (at different levels of proficiency) to assess students' attainment of knowledge and skills related to the above performance indicator. The topics represented by each strand are not all-encompassing. | | |
| **BS.01.03.01.a.** Research and summarize the emergence, evolution and implications of bioethics associated with biotechnology in agriculture. | **BS.01.03.01.b.** Analyze the implications bioethics may have on future advancements in AFNR. | **BS.01.03.01.c.** Devise and support an argument for or against an ethical issue associated with biotechnology in agriculture. |
| **BS.01.03.02.a.** Research and summarize legal issues related to biotechnology in agriculture (e.g., protection of intellectual property through patents, copyright, trademarks, etc.). | **BS.01.03.02.b.** Determine the significance and impacts of legal issues related to biotechnology in agriculture. | **BS.01.03.02.c.** Propose a solution for a legal issue associated with biotechnology in agriculture. |
| **BS.01.03.03.a.** Research and summarize public perceptions of biotechnology in agriculture (e.g., social and cultural issues). | **BS.01.03.03.b.** Analyze the impact of public perceptions on the application of biotechnology in different AFNR systems. | **BS.01.03.03.c.** Design studies to examine public perceptions of scientifically-based arguments regarding biotechnology in agriculture and reflect on the reasons why the public may support or resist significant breakthroughs using biotechnology. |
|  **BS.02. NCAE Standard: Demonstrate proficiency by safely applying appropriate laboratory skills to complete tasks in a biotechnology research and development environment (e.g., standard operating procedures, record keeping, aseptic technique, equipment maintenance, etc.).** | | |
|  **BS.02.01. Read, document, evaluate and secure accurate laboratory records of experimental protocols, observations and results.** | | |

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| Sample Measurement: The following sample measurement strands are provided to guide the development of measurable activities (at different levels of proficiency) to assess students' attainment of knowledge and skills related to the above performance indicator. The topics represented by each strand are not all-encompassing. | | |
| **BS.02.01.01.a.** Compare and contrast common record-keeping methods used in a laboratory (e.g., paper notebook, electronic notebook, etc.). | **BS.02.01.01.b.** Maintain and interpret laboratory records documented in a laboratory to ensure data accuracy and integrity (e.g., avoid bias, record any conflicts of interest, avoid misinterpreted results, etc.). | **BS.02.01.01.c.** Evaluate the strengths and weaknesses of using research documentation and propose improvements to ensure study reproduction and utility in future studies. |
| **BS.02.01.02.a.** Research and summarize the need for data and information security in a laboratory and demonstrate best practices. | **BS.02.01.02.b.** Assess when security procedures for data and information collected in a laboratory should be implemented. | **BS.02.01.02.c.** Devise a strategy for ensuring the security of data and information collected in a laboratory. |
| **BS.02.01.03.a.** Evaluate the role of bioinformatics in agriculture and summarize the types of databases that are available (e.g., genomic, transcriptomics, etc.). | **BS.02.01.03.b.** Analyze and document the security procedures for data collected using bioinformatics. | **BS.02.01.03.c.** Critique an application of bioinformatics to solve an agricultural issue and recommend procedures for keeping the information safe. |
| **BS.02.02. Implement standard operating procedures for the proper maintenance, use and sterilization of equipment in a laboratory.** | | |
| Sample Measurement: The following sample measurement strands are provided to guide the development of measurable activities (at different levels of proficiency) to assess students' attainment of knowledge and skills related to the above performance indicator. The topics represented by each strand are not all-encompassing. | | |
| **BS.02.02.01.a.** Identify, interpret, and implement standard operating procedures for laboratory equipment. | **BS.02.02.01.b.** Develop a maintenance program for laboratory equipment based upon the standard operating procedures. | **BS.02.02.01.c.** Perform ongoing maintenance of laboratory equipment according to the standard operating procedures (e.g., calibration, testing, etc.). |
| **BS.02.02.02.a.** Categorize and identify laboratory equipment according to its purpose in scientific research. | **BS.02.02.02.b.** Manipulate basic laboratory equipment and measurement devices (e.g., water bath, electrophoresis equipment, micropipettes, laminar flow hood, etc.). | **BS.02.02.02.c.** Operate advanced laboratory equipment and measurement devices (e.g., thermal cycler, imaging system, etc.). |
| **BS.02.02.03.a.** Differentiate between sterilization techniques for equipment in a laboratory (e.g., media bottles vs. laminar flow hood, etc.). | **BS.02.02.03.b.** Create a plan for sterilizing equipment in a laboratory according to standard operating procedures. | **BS.02.02.03.c.** Perform sterilization techniques for equipment in a laboratory using standard operating procedures. |

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

Sample Measurement: The following sample measurement strands are provided to guide the development of measurable activities (at different levels of proficiency) to assess students' attainment of knowledge and skills related to the above performance indicator. The topics represented by each strand are not all-encompassing.

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| **BS.02.03.01.a.** Classify and document basic aseptic techniques in the laboratory. | **BS.02.03.01.b.** Demonstrate advanced aseptic techniques in the laboratory (e.g., sterile work area, sterile handling, personal hygiene, etc.). | **BS.02.03.01.c.** Conduct assays and experiments under aseptic conditions. |
| **BS.02.03.02.a.** Examine and implement standard operating procedures for the use of biological materials according to directions and their classification (e.g., proper handling of bacteria or DNA before, during and after use). | **BS.02.03.02.b.** Analyze and select an appropriate standard operating procedure for working with biological materials based upon their classification. | **BS.02.03.02.c.** Create a standard operating procedure for a biological process. |
| **BS.02.03.03.a.** Categorize and label the types of solutions that are commonly prepared in a laboratory (e.g., buffers, reagents, media, etc.). | **BS.02.03.03.b.** Formulate and prepare solutions using standard operating procedures (e.g., proper labeling, storage, etc.). | **BS.02.03.03.c.** Verify the physical properties of solutions (e.g., molarity, percent mass/volume, dilutions, etc.). |

## BS.02.04. Safely manage and dispose of biological materials, chemicals and wastes according to standard operating procedures.

Sample Measurement: The following sample measurement strands are provided to guide the development of measurable activities (at different levels of proficiency) to assess students' attainment of knowledge and skills related to the above performance indicator. The topics represented by each strand are not all-encompassing.

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| **BS.02.04.01.a.** Classify different types of personal protective equipment and demonstrate how to properly utilize the equipment. | **BS.02.04.01.b.** Assess the need for personal protective equipment in a variety of situations and select the appropriate equipment to wear when working with biological and chemical materials. | **BS.02.04.01.c.** Evaluate the benefits and limitations of personal protective equipment. |
| **BS.02.04.02.a.** Classify and describe hazards associated with biological and chemical materials. | **BS.02.04.02.b.** Inventory biological and chemical materials and maintain accurate records of supplies and expiration dates. | **BS.02.04.02.c.** Create a plan for stocking and maintaining supplies of biological and chemical materials in a laboratory. |
| **BS.02.04.03.a.** Summarize what happens to waste after it leaves the laboratory and identify opportunities to reduce waste and unnecessary costs. | **BS.02.04.03.b.** Perform waste disposal according to the standard operating procedures. | **BS.02.04.03.c.** Propose a management plan to reduce laboratory waste and prevent ecological or health problems related to waste disposal. |

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

Sample Measurement: The following sample measurement strands are provided to guide the development of measurable activities (at different levels of proficiency) to assess students' attainment of knowledge and skills related to the above performance indicator. The topics represented by each strand are not all-encompassing.

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| **BS.02.05.01.a.** Differentiate types of organisms and demonstrate safe handling to maintain organism purity and personal safety (e.g., plant and animal tissue, cell cultures, microbes, etc.). | **BS.02.05.01.b.** Characterize the physical and biological properties of organisms. | **BS.02.05.01.c.** Isolate, maintain, quantify and store cell cultures according to standard operating procedures. |
| **BS.02.05.02.a.** Compare and contrast the structures of DNA and RNA and investigate how genotype influences phenotype. | **BS.02.05.02.b.** Analyze and interpret the molecular basis for heredity and the tools and techniques used in DNA and RNA manipulations. | **BS.02.05.02.c.** Evaluate factors that influence gene expression. |
| **BS.02.05.03.a**. Extract and purify DNA and RNA according to standard operating procedures. | **BS.02.05.03.b.** Perform electrophoretic techniques and interpret electrophoresis fragmentation patterns (e.g., gel electrophoresis, southern blotting, etc.). | **BS.02.05.03.c.** Manipulate and analyze DNA and RNA through advanced scientific procedures (e.g., southern blotting, cloning, PCR, RT-PCR, etc.). |
| **BS.02.05.04.a.** Examine and document the role and applications of proteins in agricultural biotechnology. | **BS.02.05.04.b.** Demonstrate protein separation techniques and interpret the results. | **BS.02.05.04.c.** Evaluate the biochemical properties of proteins to explain their function and predict potential uses. |
| **BS.02.05.05.a.** Synthesize the relationship between proteins, enzymes and antibodies. | **BS.02.05.05.b.** Analyze and document how antibodies are formed and describe how they can be used in agricultural biotechnology. | **BS.02.05.05.c.** Use antibodies to detect and quantify antigens by conducting an Enzyme-Linked Immunosorbent Assay (ELISA). |

# BS.03. NCAE Standard: Demonstrate the application of biotechnology to solve problems in Agriculture, Food and Natural Resources (AFNR) systems (e.g., bioengineering, food processing, waste management, horticulture, forestry, livestock, crops, etc.).

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

Sample Measurement: The following sample measurement strands are provided to guide the development of measurable activities (at different levels of proficiency) to assess students' attainment of knowledge and skills related to the above performance indicator. The topics represented by each strand are not all-encompassing.

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| **BS.03.01.01.a.** Summarize biological, social, agronomic and economic reasons for genetic modification of eukaryotes. | **BS.03.01.01.b.** Analyze and document the processes and describe the techniques used to produce transgenic eukaryotes (e.g., microbial synthetic biology, gene knockout therapy, traditional gene insertion, etc.). | **BS.03.01.01.c.** Design and conduct experiments to evaluate an existing transgenic eukaryote. |
| **BS.03.01.02.a.** Summarize the process of transformation of eukaryotic cells with transgenic DNA. | **BS.03.01.02.b.** Assess and argue the pros and cons of transgenic species in agriculture. | **BS.03.01.02.c.** Transform plant or animal cells by performing a cellular transformation. |
| **BS.03.01.03.a.** Analyze the benefits and risks associated with the use of biotechnology to increase productivity and improve quality of living species (e.g., plants, animals such as aquatic species, etc.). | **BS.03.01.03.b.** Research and evaluate genetic engineering procedures used in the production of living species. | **BS.03.01.03.c.** Conduct field or clinical trials for genetically modified species. |
| **BS.03.01.04.a.** Define and summarize epigenetics and synthesize the relationship between mutation, migration and evolution of transgenes in the environment. | **BS.03.01.04.b.** Analyze data to identify changes and patterns of transgenic species in the environment. | **BS.03.01.04.c.** Conduct studies to track the movement of transgenes in the environment. |
| **BS.03.02. Apply biotechnology principles, techniques and processes to enhance the production of food through the use of microorganisms and enzymes.** | | |
| Sample Measurement: The following sample measurement strands are provided to guide the development of measurable activities (at different levels of proficiency) to assess students' attainment of knowledge and skills related to the above performance indicator. The topics represented by each strand are not all-encompassing. | | |
| **BS.03.02.01.a**. Summarize reasons for detecting microbes and identify sources of microbes. | **BS.02.02.01.b.** Assess and describe the use of biotechnology to detect microbes. | **BS.02.02.01.c.** Design and perform an assay to detect a target microorganism in food, water or the environment. |
| **BS.03.02.02.a.** Examine enzymes, the changes they cause and the physical and chemical parameters that affect enzymatic reactions (e.g., food, cellulosic bioenergy, etc.). | **BS.03.02.02.b.** Analyze processes by which enzymes are produced through biotechnology. | **BS.03.02.02.c.** Conduct studies using scientific techniques to improve or discover enzymes for use in biotechnology (e.g., microbial strain selection). |
| **BS.03.02.03.a.** Identify and categorize foods produced through the use of biotechnology (e.g., fermentation, etc.) to change the chemical properties of food for an intended purpose (e.g., create desirable nutritional profile, preservation, flavor, etc.) | **BS.03.02.03.b.** Compare and contrast the effectiveness, purpose, and outcomes associated with biotechnology as well as conventional processes used in food processing. | **BS.03.02.03.c.** Process food using biotechnology to achieve an intended purpose (e.g., preservation, flavor enhancement, etc.). |

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| **BS.03.03. Apply biotechnology principles, techniques and processes to protect the environment and maximize use of natural resources (e.g., biomass, bioprospecting, industrial biotechnology, etc.).** | | |
| Sample Measurement: The following sample measurement strands are provided to guide the development of measurable activities (at different levels of proficiency) to assess students' attainment of knowledge and skills related to the above performance indicator. The topics represented by each strand are not all-encompassing. | | |
| **BS.03.03.01.a.** Examine the consequences of agricultural practices on natural populations. | **BS.03.03.01.b.** Analyze how biotechnology can be used to monitor the effects of agricultural practices on natural populations. | **BS.03.03.01.c.** Evaluate the impact of modified organisms on the natural environment. |
| **BS.03.03.02.a.** Define and summarize industrial biotechnology and categorize the benefits and risks associated with its use in manufacturing (e.g., fabrics, plastics, etc.). | **BS.03.03.02.b.** Apply the processes used in the production of molecules for use in industrial applications. | **BS.03.03.02.c.** Monitor and evaluate processes used in the synthesis of a molecule. |
| **BS.03.03.03.a.** Research and summarize the potential applications of bioprospecting in biotechnology and agriculture. | **BS.03.03.03.b.** Assess and document the pros and cons of bioprospecting to achieve a research or product development objective. | **BS.03.03.03.c.** Propose opportunities to use bioprospecting after weighing the short-term and long-term impacts on the environment. |
| **BS.03.04. Apply biotechnology principles, techniques and processes to enhance plant and animal care and production (e.g., selective breeding, pharmaceuticals, biodiversity, etc.).** | | |
| Sample Measurement: The following sample measurement strands are provided to guide the development of measurable activities (at different levels of proficiency) to assess students' attainment of knowledge and skills related to the above performance indicator. The topics represented by each strand are not all-encompassing. | | |
| **BS.03.04.01.a.** Research and describe the aims and techniques involved in selective plant-breeding process. | **BS.03.04.01.b.** Choose techniques and identify tools used to monitor and direct plant breeding. | **BS.03.04.01.b.** Perform plant-breeding techniques (e.g., plant tissue culture, etc.). |
| **BS.03.04.02.a.** Examine and classify biotechnology processes applicable to animal health (e.g., genetic testing, etc.). | **BS.03.04.02.b.** Assess the benefits, risks and opportunities associated with using biotechnology to promote animal health. | **BS.03.04.02.c.** Design animal-care protocols to ethically monitor and promote animal systems associated with biotechnology. |
| **BS.03.04.03.a.** Research and categorize the types of pharmaceuticals developed for animals and humans through biotechnology. | **BS.03.04.03.b.** Distinguish the difference between plant-based and animal-based pharmaceuticals and describe their role in agriculture. | **BS.03.04.03.c.** Evaluate the process used to produce pharmaceuticals from transgenic organisms (e.g., hormones for animals, etc.). |
| **BS.03.04.04.a.** Summarize the need for global biodiversity and applications of biotechnology to reduce threats to biodiversity. | **BS.03.04.04.b.** Assess whether current threats to biodiversity will have an unsustainable impact on human populations. | **BS.03.04.04.c.** Select and utilize techniques to measure biodiversity in a population. |

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| **BS.03.05. Apply biotechnology principles, techniques and processes to produce biofuels (e.g., fermentation, transesterification, methanogenesis, etc.).** | | |
| Sample Measurement: The following sample measurement strands are provided to guide the development of measurable activities (at different levels of proficiency) to assess students' attainment of knowledge and skills related to the above performance indicator. The topics represented by each strand are not all-encompassing. | | |
| **BS.03.05.01.a.** Examine and synthesize the need for biofuels (e.g., cellulosic bioenergy, etc.). | **BS.03.05.01.b.** Analyze the impact of the production and use of biofuels on the environment. | **BS.03.05.01.c.** Evaluate and support how biofuels could solve a global issue (e.g., environmental, agricultural, etc.). |
| **BS.03.05.02.a.** Differentiate between biomass and sources of biomass. | **BS.03.05.02.b.** Assess the characteristics of biomass that make it useful for biofuels production. | **BS.03.05.02.c.** Conduct a review of the technologies used to create biofuels from biomass and weigh the pros and cons of each method. |
| **BS.03.05.03.a.** Research and explain the process of fermentation and its potential applications. | **BS.03.05.03.b.** Correlate the relationship between fermentation and the process used to produce alcohol from biomass. | **BS.03.05.03.c.** Produce alcohol and co-products from biomass. |
| **BS.03.05.04.a.** Define and summarize the process of transesterification and its potential applications. | **BS.03.05.04.b.** Analyze and document the process used to produce biodiesel from biomass. | **BS.03.05.04.c.** Produce biodiesel and co-products from biomass. |
| **BS.03.05.05.a.** Examine the process of methanogenesis and its potential applications. | **BS.03.05.05.b.** Analyze and describe the process used to produce methane from biomass. | **BS.03.05.05.c.** Produce methane and co-products from biomass. |
| **BS.03.06. Apply biotechnology principles, techniques and processes to improve waste management (e.g., genetically modified organisms, bioremediation, etc.).** | | |
| Sample Measurement: The following sample measurement strands are provided to guide the development of measurable activities (at different levels of proficiency) to assess students' attainment of knowledge and skills related to the above performance indicator. The topics represented by each strand are not all-encompassing. | | |
| **BS.03.06.01.a.** Compare and contrast the use of natural organisms and genetically-engineered organisms in the treatment of wastes. | **BS.03.06.01.b.** Analyze the process by which organisms are genetically engineered for waste treatment. | **BS.03.06.01.c.** Conduct studies to evaluate the treatment of a waste product using a genetically engineered organism. |
| **BS.03.06.02.a.** Summarize the purpose of microorganisms in biological waste management. | **BS.03.06.02.b.** Assess and describe the processes involved in biotreatment of biological wastes. | **BS.03.06.02.c.** Monitor and evaluate the treatment of biological wastes with microorganisms. |

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| **BS.03.06.03.a.** Analyze the role of microorganisms in industrial chemical waste treatment. | **BS.03.06.03.b.** Evaluate and describe the processes involved in biotreatment of industrial chemical wastes. | **BS.03.06.03.c.** Monitor and review the treatment of industrial chemical wastes with microorganisms. |
| **BS.03.06.04.a.** Provide examples of instances in which bioremediation can be applied to clean up environmental contaminants. | **BS.03.06.04.b.** Analyze and summarize the risks and benefits of using biotechnology for bioremediation. | **BS.03.06.04.c.** Design a bioremediation project including plans to evaluate the effectiveness of the effort. |