Biotechnology Foundations in Agricultural and Environmental Science

8085 36 weeks

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Course Description

Suggested Grade Level: 10 or 11 or 12

This course focuses on techniques used to modify plants, animals, and microbes for specific purposes. Student activities include bioprocessing, DNA analysis, bioengineering, and forensic analysis. Students gain insight and understanding about biotechnology as it relates to agricultural and environmental science careers within the Agriculture, Food, and Natural Resources Career Cluster. Participation in FFA activities, leadership development events (LDEs), and career development events (CDEs) is encouraged.

Task Essentials Table

8085	Tasks/Competencies	
⊕	Identify the role of supervised agricultural experiences (SAEs) in agricultural education.	
⊕	Participate in an SAE.	
⊕	Identify the benefits and responsibilities of FFA membership.	
⊕	Describe leadership characteristics and opportunities as they relate to agriculture and FFA.	
○	Apply for an FFA degree and/or an agricultural proficiency award.	
⊕	Define *agricultural biotechnology*.	

⊕	Identify historical, current, and emerging developments and applications of biotechnology in agriculture.	
⊕	Describe how biotechnology is used in other disciplines.	
⊕	Identify careers related to biotechnology.	
⊕	Demonstrate safe laboratory procedures.	
⊕	Employ the scientific method and the technological/engineering method to solve biotechnology problems.	
⊕	Demonstrate standard operating procedures (SOPs) related to the agricultural biotechnology lab.	
⊕	Analyze data generated from lab activities.	
⊕	Explain the roles of sciences applicable to biotechnology.	
⊕	Explain the structure and cellular function of organic macromolecules.	
⊕	Analyze how organic macromolecules are detected and manipulated using biotechnological tools.	
⊕	Explain nucleic acids.	
⊕	Explain proteins.	
⊕	Describe the characteristics and functions of enzymes and the biotechnological processes used to produce enzymes.	
⊕	Model a biochemical pathway that includes enzymes.	
○	Explain antibodies.	
⊕	Use antibodies to detect and quantify antigens.	
⊕	Explain the function of carbohydrates and their role in biotechnology applications.	
⊕	Explain the function of lipids and their role in biotechnology applications.	
⊕	Perform separation and purification of macromolecules.	
⊕	Demonstrate the use of basic instrumentation in DNA analysis.	
⊕	Assess the social effects of environmental quality management.	
○	Investigate the purpose and design of biological treatment systems.	
⊕	Describe a bioremediation and biorestoration system.	
⊕	Investigate procedures used with tissue culture.	

⊕	Identify microbial applications in agriculture and the environment.	
⊕	Summarize the role of biotechnology in plant and/or animal modification.	
⊕	Outline the factors that jeopardize food safety.	
⊕	Examine advances of biotechnology in food science.	
⊕	Define *bioprocessing*.	
⊕	Describe the process of industrial fermentation.	
○	Investigate products generated from bioprocessing.	
⊕	Describe genetic engineering applications used in bioprocessing.	
○	Demonstrate the application of microbes in bioprocessing.	
○	Identify bioprocessing systems.	
⊕	Define *genomics*.	
⊕	Develop a historic timeline of milestones in genomics.	
⊕	Describe the importance of the genetic information contained in DNA.	
⊕	Demonstrate techniques for DNA extraction.	
⊕	Explain how genomics is related to disease prevention.	
⊕	Explain the importance of bioinformatics.	
⊕	Describe the relationship between reproduction and genetic improvement.	
⊕	Describe current technologies for genetic modification of plants, animals, and microbes.	
⊕	Outline the contributions of plant, animal, and microbial biotechnology to medicine.	
○	Describe the ethical, legal, and social effects of biomedicine.	
○	Explain vaccine (immunology) research and development.	
○	Identify emerging healthcare technologies.	
○	Explain the applications of genomics in pharmacology.	
○	Describe the effects of biotechnology on preventive health care.	
⊕	Define *forensic science.*	
⊕	Describe situations in which medical forensics can be used in agriculture.	

⊕	Describe situations in which forensic science can be used in criminal investigations related to agriculture.	
⊕	Describe situations in which biological forensic science can be used.	
⊕	Define *bioengineering*.	
⊕	Identify uses of nanobiotechnology.	
⊕	Describe how bioengineering can affect food security.	
⊕	Propose a bioengineering solution to an agricultural/environmental problem.	
⊕	Define *bioethics*.	
⊕	Analyze the effects of biotechnology in agriculture.	
⊕	Differentiate among ethical principles and legal issues as they relate to biotechnology.	
⊕	Research regulations related to biotechnology in agriculture.	

Legend: ⊕Essential ○Non-essential ⊖Omitted

Note: Competencies 39-43 have been added to ensure compliance with federal legislation: National FFA Organization's Federal Charter Amendments Act (Public Law 116-7, https://www.congress.gov/116/plaws/publ7/PLAW-116publ7.pdf). All inquiries may be sent to cte@doe.virginia.gov. Students are provided opportunities for leadership, personal growth, and career success. Instruction is delivered through three major components: classroom and laboratory instruction, supervised agricultural experience (SAE) program, and student leadership (FFA).

Curriculum Framework

Task Number 39

Identify the role of supervised agricultural experiences (SAEs) in agricultural education.

Definition

Identification should include

- defining an SAE program as *an opportunity for students to consider multiple careers and occupations in the agriculture, food, and natural resources (AFNR) industries, learn expected workplace behavior,*

develop specific skills within an industry, and apply academic and occupational skills in the workplace or a simulated workplace environment

- researching the Foundational SAE
    - career exploration and planning
    - personal financial planning and management
    - workplace safety
    - employability skills for college and career readiness
    - agricultural literacy
- researching the Immersion SAE
    - entrepreneurship/ownership
    - placement/internships
    - research (experimental, analytical, invention)
    - school business enterprises
    - service learning
- developing a plan to participate in an SAE, based on personal and career goals
- researching available awards and degrees, based on SAE participation.

Teacher resource: SAE Resources, National Council for Agricultural Education

Process/Skill Questions

- What are examples of SAEs related to this course and in the AFNR industries?
- Where can a copy of the Virginia SAE Record Book be found?
- What is an Immersion SAE?
- How does a placement/internship SAE differ from an ownership/entrepreneurship SAE?
- How does an SAE provide relevant work experience and contribute to the development of critical thinking skills?
- How is the SAE an extended individualized instructional component of a student's Career Plan of Study?
- How can an SAE be used to provide evidence of student growth and participation in authentic, work-related tasks?
- What are the four types of SAEs?
- What are the advantages of participating in work-based learning experiences and projects?
- How does one choose an appropriate SAE in which to participate?

Task Number 40

Participate in an SAE.

Definition

Participation should include

- developing, completing, or continuing a plan to participate in an SAE as a work-based learning experience, based on personal and career goals
- documenting experience, connections, positions held, and competencies attained, using the *Virginia SAE Record Book*

- researching available awards and degrees, based on SAE participation.

Teacher resources:
FFA SAE
The Agricultural Experience Tracker
Virginia SAE Record Book

Process/Skill Questions

- What are the advantages of participating in work-based learning experiences and projects?
- How do SAEs help prepare students for the workforce?
- What are some examples of SAEs in AFNR?

Demonstrating Leadership Skills

Task Number 41

Identify the benefits and responsibilities of FFA membership.

Definition

Identification should include

- benefits
  - listing opportunities to participate in community improvement projects and career development events (CDEs) and leadership development events (LDEs)
  - exploring leadership development opportunities

- responsibilities
  - researching the responsibilities of FFA officers, committees, and members
  - locating resources that guide participation in FFA activities
  - explaining the FFA Creed, Motto, Salute, and mission statement
  - explaining the meaning of the FFA emblem, colors, and symbols
  - explaining significant events and the history of the organization.

Process/Skill Questions

- How does one become an FFA member?
- What is the FFA's mission and how does it accomplish its mission?
- What are the benefits and responsibilities of FFA membership?
- What five FFA activities are available through the local chapter?
- What are some significant events in FFA history? How have these events shaped membership over time?

- What is the FFA program of activities (POA), and how is it used?

Task Number 42

Describe leadership characteristics and opportunities as they relate to agriculture and FFA.

Definition

Description should include

- examples of successful leaders
- types of leadership
    - autocratic
    - participative
    - laissez-faire
    - servant
    - followership
- positive leadership qualities and traits of successful leaders
- opportunities for participating in leadership activities in FFA
- demonstrating methods for conducting an effective meeting.

Process/Skill Questions

- Who are some successful leaders in the agriculture industry?
- What qualities make a successful leader?
- What are leadership traits?
- What is the difference between positive and negative leadership?

Task Number 43

Apply for an FFA degree and/or an agricultural proficiency award.

Definition

Application should include

- identifying types of FFA degrees
    - Greenhand
    - Chapter
    - State
    - American
- identifying proficiency award areas
    - entrepreneurship
    - placement
    - combined
    - agriscience research

- exploring CDEs and LDEs related to this course
- identifying all SAE criteria to be eligible for the award
- identifying the type of award
- applying for an FFA award.

Teacher resource: FFA Agricultural Proficiency Awards

Process/Skill Questions

- Where are the awards and their application criteria located?
- What are the benefits of winning an FFA award?
- What are the benefits and requirements of an FFA degree?
- What FFA awards are available?
- How does the FFA degree program reward FFA members in all phases of leadership, skills, and occupational development?
- What is the highest degree that can be conferred upon an FFA member at the national level?
- What are the requirements for a Greenhand FFA degree?

Exploring Foundations in Biotechnology

Task Number 44

Define *agricultural biotechnology*.

Definition

Definition should follow the language provided by the U.S. Department of Agriculture (USDA):

Agricultural biotechnology is a range of tools, including traditional breeding techniques that alter living organisms, or parts of organisms, to make or modify products; improve plants or animals; or develop microorganisms for specific agricultural uses. Modern biotechnology today includes the tools of genetic engineering.

Source: USDA

Process/Skill Questions

- What is the origin of the word *biotechnology*?
- What resources describe biotechnology?
- How has biotechnology affected agriculture throughout history?

Task Number 45

Identify historical, current, and emerging developments and applications of biotechnology in agriculture.

Definition

Identification should include developments and applications from early cultures (e.g., China, Greece, and Egypt) as well as recent advances and emergent technologies. Developments identified should include examples from various categories, such as the domestication of animals, plants, and the development of food products (e.g., transgenic crops, biological controls).

Process/Skill Questions

- How have historical events influenced and been influenced by biotechnology?
- What discoveries have accelerated advancements in biotechnology?

The National Council for Agricultural Education: Agriculture, Food and Natural Resources Content Standards

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.).

BS.03.04. Apply biotechnology principles, techniques, and processes to enhance plant and animal care and production (e.g., selective breeding, pharmaceuticals, biodiversity, etc.).

Task Number 46

Describe how biotechnology is used in other disciplines.

Definition

Description should include examples of the interdisciplinary nature of biotechnology, such as how biotechnology relates to

- food production/processing
- medical science
- pharmaceuticals
- water quality
- materials science
- energy production (e.g., biofuels)
- computer science
- forensic science.

Process/Skill Questions

- What are some important developments in biotechnology related to technology transfer?
- Why is interdisciplinary collaboration important in technology transfer?
- What is an example of spin-off technology?
- How has the coupling of technologies created new fields in biotechnology (e.g., mathematical biology, bioinformatics)?

The National Council for Agricultural Education: Agriculture, Food and Natural Resources Content Standards

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.).

BS.03.04. Apply biotechnology principles, techniques, and processes to enhance plant and animal care and production (e.g., selective breeding, pharmaceuticals, biodiversity, etc.).

BS.03.05. Apply biotechnology principles, techniques, and processes to produce biofuels (e.g., fermentation, transesterification, methanogenesis, etc.).

Task Number 47

Identify careers related to biotechnology.

Definition

Identification should include careers in science, mathematics, medicine, agriculture, engineering, law, and others.

For each career, the following should be addressed:

- Responsibilities
- Salaries
- Working environment
- Required education/training
- Job outlook

Many websites offer career exploration resources, including the Virginia Department of Education's Career Planning Guide, Virginia Education Wizard, Bureau of Labor Statistics, and the FFA Agricultural Career Network (available on the National FFA Organization website).

Process/Skill Questions

- What certifications, licenses, and degrees are available for careers in biotechnology?
- What is the outlook for careers in biotechnology?
- What resources have information about careers in biotechnology?
- What educational opportunities in biotechnology are available in higher education?

- What are the potential salaries and opportunities for advancement in biotechnology careers within the agriculture industry?
- How would an individual start his/her own biotechnology-related agricultural or environmental business?
- What is the career outlook for biotechnology careers related to the agricultural or environmental industries?
- What level of education or training is required for any entry-level position in a chosen agricultural or environmental biotechnology occupation?

Preparing for Biotechnology Experiences

Task Number 48

Demonstrate safe laboratory procedures.

Definition

Demonstration should

- reflect a knowledge of hazards and general safety rules (e.g., those related to fire, electricity, infection prevention, transmission of diseases), aseptic technique, and industry-specified guidelines (e.g., Occupational Safety and Health Administration [OSHA] and Clinical Laboratory Improvement Amendment [CLIA])
- interpret safety data sheets (SDS)
- follow manufacturers' guidelines for equipment and material use
- include safety procedures related to the use, storage, and disposal of sharps, hazardous materials, biohazards, and other items
- include wearing personal protective equipment (PPE)
- identify biosafety levels (e.g., of microorganisms)
    - BSL1
    - BSL2
    - BSL3
    - BSL4.

Process/Skill Questions

- What are specific rules and procedures involved in aseptic technique?
- Why are aseptic rules important?
- What are the components of the chain of infection? Why is it important?
- What are appropriate cleanup procedures for hazardous materials?
- What is an SDS? Why is it important?
- Why is documentation important to safety?

The National Council for Agricultural Education: Agriculture, Food and Natural Resources Content Standards

BS.02.01. Read, document, evaluate, and secure accurate laboratory records of experimental protocols, observations, and results.

BS.02.02. Implement standard operating procedures for the proper maintenance, use, and sterilization of equipment in a laboratory.

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

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

Task Number 49

Employ the scientific method and the technological/engineering method to solve biotechnology problems.

Definition

Employing the scientific method involves:

- Identifying the problem
- Formulating a hypothesis
- Designing and conducting an experiment
- Collecting data
- Analyzing data
- Drawing conclusions
- Making recommendations.

Employing the engineering design process should be based on the understanding that this process is concerned with the phenomena of the human-designed world and with obtaining artifacts and solutions to problems. The steps include

- identifying the need or opportunity for an engineering solution
- defining a design problem
- identifying the constraints of a design problem
- researching potential solutions to a design problem
- generating multiple solutions (brainstorming) to a design problem
- sketching solutions for a design problem
- evaluating potential solutions to a design problem
- choosing the optimal solution to a design problem
- implementing the solutions to a design problem
- communicating the solution to stakeholders

- testing the solution
- evaluating the test results
- improving the solution
- documenting the process.

The written report should include elements outlined in the FFA Agriscience Fair Final Report such as

- title page
- table of contents
- abstract
- introduction
- review of literature
- materials and methods
- results
- discussion and conclusion
- acknowledgements
- literature cited.

Process/Skill Questions

- What are the steps in the scientific method? Scientific argumentation? Inquiry method? Why is each step important?
- What are the steps in the technological/engineering design method? Why is each step important?
- What are the similarities and differences between the scientific method and the technological/engineering design method? What conditions determine the method one would use?

The National Council for Agricultural Education: Agriculture, Food and Natural Resources Content Standards

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).

BS.02.01. Read, document, evaluate, and secure accurate laboratory records of experimental protocols, observations, and results.

Task Number 50

Demonstrate standard operating procedures (SOPs) related to the agricultural biotechnology lab.

Definition

Demonstration should include

- locating the SOPs
- reading the SOPs

- adhering to the SOPs.

Process/Skill Questions

- How would one find the SOPs in the lab?
- Who is responsible for the SOPs in the lab?
- Why are the SOPs in the lab important?
- How might one demonstrate compliance with the SOPs?

The National Council for Agricultural Education: Agriculture, Food and Natural Resources Content Standards

BS.02.01. Read, document, evaluate, and secure accurate laboratory records of experimental protocols, observations, and results.

BS.02.02. Implement standard operating procedures for the proper maintenance, use, and sterilization of equipment in a laboratory.

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

Task Number 51

Analyze data generated from lab activities.

Definition

Analysis should include

- comparative research
- quantitative and qualitative data
- documentation (e.g., lab journals and logs)
- data visualization
- application of formulas
- data interpretation
- development of conclusions
- use of quality control (e.g., identification of quality standard, data validation)
- data reporting.

Process/Skill Questions

- How are quality controls maintained?
- What would be the consequences of not maintaining quality controls?
- How are data standards identified?
- How and why is data collected before, during, and/or after lab activities?
- How might one document the data collected during a lab activity?

- How might mode of data collection affect the desired analysis technique?
- How are data used to model biotechnical processes?

The National Council for Agricultural Education: Agriculture, Food and Natural Resources Content Standards

BS.02.01. Read, document, evaluate, and secure accurate laboratory records of experimental protocols, observations, and results.

BS.02.02. Implement standard operating procedures for the proper maintenance, use, and sterilization of equipment in a laboratory.

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

Introducing Macromolecules

Task Number 52

Explain the roles of sciences applicable to biotechnology.

Definition

Explanation should include the roles of organic chemistry, biochemistry, genetics, and microbiology in biotechnology.

Process/Skill Questions

- What is the difference between basic organic chemistry and biochemistry?
- What basic chemical processes and terminology are involved in organic chemistry/biochemistry?
- How are microbes used in biotechnology?
- How are biochemical reactions used in biotechnology research?

Task Number 53

Explain the structure and cellular function of organic macromolecules.

Definition

Explanation should

- defining *macromolecule*
- understanding that there are four types of macromolecules that include
    - nucleic acids
    - proteins
    - carbohydrates
    - lipids
- differentiating the roles of carbohydrates, lipids, and proteins in biotechnology applications.

Process/Skill Questions

- What are macromolecules?
- What mechanisms (sensors and gauges) are used to monitor carbohydrates?

Task Number 54

Analyze how organic macromolecules are detected and manipulated using biotechnological tools.

Definition

Analysis should describe current research; the manipulation of carbohydrates, lipids, and proteins; and how nucleic acids are designed for innovative processes within the field of biochemistry.

Process/Skill Questions

- How are organic macromolecules manipulated?
- What are some innovative uses for each group of these new macromolecules?
- What mechanisms (sensors and gauges) are used to monitor carbohydrates?
- How are cancer diagnostics and therapeutics possible?

Task Number 55

Explain nucleic acids.

Definition

Explanation should include

- structure and function of deoxyribonucleic acid (DNA) and ribonucleic acid (RNA)
- protein synthesis
- the importance of genetic variation/biodiversity.

Process/Skill Questions

- What is the difference between the function of DNA and the function of RNA?
- Why is biodiversity important?

The National Council for Agricultural Education: Agriculture, Food and Natural Resources Content Standards

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

Task Number 56

Explain proteins.

Definition

Explanation should include that a protein is a substance consisting of amino acids and that the biochemical properties of proteins affect their function and potential uses. Explanation should include how structure relates to function and should differentiate among the types of proteins found in organisms, such as

- hormones
- receptors
- contractile
- structural
- storage
- transport
- defensive
- enzymatic.

Process/Skill Questions

- How are proteins used in genome projects?
- Why is protein structure important to function?
- How can protein structure be manipulated?
- What are examples of the different types of proteins?
- What are the functions of the different types of proteins?

The National Council for Agricultural Education: Agriculture, Food and Natural Resources Content Standards

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

Task Number 57

Describe the characteristics and functions of enzymes and the biotechnological processes used to produce enzymes.

Definition

Description should emphasize that enzymes

- are proteins in all living cells
- are catalytic molecules that speed up the rate of biological and chemical reactions
- aid in the breakdown of food particles into smaller compounds such as amino acids, simple sugars, glycerol, and fatty acids.

Process/Skill Questions

- What are the characteristics and functions of enzymes?
- How are enzymes used in making detergents and cleaning products?
- What are some common enzymes in plants and animals?
- How are enzymes used in industrial settings to optimize processes?
- What are the physical and chemical parameters that affect enzymatic reactions?
- What is the effect of industrial enzyme use on the environment?

The National Council for Agricultural Education: Agriculture, Food and Natural Resources Content Standards

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

BS.03.02. Apply biotechnology principles, techniques, and processes to enhance the production of food through the use of microorganisms and enzymes.

Task Number 58

Model a biochemical pathway that includes enzymes.

Definition

Modeling should include identification of

- an initial chemical reactant
- the steps and the enzymes that catalyze each step
- the final product(s).

Process/Skill Questions

- What organisms can be used for a model?
- What are the characteristics of the model?
- What are the parts and how do they work?
- What mechanisms are used to monitor the system?
- What are some real-life applications of using enzymes?

The National Council for Agricultural Education: Agriculture, Food and Natural Resources Content Standards

BS.03.02. Apply biotechnology principles, techniques, and processes to enhance the production of food through the use of microorganisms and enzymes.

Task Number 59

Explain antibodies.

Definition

Explanation should include the

- ways antibodies are formed
- structure of antibodies
- concept that antibodies play a role in immunity
- utilization of antibodies for therapeutic and diagnostic purposes in agriculture. (e.g., monoclonal antibody technologies)

Process/Skill Questions

- How would one draw and label an antibody?
- How are antibodies related to immunity?

The National Council for Agricultural Education: Agriculture, Food and Natural Resources Content Standards

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

Task Number 60

Use antibodies to detect and quantify antigens.

Definition

Use of antibodies to detect and quantify antigens should be accomplished by conducting an enzyme-linked immunosorbent assay (ELISA).

Process/Skill Questions

- What is ELISA? Why would an ELISA be conducted?

The National Council for Agricultural Education: Agriculture, Food and Natural Resources Content Standards

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

Task Number 61

Explain the function of carbohydrates and their role in biotechnology applications.

Definition

Explanation should point out that carbohydrates form chains of polysaccharides (long chains of sugar molecules), which are essential building blocks for life.

Process/Skill Questions

- What are the functions of carbohydrates in an organism?
- What are the types of carbohydrates?
- How are carbohydrates used in biotechnology?

Task Number 62

Explain the function of lipids and their role in biotechnology applications.

Definition

Explanation should include

- definition of *lipid*
- types of lipids
- cellular membranes
- biotechnological applications.

Process/Skill Questions

- How might one draw and label a cell membrane?
- What is the difference between saturated and unsaturated fats?
- How are lipids used in biotechnology?

Task Number 63

Perform separation and purification of macromolecules.

Definition

Performance should include the use of safety procedures (e.g., CLIA guidelines), SOPs, sterilization, and correct disposal of hazardous waste. Examples include filtration, chromatography, and solvent extraction.

Process/Skill Questions

- What is the purpose of separation and purification in bioprocessing?
- What products are produced through separation and purification techniques?

The National Council for Agricultural Education: Agriculture, Food and Natural Resources Content Standards

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

BS.03.06. Apply biotechnology principles, techniques, and processes to improve waste management (e.g., genetically modified organisms, bioremediation, etc.).

Task Number 64

Demonstrate the use of basic instrumentation in DNA analysis.

Definition

Demonstration should include

- DNA extraction and purification from living tissue, following SOPs
- pipetting technique
- gel electrophoresis
- polymerase chain reaction (PCR).

Process/Skill Questions

- What are the primary types of instruments and equipment used in forensic science?

- What purpose do the instruments serve?
- What safety practices are important when using the instruments of forensic science?

The National Council for Agricultural Education: Agriculture, Food and Natural Resources Content Standards

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

Exploring Biotechnology in Environmental Science

Task Number 65

Assess the social effects of environmental quality management.

Definition

Assessment should include the history, legislation, and organizations (e.g., USDA, Virginia Department of Environmental Quality [DEQ], U.S. Environmental Protection Agency [EPA], and water and soil conservation districts) associated with environmental quality management, as well as the effects of environmental quality management on society.

Process/Skill Questions

- How might one categorize current environmental issues associated with biotechnology?
- In which environmental issue is biotechnology most likely to be used for quality management?
- What would be the consequences of not having environmental quality management?
- How has society benefited from environmental quality management?

The National Council for Agricultural Education: Agriculture, Food and Natural Resources Content Standards

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.).

Task Number 66

Investigate the purpose and design of biological treatment systems.

Definition

Investigation should include

- the function of various types of biological treatment systems (e.g., solid wastes, hazardous wastes, wastewater treatment, soil reclamation, treatment of airborne contaminants)
- design considerations in the application of each.

Process/Skill Questions

- What are the key characteristics of biological treatment systems?
- How does the method of biological treatment affect the design of the system?
- What biotechnology techniques are used in biological treatment systems?
- In what ways can biological treatment systems benefit the environment?
- How has the lack of biological treatment systems in underdeveloped countries affected the environment?

The National Council for Agricultural Education: Agriculture, Food and Natural Resources Content Standards

BS.03.06. Apply biotechnology principles, techniques, and processes to improve waste management (e.g., genetically modified organisms, bioremediation, etc.).

Task Number 67

Describe a bioremediation and biorestoration system.

Definition

Description should include

- the definition of *bioremediation* and *biorestoration*
- examples of a bioremediation system
- examples of a biorestoration system.

Process/Skill Questions

- What are examples of bioremediation systems?
- What is the difference between bioremediation and biorestoration?
- What are some circumstances when one system may be selected over the other?
- How can a bioremediation system positively and/or negatively affect the environment?

The National Council for Agricultural Education: Agriculture, Food and Natural Resources Content Standards

BS.03.06. Apply biotechnology principles, techniques, and processes to improve waste management (e.g., genetically modified organisms, bioremediation, etc.).

Applying Biotechnology to Agricultural Species

Task Number 68

Investigate procedures used with tissue culture.

Definition

Investigation should include

- the definition of *tissue culture*
- techniques for the collection, storage, multiplication, and transportation of tissue-cultured plant/animal cells.

Process/Skill Questions

- Why is aseptic technique important in tissue culture?
- How is specimen collection accomplished in tissue culture?
- What is the advantage of the multiplication stage in increasing plant numbers?
- How does the federal Plant Variety Protection Act (PVPA) affect tissue culture?

The National Council for Agricultural Education: Agriculture, Food and Natural Resources Content Standards

BS.03.04. Apply biotechnology principles, techniques, and processes to enhance plant and animal care and production (e.g., selective breeding, pharmaceuticals, biodiversity, etc.).

Task Number 69

Identify microbial applications in agriculture and the environment.

Definition

Identification should include

- activities in which microbial applications are used as change agents in agricultural processes
- an exploration of microbiomes in plants, animals, and soils

- how microbes can be used for sustainable agriculture and environmental protection.

Process/Skill Questions

- What is a microbiome?
- What is a microbe's traditional role in nature?
- How can a microbe be used as a change agent?
- What are the steps in using microbes as change agents?
- Which microbes are used for which alterations in life processes?

The National Council for Agricultural Education: Agriculture, Food and Natural Resources Content Standards

BS.02.02. Implement standard operating procedures for the proper maintenance, use, and sterilization of equipment in a laboratory.

BS.03.02. Apply biotechnology principles, techniques, and processes to enhance the production of food through the use of microorganisms and enzymes.

Task Number 70

Summarize the role of biotechnology in plant and/or animal modification.

Definition

Summary should be made by examining an example of the

- production and use of biodegradable pesticides, herbicide-resistant crops, and fertilizers
- DNA marker technology for plant and animal breeding
- development of pathogen-resistant and insect-resistant plants
- development of plant and animal byproducts.

Process/Skill Questions

- What are some examples of genetically modified organisms that are used to support crop production?
- What innovations are the result of plant modification?
- What uses and applications do genetically modified plants and/or animals currently have?

The National Council for Agricultural Education: Agriculture, Food and Natural Resources Content Standards

BS.03.04. Apply biotechnology principles, techniques, and processes to enhance plant and animal care and production (e.g., selective breeding, pharmaceuticals, biodiversity, etc.).

Task Number 71

Outline the factors that jeopardize food safety.

Definition

Outline should include factors that prevent food spoilage or cause food spoilage (e.g., disease, bioterrorism, agroterrorism) and methods of safely processing, storing, and transporting foods.

Process/Skill Questions

- What steps are required in food processing to meet safety regulations?
- What regulations and agencies govern food safety guidelines?
- What are the consequences of poor food processing, storage, and transportation?
- What are some causes of food spoilage?

The National Council for Agricultural Education: Agriculture, Food and Natural Resources Content Standards

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.).

Task Number 72

Examine advances of biotechnology in food science.

Definition

Examination should include biotechnological advances in food science, such as

- processing techniques (e.g., fermentation and irradiation)
- preservation/storage methods (e.g., use of spices to control microbial growth).

Process/Skill Questions

- What are examples of advances in food science related to biotechnology?
- What role has biotechnology played in food science advances?
- How can biotechnological advances in food science affect global food supplies?

The National Council for Agricultural Education: Agriculture, Food and Natural Resources Content Standards

BS.03.02. Apply biotechnology principles, techniques, and processes to enhance the production of food through the use of microorganisms and enzymes.

Exploring Bioprocessing

Task Number 73

Define *bioprocessing*.

Definition

Definition should include that bioprocessing is the use of biological materials to carry out a process, such as bioprocessing techniques to develop

- specialty chemicals
- new pharmaceuticals
- alternative fuels
- feed stocks
- biopolymers
- bioremediation.

Process/Skill Questions

- What are biopolymers?
- What is bioremediaton?
- How are alternative fuels and feed stocks produced using bioprocessing?
- What is pharming?

Task Number 74

Describe the process of industrial fermentation.

Definition

Description should include

- agricultural products (e.g., beer, wine, bread, yogurt, kefir, kombucha)
- industrial products (e.g., ethanol, butanol, acetone)
- medical products (e.g., antibiotics, antiseptics, anti-inflammatories, anticoagulants, antidepressants, vasodilators).

Description should also focus on the generation of energy by the breakdown of organic compounds (aerobic and anaerobic microorganisms).

Process/Skill Questions

- How long and in what contexts has the fermentation process been used?
- What conditions must exist for these processes to take place?
- What steps are necessary for fermentation to take place?

The National Council for Agricultural Education: Agriculture, Food and Natural Resources Content Standards

BS.03.02. Apply biotechnology principles, techniques, and processes to enhance the production of food through the use of microorganisms and enzymes.

Task Number 75

Investigate products generated from bioprocessing.

Definition

Investigation should include products from industries such as

- biopharmaceuticals
    - therapeutic proteins
    - polysaccharides
    - vaccines
    - diagnostics
- specialty products and industrial chemicals
    - antibiotics
    - value-added food
- environmental management aids
    - bioprocessing products and services used to control or remediate toxic wastes.

Process/Skill Questions

- What are examples of bioprocessed products?
- How are bioprocessed products used?
- What equipment is used in bioprocessing?

The National Council for Agricultural Education: Agriculture, Food and Natural Resources Content Standards

BS.03.06. Apply biotechnology principles, techniques, and processes to improve waste management (e.g., genetically modified organisms, bioremediation, etc.).

Task Number 76

Describe genetic engineering applications used in bioprocessing.

Definition

Description should include

- genetic applications in designer pharmaceuticals
- genetically modified organisms
- bioremediation
- alternative fuels
- biopolymers
- use of microbes.

Process/Skill Questions

- What are some examples of genetic engineering applications?
- What are some examples of ethical controversies surrounding genetic engineering? Why are they important?

The National Council for Agricultural Education: Agriculture, Food and Natural Resources Content Standards

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.).

BS.03.06. Apply biotechnology principles, techniques, and processes to improve waste management (e.g., genetically modified organisms, bioremediation, etc.).

Task Number 77

Demonstrate the application of microbes in bioprocessing.

Definition

Demonstration should include the use of safety practices (e.g., CLIA guidelines), SOPs, sterilization, and correct disposal of hazardous waste.

Process/Skill Questions

- What are examples of microbes used in bioprocessing?
- What are examples of end-products of bioprocessing?

The National Council for Agricultural Education: Agriculture, Food and Natural Resources Content Standards

BS.03.06. Apply biotechnology principles, techniques, and processes to improve waste management (e.g., genetically modified organisms, bioremediation, etc.).

Task Number 78

Identify bioprocessing systems.

Definition

Identification should include an example of a bioprocessing system and its use (e.g., stainless steel, single-use). Identification should also include the concept that a biological component is responsible for the production of the desired product.

Process/Skill Questions

- What are examples of bioprocessing techniques?
- How can microbes be used to reduce pollution?

Investigating Genome Sciences

Task Number 79

Define *genomics*.

Definition

Definition should include genome

- structure
- composition
- phenotype/genotype relationship.

Process/Skill Questions

- What are the building blocks of an organism's genome?
- How are genes introduced or eliminated from the genome of an organism using biotechnology techniques?

Task Number 80

Develop a historic timeline of milestones in genomics.

Definition

Development of the timeline should include, but not be limited to, major events in genetic engineering such as

- Mendel's discovery
- DNA sequencing technologies
- gene therapy
- cloning
- gene editing
- PCR.

Process/Skill Questions

- What was Mendel's contribution to the field of genetic engineering?
- What is the importance of DNA modeling?
- What is the importance of gene therapy in modern medicine?
- What is cloning, and why is it controversial?

The National Council for Agricultural Education: Agriculture, Food and Natural Resources Content Standards

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.).

Task Number 81

Describe the importance of the genetic information contained in DNA.

Definition

Description should include

- understanding how the structure of DNA relates to specific traits in an organism
- constructing and explaining the components of a DNA model
- recognizing the importance of genetic diversity to
    - the organism
    - the ecosystem
    - biotechnology solutions (present and future).

Process/Skill Questions

- How is the DNA molecule different in prokaryotes and eukaryotes?
- What are the components of a DNA molecule?
- How does DNA direct the formation of proteins?
- How is gene expression a regulatory mechanism?
- How does DNA affect the genetic makeup of a living organism?

The National Council for Agricultural Education: Agriculture, Food and Natural Resources Content Standards

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

Task Number 82

Demonstrate techniques for DNA extraction.

Definition

Demonstration may include the following techniques of DNA extraction:

- Centrifugation
- Precipitation
- Spooling
- DNA gel electrophoresis

Process/Skill Questions

- What lab equipment is used for the extraction of DNA?
- What lab safety precautions should be taken when performing DNA extraction?
- What part do centrifugation, precipitation, and spooling play in extraction of DNA?
- What is the purpose of genetic manipulation?

The National Council for Agricultural Education: Agriculture, Food and Natural Resources Content Standards

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

Task Number 83

Explain how genomics is related to disease prevention.

Definition

Explanation should include current information on the contribution of genomics in disease prevention through diagnostics and therapeutics.

Process/Skill Questions

- How is genetic engineering used to diagnose disease?
- How is genetic engineering used to treat disease?
- How is genetic engineering used to personalize therapeutics?

Task Number 84

Explain the importance of bioinformatics.

Definition

Explanation should include

- defining *bioinformatics*
- using a current technology to analyze DNA sequences, identify DNA variations, or compare evolutionary relationships.

Process/Skill Questions

- What value does this information have to biotechnology research?
- What is the value of informational components of DNA sequencing projects?

The National Council for Agricultural Education: Agriculture, Food and Natural Resources Content Standards

BS.02.01. Read, document, evaluate, and secure accurate laboratory records of experimental protocols, observations, and results.

Task Number 85

Describe the relationship between reproduction and genetic improvement.

Definition

Description should include

- how traits are inherited
- how genetic processes and structures control inheritance
- differences between dominant and recessive traits

- how genotype influences phenotype
- predicting probable results of single and/or multiple trait crosses.

Process/Skill Questions

- How do genotypes influence phenotypes? Give examples.
- Using the Punnett square to predict the genotypes and phenotypes of the following monohybrid cross, (PP X pp), where PP is a true breeding purple flower and pp is a white flower, what are the probabilities associated with homozygous dominant offspring and heterozygous offspring in the F1 and F2 generations?
- What is a test cross? Why is it used?
- How does using a test cross determine the genotype of an individual?

The National Council for Agricultural Education: Agriculture, Food and Natural Resources Content Standards

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

Task Number 86

Describe current technologies for genetic modification of plants, animals, and microbes.

Definition

Description should include

- introduction of foreign genes
- alteration of existing genes
- modification of gene regulation
- identification and use of genetic markers
- exploration of synthetic biology
    - animals
    - plants
    - microbes.

Process/Skill Questions

- What is synthetic biology?
- How can synthetically bioengineered organisms be used?
- How has agriculture changed as a result of genetic modification?

The National Council for Agricultural Education: Agriculture, Food and Natural Resources Content Standards

BS.03.04. Apply biotechnology principles, techniques, and processes to enhance plant and animal care and production (e.g., selective breeding, pharmaceuticals, biodiversity, etc.).

Examining the Role of Biotechnology in Medicine

Task Number 87

Outline the contributions of plant, animal, and microbial biotechnology to medicine.

Definition

Outline should include historical, societal, cultural, and financial influences of biotechnology in the medical fields.

Process/Skill Questions

- What medical discoveries would be categorized under biotechnology, as opposed to biomedicine?
- In what ways has biotechnology in medicine improved society?

The National Council for Agricultural Education: Agriculture, Food and Natural Resources Content Standards

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.).

BS.03.04. Apply biotechnology principles, techniques, and processes to enhance plant and animal care and production (e.g., selective breeding, pharmaceuticals, biodiversity, etc.).

Task Number 88

Describe the ethical, legal, and social effects of biomedicine.

Definition

Description should

- address the ethical, legal, and social effects of biomedicine throughout history
- include the ethical decision-making processes involving governmental influence on biomedical research.

Process/Skill Questions

- What are the positive and negative effects of genetic selection, gene therapy, and cloning?
- What are examples of negative effects of biomedicine?
- How is legislation developed and influenced by biomedicine?

The National Council for Agricultural Education: Agriculture, Food and Natural Resources Content Standards

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).

Task Number 89

Explain vaccine (immunology) research and development.

Definition

Explanation should include current information on the contributions of biotechnology to the development and improvement of vaccines.

Process/Skill Questions

- How does industry develop new vaccines?
- How can biotechnology improve the effectiveness of vaccines?

The National Council for Agricultural Education: Agriculture, Food and Natural Resources Content Standards

BS.03.04. Apply biotechnology principles, techniques, and processes to enhance plant and animal care and production (e.g., selective breeding, pharmaceuticals, biodiversity, etc.).

Task Number 90

Identify emerging healthcare technologies.

Definition

Identification should include trends in biomedical diagnostic tools, treatment processes, and genetic materials.

Process/Skill Questions

- How will microarrays affect diagnosis?
- What are the new methods of treatment in areas such as genetics and cellular research?
- How do emerging healthcare technologies affect a patient's quality of life?
- What new healthcare technologies are being developed as a result of advances in agriculture, biotechnology, and medicine?
- How are viruses used to transport genes into cells?

Task Number 91

Explain the applications of genomics in pharmacology.

Definition

Explanation should include major contributions of genomics to pharmacology, as well as the influence of pharmacology on biomedicine.

Process/Skill Questions

- What is personalized medicine?
- How does a pharmaceutical affect a patient and treatment?
- What are the positive and negative effects of genetic applications in pharmacology on a patient?

The National Council for Agricultural Education: Agriculture, Food and Natural Resources Content Standards

BS.03.04. Apply biotechnology principles, techniques, and processes to enhance plant and animal care and production (e.g., selective breeding, pharmaceuticals, biodiversity, etc.).

Task Number 92

Describe the effects of biotechnology on preventive health care.

Definition

Description should include examples of biotechnology-related ethical, legal, and social issues in preventive health care, as well as new advances in the field of preventive health care.

Process/Skill Questions

- How has the Human Genome Project influenced immunology?
- How have society and governmental influences influenced preventive healthcare?
- What are basic processes in preventive health care, and what is their relation to biomedicine?

Investigating Forensics

Task Number 93

Define *forensic science.*

Definition

Definition should explain that forensic science is the application of scientific principles and techniques as related to matters regarding the judicial system (particularly criminal justice) in the collection, examination, and analysis of physical evidence.

Biotechnological aspects include DNA testing, epidemiology, paternity testing, serology testing, and special applications in wildlife/species determination.

Process/Skill Questions

- What is the purpose of forensic science?
- What are the processes involved with identifying a person through DNA analysis?
- When did the use of DNA analysis first begin in forensic science? How has it evolved over the years?
- What is serology testing? How has it evolved over the years?
- What role does DNA testing play in the determination of new species and wildlife forensics?
- What resources offer information about forensic science in the criminal, medical, and biological fields?

Task Number 94

Describe situations in which medical forensics can be used in agriculture.

Definition

Description should include how agricultural forensics is used with livestock and crops, to determine paternity, food quality and adulteration, causes of death, effects of disease treatment, and pharmaceutical efficacy.

Process/Skill Questions

- What are the types and purposes of paternity tests for humans and animals?
- What are some of the tests used to determine cause of death?
- How can biological forensic evidence be collected and protected?
- How can the study of DNA analysis affect future treatments of disease?

The National Council for Agricultural Education: Agriculture, Food and Natural Resources Content Standards

BS.03.04. Apply biotechnology principles, techniques, and processes to enhance plant and animal care and production (e.g., selective breeding, pharmaceuticals, biodiversity, etc.).

Task Number 95

Describe situations in which forensic science can be used in criminal investigations related to agriculture.

Definition

Description may include gathering and preserving evidence related to a criminal act. Situations may include those involving

- agroterrorist acts
- presence of suspect materials (e.g., anthrax)
- entomology
- plant, animal, and microbial material used as evidence.

Process/Skill Questions

- What types of evidence may be collected from a crime scene?
- How does the type of crime determine the evidence gathered?
- What steps are involved in gathering and preserving evidence from a crime scene?
- What evidence suggests a criminal vs. an accidental act?
- What skills are important to have as a team member (whether law enforcement, medical professionals, scientists, government agencies, or media) in criminal forensics?
- How does television's portrayal of forensic science influence society's perception of the field?

Task Number 96

Describe situations in which biological forensic science can be used.

Definition

Description should include situations such as those involving any living organisms (e.g., disruptions in plant and animal life cycles, endangered species, extinct species, plant and animal mutations, epidemiology, archaeological applications, and animal habitat degradation).

Process/Skill Questions

- How might one describe the interrelationship of criminal, medical, and biological forensic sciences?

- What basic skills are required to collect evidence for biological forensics? Why is each skill important?
- How and where is biological forensic evidence processed?
- In what recent events have biological forensics been used? What impact did they have?

The National Council for Agricultural Education: Agriculture, Food and Natural Resources Content Standards

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.).

Understanding Bioengineering

Task Number 97

Define *bioengineering*.

Definition

Definition should explain that bioengineering is the design and manipulation of materials and organisms to create new products for medical, agricultural, and engineering applications.

Process/Skill Questions

- What are some examples of bioengineered products in the field of medicine? Agriculture? Engineering?
- What are the steps in the engineering design process?
- What are some of the ethical and legal issues associated with bioengineering?

The National Council for Agricultural Education: Agriculture, Food and Natural Resources Content Standards

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

Task Number 98

Identify uses of nanobiotechnology.

Definition

Identification should include nanobiotechnology applications in medicine, agriculture, and engineering.

Process/Skill Questions

- What is the history of nanobiotechnology?
- How do patients benefit from nanobiotechnology?

Task Number 99

Describe how bioengineering can affect food security.

Definition

Description should include

- positive (e.g., herbicide-resistant plants) and negative (e.g., monocultures/loss of biodiversity) aspects
- advantages and disadvantages of transgenic species.

Process/Skill Questions

- How might bioengineering affect biodiversity?
- How might bioengineering address the food needs of a growing population?

The National Council for Agricultural Education: Agriculture, Food and Natural Resources Content Standards

BS.03.04. Apply biotechnology principles, techniques, and processes to enhance plant and animal care and production (e.g., selective breeding, pharmaceuticals, biodiversity, etc.).

Task Number 100

Propose a bioengineering solution to an agricultural/environmental problem.

Definition

Proposal may include all aspects of the engineering design process, to include developing a hypothetically engineered species to solve an agricultural and/or environmental problem.

Process/Skill Questions

- What are the steps in the engineering design process?
- What environmental problem(s) could be addressed through bioengineering?

The National Council for Agricultural Education: Agriculture, Food and Natural Resources Content Standards

BS.03.06. Apply biotechnology principles, techniques, and processes to improve waste management (e.g., genetically modified organisms, bioremediation, etc.).

Examining Social Aspects and Ethics of Biotechnology

Task Number 101

Define *bioethics.*

Definition

Definition should include the standard description of ethics and the relationship of biotechnology to ethics.

Process/Skill Questions

- Why does the study of biotechnology require the study of ethics?
- What are prominent ethical issues raised by biotechnology?

The National Council for Agricultural Education: Agriculture, Food and Natural Resources Content Standards

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).

Task Number 102

Analyze the effects of biotechnology in agriculture.

Definition

Analysis should include

- the ways biotechnology has accelerated changes in the field of agriculture throughout history (e.g., animal husbandry, seed modification) and contributed to advanced research in other fields
- a description of the process and effects of the social transition from an agrarian society to a technology state
- current effects
- positive and negative effects.

Analysis should also include components of biotechnology, such as bioprocessing and genomics research.

Process/Skill Questions

- How has public, scientific, and corporate awareness affected biotechnology?
- What have been the major positive and negative social effects of biotechnology in agriculture?
- Who benefits from genomics?
- How do government regulations affect product development and distribution?
- How does consumer confidence affect product development and distribution?
- Who might benefit from bioprocessing, and how?
- What are common misconceptions of bioprocessing?
- What are the potential risks or dangers of bioprocessing?

The National Council for Agricultural Education: Agriculture, Food and Natural Resources Content Standards

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.).

Task Number 103

Differentiate among ethical principles and legal issues as they relate to biotechnology.

Definition

Differentiation should be made among ethical principles and legal issues reflected in social, religious, economic, and political segments of society.

Process/Skill Questions

- How are ethics different from laws?
- Why are the different principles of ethics essential?
- Why are there differences in ethical principles from one person or group to another?
- Whose ethics should guide biotechnology? Why?

Task Number 104

Research regulations related to biotechnology in agriculture.

Definition

Research should include

- legislation and safety guidelines
- ways private industry and U.S. regulatory agencies (e.g., USDA, USDA's Animal and Plant Health Inspection Service [APHIS], EPA, U.S. Food and Drug Administration [FDA]) influence the regulation of biotechnology.

Process/Skill Questions

- How do regulatory agencies/organizations influence biotechnology?
- What are the short-term and long-term benefits to the general public and individual consumer as a result of the regulations developed by the regulatory agencies and organizations targeting biotechnology?
- What are the advantages and disadvantages of biotechnology regulations as they relate to the various sectors in the agriculture industry?

The National Council for Agricultural Education: Agriculture, Food and Natural Resources Content Standards

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.).

SOL Correlation by Task

39	Identify the role of supervised agricultural experiences (SAEs) in agricultural education.	English: 10.3, 10.5, 11.3, 11.5, 12.3, 12.5
40	Participate in an SAE.	English: 10.5, 10.8, 11.5, 11.8, 12.5, 12.8
41	Identify the benefits and responsibilities of FFA membership.	English: 10.5, 10.6, 10.7, 10.8, 11.5, 11.6, 11.7, 11.8, 12.5, 12.6, 12.7, 12.8
42	Describe leadership characteristics and opportunities as they relate to agriculture and FFA.	English: 10.5, 11.5, 12.5 History and Social Science: VUS.8, VUS.9, VUS.10, VUS.11, WHII.8, WHII.10, WHII.11
43	Apply for an FFA degree and/or an agricultural proficiency award.	English: 10.5, 11.5, 12.5
44	Define *agricultural biotechnology*.	English: 10.3, 11.3, 12.3
45	Identify historical, current, and emerging developments and applications of biotechnology in agriculture.	English: 10.5, 11.5, 12.5 History and Social Science: WHI.2, WHI.3, WHI.4, WHI.5, WHI.6
46	Describe how biotechnology is used in other disciplines.	English: 10.5, 11.5, 12.5

		History and Social Science: GOVT.9, VUS.14, WG.2
47	Identify careers related to biotechnology.	English: 10.5, 11.5, 12.5
48	Demonstrate safe laboratory procedures.	History and Social Science: GOVT.1, GOVT.11, GOVT.15, GOVT.16 Science: BIO.1, CH.1
49	Employ the scientific method and the technological/engineering method to solve biotechnology problems.	English: 10.1, 10.3, 10.5, 10.6, 10.7, 10.8, 11.1, 11.3, 11.5, 11.6, 11.7, 11.8, 12.1, 12.3, 12.5, 12.6, 12.7, 12.8 Mathematics: A.9, AFDA.1, AFDA.3, AFDA.4, AFDA.8, AII.7, AII.9, PS.5, PS.1*, PS.18, PS.2*, PS.3*, PS.7*, PS.8*, PS.10* Science: BIO.1, CH.1
50	Demonstrate standard operating procedures (SOPs) related to the agricultural biotechnology lab.	English: 10.5, 11.5, 12.5
51	Analyze data generated from lab activities.	English: 10.5, 10.6, 10.7, 10.8, 11.5, 11.6, 11.7, 11.8, 12.5, 12.6, 12.7, 12.8 Mathematics: A.4, A.9, AFDA.1, AFDA.3, AFDA.4, AFDA.8, AII.7, AII.8, AII.9, COM.1, PS.5, PS.1*, PS.2*, PS.20, PS.3*, PS.4*, PS.7*, PS.8*, PS.9*, PS.10* Science: BIO.1, CH.1
52	Explain the roles of sciences applicable to biotechnology.	English: 10.5, 11.5, 12.5 Science: BIO.2, CH.6
53	Explain the structure and cellular function of organic macromolecules.	English: 10.3, 10.5, 11.3, 11.5, 12.3, 12.5 Science: BIO.2
54	Analyze how organic macromolecules are detected and manipulated using biotechnological tools.	English: 10.5, 11.5, 12.5 Science: CH.6
55	Explain nucleic acids.	English: 10.5, 11.5, 12.5 Science: BIO.5
56	Explain proteins.	English: 10.5, 11.5, 12.5 Science: BIO.5
57	Describe the characteristics and functions of enzymes and the biotechnological processes used to produce enzymes.	English: 10.5, 11.5, 12.5 Science: BIO.2, CH.6
58	Model a biochemical pathway that includes enzymes.	English: 10.5, 11.5, 12.5 Science: BIO.2

59	Explain antibodies.	English: 10.5, 11.5, 12.5
60	Use antibodies to detect and quantify antigens.	
61	Explain the function of carbohydrates and their role in biotechnology applications.	English: 10.5, 11.5, 12.5 Science: BIO.2
62	Explain the function of lipids and their role in biotechnology applications.	English: 10.5, 11.5, 12.5 Science: BIO.2
63	Perform separation and purification of macromolecules.	
64	Demonstrate the use of basic instrumentation in DNA analysis.	Science: BIO.2
65	Assess the social effects of environmental quality management.	English: 10.5, 10.8, 11.5, 11.8, 12.5, 12.8 History and Social Science: GOVT.1, GOVT.15, VUS.1, VUS.14, WG.1, WG.2
66	Investigate the purpose and design of biological treatment systems.	English: 10.8, 11.8, 12.8
67	Describe a bioremediation and biorestoration system.	English: 10.5, 11.5, 12.5
68	Investigate procedures used with tissue culture.	English: 10.8, 11.8, 12.8
69	Identify microbial applications in agriculture and the environment.	English: 10.5, 11.5, 12.5
70	Summarize the role of biotechnology in plant and/or animal modification.	English: 10.5, 11.5, 12.5 History and Social Science: VUS.14, WG.1, WG.17, WG.18 Science: BIO.5
71	Outline the factors that jeopardize food safety.	English: 10.6, 10.7, 11.6, 11.7, 12.6, 12.7
72	Examine advances of biotechnology in food science.	English: 10.5, 11.5, 12.5
73	Define *bioprocessing*.	English: 10.3, 11.3, 12.3
74	Describe the process of industrial fermentation.	English: 10.5, 11.5, 12.5 Science: BIO.2
75	Investigate products generated from bioprocessing.	English: 10.8, 11.8, 12.8
76	Describe genetic engineering applications used in bioprocessing.	English: 10.5, 11.5, 12.5 Science: BIO.5
77	Demonstrate the application of microbes in bioprocessing.	English: 10.5, 11.5, 12.5
78	Identify bioprocessing systems.	English: 10.5, 11.5, 12.5
79	Define *genomics*.	English: 10.3, 11.3, 12.3 Science: BIO.5

80	Develop a historic timeline of milestones in genomics.	English: 10.6, 10.7, 10.8, 11.6, 11.7, 11.8, 12.6, 12.7, 12.8 History and Social Science: GOVT.1, GOVT.15, VUS.1, VUS.14, WHII.1, WHII.13, WHII.14 Science: BIO.1, BIO.5
81	Describe the importance of the genetic information contained in DNA.	English: 10.5, 11.5, 12.5 Science: BIO.5
82	Demonstrate techniques for DNA extraction.	Science: BIO.1, BIO.5
83	Explain how genomics is related to disease prevention.	English: 10.5, 11.5, 12.5
84	Explain the importance of bioinformatics.	English: 10.3, 10.5, 11.3, 11.5, 12.3, 12.5
85	Describe the relationship between reproduction and genetic improvement.	English: 10.5, 11.5, 12.5
86	Describe current technologies for genetic modification of plants, animals, and microbes.	English: 10.5, 10.8, 11.5, 11.8, 12.5, 12.8 Science: BIO.5
87	Outline the contributions of plant, animal, and microbial biotechnology to medicine.	English: 10.6, 10.7, 11.6, 11.7, 12.6, 12.7 History and Social Science: GOVT.1, GOVT.9, GOVT.11, GOVT.15, VUS.1, VUS.14
88	Describe the ethical, legal, and social effects of biomedicine.	English: 10.5, 11.5, 12.5 History and Social Science: GOVT.1, GOVT.9, GOVT.11, GOVT.15, VUS.1, VUS.14, WG.18
89	Explain vaccine (immunology) research and development.	English: 11.5, 12.5 Science: BIO.4
90	Identify emerging healthcare technologies.	English: 10.5, 11.5, 12.5 History and Social Science: VUS.14, WHII.13
91	Explain the applications of genomics in pharmacology.	English: 10.5, 11.5, 12.5
92	Describe the effects of biotechnology on preventive health care.	English: 10.5, 11.5, 12.5 History and Social Science: GOVT.15, WG.1, WG.2, WG.3, WG.4, WG.17, WG.18
93	Define *forensic science.*	English: 10.3, 11.3, 12.3
94	Describe situations in which medical forensics can be used in agriculture.	English: 10.5, 11.5, 12.5
95	Describe situations in which forensic science can be used in criminal investigations related to agriculture.	English: 10.5, 11.5, 12.5
96	Describe situations in which biological forensic science can be used.	English: 10.5, 11.5, 12.5
97	Define *bioengineering*.	English: 10.3, 11.3, 12.3
98	Identify uses of nanobiotechnology.	English: 10.5, 11.5, 12.5

99	Describe how bioengineering can affect food security.	English: 10.5, 11.5, 12.5
100	Propose a bioengineering solution to an agricultural/environmental problem.	English: 10.5, 11.5, 12.5
101	Define *bioethics*.	English: 10.3, 11.3, 12.3
102	Analyze the effects of biotechnology in agriculture.	English: 10.5, 11.5, 12.5 History and Social Science: WHII.1
103	Differentiate among ethical principles and legal issues as they relate to biotechnology.	English: 10.5, 11.5, 12.5 History and Social Science: GOVT.1, GOVT.3, GOVT.9, GOVT.11, GOVT.15, VUS.14
104	Research regulations related to biotechnology in agriculture.	English: 10.8, 11.8, 12.8 History and Social Science: GOVT.9, GOVT.11, GOVT.15

Entrepreneurship Infusion Units

Entrepreneurship Infusion Units may be used to help students achieve additional, focused competencies and enhance the validated tasks/competencies related to identifying and starting a new business venture. Because the unit is a complement to certain designated courses and is not mandatory, all tasks/competencies are marked "optional."

Appendix: Credentials, Course Sequences, and Career Cluster Information

Industry Credentials: Only apply to 36-week courses

- Agricultural Biotechnology Assessment
- Animal Systems Assessment
- Biotechnology Assessment
- College and Work Readiness Assessment (CWRA+)
- Customer Service Specialist (CSS) Examination
- Natural Resources Systems Assessment
- Production Agriculture Assessment

Concentration sequences: *A combination of this course and those below, equivalent to two 36-week courses, is a concentration sequence. Students wishing to complete a specialization may take additional courses based on their career pathways. A program completer is a student who has met the requirements for a CTE concentration sequence and all other requirements for high school graduation or an approved alternative education program.*

- Applied Agricultural Concepts (8072/18 weeks)
- Applied Agricultural Concepts (8073/36 weeks)
- Biological Applications in Agriculture (8086/36 weeks)
- Biomedical Engineering (8467/36 weeks)
- Biomedical Technician (8347/36 weeks)
- Biotechnology Applications in Agriculture (8087/36 weeks)
- Ecology and Environmental Management (8046/36 weeks)
- Ecology and Environmental Management (8045/18 weeks)
- Equine Science (8015/18 weeks)
- Equine Science (8080/36 weeks)
- Equine Science, Advanced (8094/36 weeks)
- Fisheries and Wildlife Management (8041/36 weeks)
- Food Science and Dietetics (8239/36 weeks)
- Forensic Technology (8409/36 weeks)
- Forestry Management (8042/36 weeks)
- Forestry Management, Advanced (8044/36 weeks)
- Foundations of Agriculture, Food, and Natural Resources (8006/36 weeks)
- Greenhouse Plant Production and Management (8035/36 weeks)
- Horticulture Sciences (8034/36 weeks)
- Introduction to Animal Systems (8008/36 weeks)
- Introduction to Natural Resources and Ecology Systems (8040/36 weeks)
- Introduction to Plant Systems (8007/36 weeks)
- Medical Laboratory Technology I (8377/36 weeks)
- Medical Laboratory Technology II (8378/36 weeks)
- Small Animal Care I (8081/18 weeks)
- Small Animal Care I (8083/36 weeks)
- Small Animal Care II (8084/36 weeks)
- Veterinary Science I (8088/36 weeks, 140 hours)
- Veterinary Science II (8089/36 weeks, 140 hours)

Career Cluster: Agriculture, Food and Natural Resources	
Pathway	**Occupations**
Animal Systems	**Animal Breeder, Husbandry** **Animal Geneticist** **Animal Scientist** **Aquacultural Manager**
Environmental Service Systems	**Environmental Compliance Inspector** **Environmental Sampling and Analysis Technician** **Toxicologist**
Food Products and Processing Systems	**Biochemist** **Food Scientist**
Natural Resources Systems	**Ecologist** **Fisheries Technician** **Forest Technician** **Microbiologist**
Plant Systems	**Botanist** **Certified Crop Advisor** **Crop Grower** **Forest Geneticist** **Ornamental Horticulturist** **Plant Breeder/ Geneticist** **Soil and Plant Scientist** **Tree Surgeon**
Power, Structural, and Technical Systems	**Agricultural Engineer**

Career Cluster: Health Science	
Pathway	**Occupations**
Biotechnology Research and Development	**Biochemist** **Cell Biologist** **Research Assistant**
Diagnostics Services	**Cardiovascular Technologist** **Computer Tomography (CT) Technologist** **Medical, Clinical Laboratory Technician** **Radiologic Technologist, Radiographer**
Health Informatics	**Epidemiologist**
Support Services	**Environmental Sampling and Analysis Technician** **Medical, Clinical Laboratory Technologist**

Career Cluster: Science, Technology, Engineering and Mathematics	
Pathway	**Occupations**
Engineering and Technology	**Agricultural Engineer** **Biomedical Engineer** **Environmental Engineer** **Petroleum Engineer**
Science and Mathematics	**Animal Nutritionist** **Animal Scientist** **Biologist** **Botanist** **Chemist** **Ecologist**

Career Cluster: Science, Technology, Engineering and Mathematics	
Pathway	**Occupations**
	Environmental Scientist **Geoscientist** **Hydrologist** **Microbiologists** **Oceanographer** **Plant Biologist** **Plant Breeder and Geneticist** **Plant Pathologist** **Research Chemist** **Secondary School Teacher** **Toxicologist** **Veterinarian**