Biotechnology Applications in Agriculture

8087 36 weeks

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Acknowledgments

The components of this instructional framework were developed by the following curriculum development panelists:

Jeb Barrett, Professor of Biological Sciences, Virginia Tech, Blacksburg
Brittany Council-Morton, 4-H Youth Development/Urban Agriculture Extension, Virginia Tech, Richmond
Carrie Gray, Instructor, Turner Ashby High School, Rockingham County Public Schools
Renee Hypes, Instructor, Gloucester High School, Gloucester County Public Schools
Breyon Pierce, Owner, Pierce Farms LLC, Surry
Dan Swafford, 4-H Curriculum Specialist, Virginia Tech, Blacksburg

Correlations to the Virginia Standards of Learning were reviewed and updated by:

Leslie R. Bowers, English Teacher (ret.), Newport News Public Schools
Vickie L. Inge, Mathematics Committee Member, Virginia Mathematics and Science Coalition
Anne F. Markwith, New Teacher Mentor (Science), Gloucester County Public Schools
Michael Nagy, Social Studies Department Chair, Rustburg High School, Campbell County Public Schools

The framework was edited and produced by the CTE Resource Center:

Averill P. Byrd, Writer/Editor
Kevin P. Reilly, Administrative Coordinator

LaVeta Nutter, Specialist, Agricultural Education and Related Clusters
J. Anthony Williams, Curriculum and Instruction Coordinator
Dr. David S. Eshelman, Director, Workforce Development and Initiatives
George R. Willcox, Director, Operations and Accountability

Office of Career, Technical, and Adult Education
Virginia Department of Education

Course Description

Suggested Grade Level: 11 or 12
Prerequisites: 8085

This course introduces students to biotechnological research and experimentation techniques used in the plant, animal, environmental, and food science industries. Students develop occupational skills, learn to think critically, work collaboratively, and use data analysis to make informed decisions regarding societal, legal, and ethical concerns posed by agricultural biotechnology. This course prepares students for postsecondary educational opportunities in biotechnology-related careers in the agriculture, food, and natural resources (AFNR) industries.

Task Essentials Table

8087	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.	
⊕	Implement safe laboratory and experimental procedures.	
⊕	Conduct an experiment or a research project in agriculture.	

⊕	Practice standard operating procedures (SOPs) related to the agricultural biotechnology lab.	
⊕	Identify state and federal agencies relevant to one's chosen research field.	
⊕	Research the emergence, evolution, and implications of bioethics associated with AFNR industries.	
⊕	Present views on a current bioethics issue in agriculture.	
⊕	Analyze a biotechnological innovation.	
⊕	Simulate biotechnological innovation.	
⊕	Analyze methods of plant breeding.	
⊕	Conduct an investigation that incorporates agricultural biotechnology.	
○	Demonstrate cloning methods used in plant science.	
⊕	Produce a plant, using tissue culture.	
⊕	Analyze gene transfer.	
⊕	Recommend biological controls, based on a case study.	
⊕	Investigate animal reproductive technologies.	
⊕	Conduct an economic analysis of genetically engineered plants or animals vs. traditional crops and breeds.	
⊕	Explore the use of biotechnology in food science.	
⊕	Conduct an experiment with enzyme(s) that are used in the food industry.	
⊕	Preserve food.	
⊕	Investigate the use of bioremediation and biorestoration in environmental management.	
⊕	Demonstrate how phytoremediation is used in environmental management.	
⊕	Assess air, soil, and water quality.	
⊕	Create a bioremediation plan.	
⊕	Explain gene mapping.	
⊕	Investigate applications of genomics in AFNR.	
⊕	Analyze genetic sequence data using bioinformatic tools.	

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

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?

Exploring Leadership Skills and FFA Membership

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?

Applying Biotechnology in Agriculture

Task Number 44

Implement safe laboratory and experimental procedures.

Definition

Implementation should include

- personal protective equipment (PPE)
- first aid
- general safety rules and regulations, including identifying safety symbols and signs
- industry practices in the handling and disposal of hazardous materials
- safety data sheets (SDS)
- chemical hygiene plan
- record-keeping and retention
- manufacturer guidelines for equipment and material use.

Process/Skill Questions

- Why is documentation of safety procedures and protocols important?
- Why is it necessary to know, practice, and have access to safety instruction in the laboratory?
- Why are specific clean-up procedures for hazardous materials important?
- Where in the laboratory should written information and/or visuals demonstrating proper safety procedures be kept?
- What is the procedure for handling and reporting accidents and injuries?

Task Number 45

Conduct an experiment or a research project in agriculture.

Definition

Conducting research or an experiment should include

- use of the scientific method or the engineering design process
- completed experimental design diagram
- recording data using the International System of Units (SI)
- summarizing data
- drawing conclusions
- planning follow-up experiments
- writing a laboratory report and recommendations.

Process/Skill Questions

- Why is it important to do initial research before conducting an experiment?
- What is the purpose of developing a hypothesis? Of having constants and a control in an experiment?
- What is the role of repeated trials in an experiment?
- Why is it important to complete a written laboratory report of the experiment?
- Why is it important to identify possible sources of error in an experiment?

Task Number 46

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

Definition

Practice should include

- writing the SOPs, with emphasis on quality control and data collection
    - identifying type of data to collect
    - collecting and recording data and metadata
    - organizing data
    - analyzing data
- implementing the SOPs.

Process/Skill Questions

- How would one find the SOPs in the lab?
- What type of information (data) should be collected in a logbook?
- Why are metric units of measurement used in experiments?
- What are some steps that can be taken to secure valid and reliable data?
- What type of environmental issues could affect the quality control of an experiment?

Task Number 47

Identify state and federal agencies relevant to one's chosen research field.

Definition

Identification should include the names of agencies along with a description of their role in funding or regulating one's chosen research field. Some agencies include

- U.S. Department of Agriculture
- U.S. Food and Drug Administration
- U.S. Environmental Protection Agency
- U.S. Fish and Wildlife Service
- Virginia Department of Agriculture
- Virginia Department of Forestry
- Virginia Department of Game and Inland Fisheries
- Virginia Department of Environmental Quality
- Virginia Department of Conservation and Recreation
- Farm Service Agency
- Natural Resource Conservation Service
- Farm Bureau

- Sustainable Agriculture Research Education
- soil and water conservation districts
- local cooperative extension offices.

Process/Skill Questions

- How do agencies work together to regulate and monitor agricultural products?
- How are the various agencies funded?

Task Number 48

Research the emergence, evolution, and implications of bioethics associated with AFNR industries.

Definition

Research could include

- implications on future advancements
- intellectual property
- emerging technologies in AFNR (e.g., transgenics, biologics)
- biosecurity
- food safety
- food security
- sustainability.

Process/Skill Questions

- What role do regulatory agencies have in the evolution of biotechnology in the AFNR industries?
- How can regulatory agencies keep up with scientific advancements?
- What are the implications for food safety and food security if biotechnology is not regulated?

Task Number 49

Present views on a current bioethics issue in agriculture.

Definition

Presentation should include a critique and explanation of ethical principles reflected through economic, social, legal, cultural, environmental, and religious aspects of society.

Process/Skill Questions

- What are the similarities and differences between ethics and bioethics?
- What is *biotechnology*? How is it related to genetic engineering?
- Why are ethics essential in biotechnology? In genetic engineering?

- How are ethical principles developed? Who develops ethical principles?

Task Number 50

Analyze a biotechnological innovation.

Definition

Analysis should include the effects of biotechnological innovations on the AFNR industries and could include

- increased crop yields through plant modifications that help reduce pesticide and water use and/or improve tolerance to climatic factors
- improved food nutrient content and preservation techniques
- detection and management of pollution
- alternative fuel sources
- new tools and drugs for managing health
- the use of transgenic organisms in biomanufacturing.

Process/Skill Questions

- How has plant biotechnology affected the agriculture industry?
- How have plant biotechnology products been used in the food and technology industry, in environmental applications, and in the medical field?

Task Number 51

Simulate biotechnological innovation.

Definition

Simulation should include

- collaborating with other students
- assigning roles to each member of the team
- creating SOPs
- using the engineering design process
- developing solutions that address real-world problems
- identifying resources and techniques to be used for production.

Process/Skill Questions

- What is *biotechnological innovation*?
- What areas of need or questions need to be addressed in the field of biotechnology?
- How can the engineering design process be applied to address innovation?

Applying Biotechnology to Agricultural Species

Task Number 52

Analyze methods of plant breeding.

Definition

Analysis should include

- selection
- hybridization
- polyploidy
- induced mutations (mutagenesis)
- marker-assisted selection
- micropropagation (in vitro cultivation)
- genetic engineering
- cloning.

Process/Skill Questions

- What is the difference between line breeding and crossbreeding?
- What is the purpose of plant breeding?
- What are some popular uses of hybrid plants?

Task Number 53

Conduct an investigation that incorporates agricultural biotechnology.

Definition

Conducting an investigation may include

- DNA extraction
- polymerase chain reaction (PCR)
- gel electrophoresis
- spectrophotometry
- creation of transgenic organisms
- gene knockout technology
- use of somatic cell nuclear transfer (i.e., cloning).

Process/Skill Questions

- What steps are taken to plan and develop a plant field trial?
- Why is it important to conduct and collect data from field trials?

- What can be learned from analyzing data collected from a field trial?
- What is the difference between cloning from embryos and cloning from differentiated cells?
- What government agencies are involved in regulating animal biotechnology?

Task Number 54

Demonstrate cloning methods used in plant science.

Definition

Demonstration should include

- researching the definition and applications of cloning
- using a cloning method
    - cuttings
    - grafting
    - layering
    - division
    - separation.

Process/Skill Questions

- What are examples of organisms that have been cloned?
- What are ethical issues associated with the cloning of organisms?
- What is *eugenics*?
- How might one summarize the guidelines for research that were originally developed to guide eugenics?

Task Number 55

Produce a plant, using tissue culture.

Definition

Production should include

- sterilization techniques for equipment in a laboratory, using SOPs
- the use of plant cells grown in aseptic, controlled conditions
- media preparation
- recording data and results
- preparing a written report.

Process/Skill Questions

- What steps are taken to plan and develop a plant field trial?
- Why is it important to conduct and collect data from field trials?
- What can be learned from analyzing data collected from a field trial?

Task Number 56

Analyze gene transfer.

Definition

Analysis should include common techniques for moving a gene from one organism to another, including

- indirect transfer by vector-mediated gene transfer (e.g., *Agrobacterium tumefaciens*, vaccines)
- direct transfer (e.g., chemical mediation, microinjection, electroporation, particle bombardment)

Process/Skill Questions

- What are some of the processes of gene transfer, and what are the differences between them?
- How has gene transfer affected plant specialization?

Task Number 57

Recommend biological controls, based on a case study.

Definition

Recommendations could include

- alternatives to pesticides
- integrated pest management (IPM)
- microbiomes (e.g., mychorrizae, plant epiphytes, gut microbes).

Process/Skill Questions

- How do biological controls alter a plant?
- How are biological controls used in biotechnology?
- How do biological controls help manage disease?

Task Number 58

Investigate animal reproductive technologies.

Definition

Investigation should include

- natural breeding systems
- artificial insemination
- in vitro fertilization
- gender preselection

- embryo transfer.

Process/Skill Questions

- What is *in vitro fertilization*?
- What are the advantages of artificial insemination?
- What steps comprise the artificial insemination process?
- How is embryo transfer accomplished?
- Why would one opt for animal reproductive technology vs. natural breeding practices?

Task Number 59

Conduct an economic analysis of genetically engineered plants or animals vs. traditional crops and breeds.

Definition

Conducting an economic analysis should include an evaluation of the effectiveness, feasibility, and profitability of genetically engineering agricultural species and could address

- inputs (e.g., fertilizers, pesticides, irrigation)
- crop yield
- enhanced quality of commodities
- optimum use of scarce resources
- the establishment of a more abundant, inexpensive, and varied food supply
- externalities (e.g., pollution, emerging diseases).

Process/Skill Questions

- What are the positive and negative impacts of the use of animal biotechnology on society?
- How has the use of animals in biotechnology increased the understanding of human diseases?

Examining Food Science

Task Number 60

Explore the use of biotechnology in food science.

Definition

Exploration should include

- biotechnology's role in the development of new food products through a variety of scientific tools and techniques
- products that have never been used as a food
- foods that have been modified by genetic manipulation, also known as genetically modified foods, genetically engineered foods, or biotechnology-derived foods.

Process/Skill Questions

- What are *macronutrients*? *Micronutrients*? What are their roles in biotechnology and food science?
- How is genetic engineering used to produce bio-fortified crops?

Task Number 61

Conduct an experiment with enzyme(s) that are used in the food industry.

Definition

Conducting an experiment could include the use of various enzymes to

- process food
- ferment food
- make food easier to digest
- break down by-products for disposal.

Process/Skill Questions

- What are some of the important microbial enzymes used in the food processing industry?
- How are lipases, amylases, proteases, rennet, pectinases, invertases, cellulases, and glucose oxidase used in the food industry?
- What are some functions of enzymes in the human body?
- How is genetic engineering used to produce enzymes through biomanufacturing?

Task Number 62

Preserve food.

Definition

Food preservation could include

- fermenting
- pickling
- drying
- salting
- smoking
- curing

and discussing how these methods

- prevent the growth of bacteria, fungi (e.g., yeasts), or other microorganisms
- retard the oxidation of fats that cause rancidity
- inhibit visual deterioration
- simplify food production.

Teacher resource: Dry Curing Virginia-Style Ham, Virginia Cooperative Extension

Process/Skill Questions

- What challenges might be faced when preserving food?
- What are some of the important developments in food preservation?
- What is *fermentation*? What is its role in bioprocessing?
- What are examples of microbial applications?
- What are the elements of a successful processing design?

Applying Biotechnology in Environmental Science

Task Number 63

Investigate the use of bioremediation and biorestoration in environmental management.

Definition

Investigation should include the use of microbes to address

- oil spills
- wastewater management
- chemical spills
- nitrogen fixation
- carbon sequestration.

Process/Skill Questions

- How can microbes help restore an environment that has been polluted?
- How are microbes used in the bioremediation process?

Task Number 64

Demonstrate how phytoremediation is used in environmental management.

Definition

Demonstration should include the ways plants are used to maintain and repair the environment, such as

- pollution prevention and clean-up
- conservation and preservation of water (e.g., riparian buffers)
- soil management (e.g., cover crops)
- biofilters
- other best management practices (BMP).

Process/Skill Questions

- What characteristics are used when selecting plants to manage the environment?
- How are plants used to prevent nutrient run-off in lakes and rivers?

Task Number 65

Assess air, soil, and water quality.

Definition

Assessment could include

- identifying resident bioindicators (e.g., macroinvertebrates in streams)
- considering abiotic factors (e.g., nitrates, phosphates, pH, turbidity).

Teacher resources:

- Virginia Department of Environmental Quality
- Virginia Department of Game and Inland Fisheries

Process/Skill Questions

- What type of system is used to help monitor soil contamination?
- How is the data collected from monitoring systems used?

Task Number 66

Create a bioremediation plan.

Definition

Creation of a plan should include

- assessment of area
- identification of the problem
- identification of stakeholders
- proposed solution
- analysis of the bioremediation plan.

Process/Skill Questions

- What is the problem?
- Who are the stakeholders?
- What are potential solutions?
- What is the best solution?
- How will the plan's effectiveness be analyzed?

Investigating Bioinformatics and Genomics

Task Number 67

Explain gene mapping.

Definition

Explanation should include the concept that gene mapping involves the use of DNA markers to locate the genes on chromosomes that will identify plant traits.

Process/Skill Questions

- Why is gene mapping important to plant biotechnology?
- What is a DNA marker?
- What are some uses for gene mapping?

Task Number 68

Investigate applications of genomics in AFNR.

Definition

Investigation should include the interaction between the genome and the environment (e.g., epigenetics, gene editing, environmental genomics).

Process/Skill Questions

- How do environmental factors affect gene expression?

- How does epigenetics affect the gene editing process/research?

Task Number 69

Analyze genetic sequence data using bioinformatic tools.

Definition

Analysis can be conducted using tools such as Basic Local Alignment Search Tool (BLAST) and GenBank.

Process/Skill Questions

- How does one identify a genetic sequence for research purposes?
- How does one use a genomic database to analyze a genetic sequence?
- How can a genomic database be useful in biotechnology research?

SOL Correlation by Task

39	Identify the role of supervised agricultural experiences (SAEs) in agricultural education.	English: 11.3, 11.5, 12.3, 12.5
40	Participate in an SAE.	English: 11.5, 11.8, 12.5, 12.8
41	Identify the benefits and responsibilities of FFA membership.	English: 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: 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: 11.5, 12.5
44	Implement safe laboratory and experimental procedures.	English: 11.5, 12.5 Science: CH.1
45	Conduct an experiment or a research project in agriculture.	English: 11.8, 12.8 Mathematics: AFDA.8, AII.9, AII.11, PS.1*, PS.2*, PS.3*, PS.4*, PS.8*, PS.10* Science: BIO.1, CH.1, PH.1
46	Practice standard operating procedures (SOPs) related to the agricultural biotechnology lab.	English: 11.6, 11.7, 12.6, 12.7 Mathematics: AFDA.8, AII.9, AII.11, PS.1*, PS.2*, PS.3*, PS.4*, PS.8*, PS.10*
47	Identify state and federal agencies relevant to one's chosen research field.	English: 11.5, 11.8, 12.5, 12.8 History and Social Science: GOVT.7, GOVT.8, GOVT.12, GOVT.14, GOVT.15

48	Research the emergence, evolution, and implications of bioethics associated with AFNR industries.	English: 11.8, 12.8 History and Social Science: GOVT.7, GOVT.8, GOVT.12, GOVT.14, GOVT.15, VUS.14, WG.17, WHII.14
49	Present views on a current bioethics issue in agriculture.	English: 11.1, 12.1 History and Social Science: GOVT.7, GOVT.8, GOVT.12, GOVT.14, GOVT.15, VUS.14, WG.17, WHII.14
50	Analyze a biotechnological innovation.	English: 11.5, 12.5 History and Social Science: GOVT.7, GOVT.8, GOVT.12, GOVT.14, GOVT.15, VUS.14, WG.17, WHII.14 Science: PH.3, PH.4
51	Simulate biotechnological innovation.	English: 11.1, 11.5, 12.1, 12.5 History and Social Science: GOVT.7, GOVT.8, GOVT.12, GOVT.14, GOVT.15, VUS.14, WG.17, WHII.14 Science: PH.4
52	Analyze methods of plant breeding.	English: 11.5, 12.5
53	Conduct an investigation that incorporates agricultural biotechnology.	English: 11.8, 12.8
54	Demonstrate cloning methods used in plant science.	English: 11.8, 12.8 Science: BIO.5
55	Produce a plant, using tissue culture.	English: 11.1, 11.6, 11.7, 12.1, 12.6, 12.7 Mathematics: AFDA.8, AII.9, AII.11, PS.1*, PS.2*, PS.3*, PS.4*, PS.8*, PS.10*
56	Analyze gene transfer.	English: 11.5, 12.5
57	Recommend biological controls, based on a case study.	English: 11.5, 12.5
58	Investigate animal reproductive technologies.	English: 11.5, 11.8, 12.5, 12.8
59	Conduct an economic analysis of genetically engineered plants or animals vs. traditional crops and breeds.	English: 11.5, 12.5 History and Social Science: GOVT.7, GOVT.8, GOVT.12, GOVT.14, GOVT.15, VUS.14, WG.17, WHII.14
60	Explore the use of biotechnology in food science.	English: 11.5, 12.5 History and Social Science: GOVT.7, GOVT.8, GOVT.12, GOVT.14, GOVT.15, VUS.14, WG.17, WHII.14

61	Conduct an experiment with enzyme(s) that are used in the food industry.	History and Social Science: GOVT.7, GOVT.8, GOVT.12, GOVT.14, GOVT.15, VUS.14, WG.17, WHII.14
62	Preserve food.	
63	Investigate the use of bioremediation and biorestoration in environmental management.	English: 11.5, 11.8, 12.5, 12.8 History and Social Science: GOVT.7, GOVT.8, GOVT.12, GOVT.14, GOVT.15, VUS.14, WG.17, WHII.14 Science: BIO.8
64	Demonstrate how phytoremediation is used in environmental management.	History and Social Science: GOVT.7, GOVT.8, GOVT.12, GOVT.14, GOVT.15, VUS.14, WG.17, WHII.14
65	Assess air, soil, and water quality.	English: 11.5, 11.8, 12.5, 12.8 History and Social Science: GOVT.7, GOVT.8, GOVT.12, GOVT.14, GOVT.15, VUS.14, WG.17, WHII.14 Science: BIO.8
66	Create a bioremediation plan.	English: 11.1, 11.5, 12.1, 12.5 History and Social Science: GOVT.7, GOVT.8, GOVT.12, GOVT.14, GOVT.15, VUS.14, WG.17, WHII.14
67	Explain gene mapping.	English: 11.5, 12.5 Science: BIO.5
68	Investigate applications of genomics in AFNR.	English: 11.5, 11.8, 12.5, 12.8 Science: BIO.5
69	Analyze genetic sequence data using bioinformatic tools.	English: 11.5, 12.5 Science: BIO.5

FFA Information

The National FFA is an organization dedicated to preparing members for leadership and careers in the science, business, and technology of agriculture. Local, state, and national activities and award programs provide opportunities to apply knowledge and skills acquired through agriculture education.

For additional information about the student organization, see the National FFA website and the Virginia FFA Association website.

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
- College and Work Readiness Assessment (CWRA+)
- Customer Service Specialist (CSS) Examination
- National Career Readiness Certificate Assessment
- Natural Resources Systems Assessment
- Production Agriculture Assessment
- Small Animal Science and Technology Assessment
- Workplace Readiness Skills for the Commonwealth Examination

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)
- Biotechnology Foundations in Agricultural and Environmental Science (8085/36 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)
- Forestry Management (8042/36 weeks)
- Forestry Management, Advanced (8044/36 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)
- Small Animal Care I (8083/36 weeks)
- Small Animal Care I (8081/18 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	**Agricultural Products Sales Representative** **Animal Breeder, Husbandry** **Animal Geneticist**

Career Cluster: Agriculture, Food and Natural Resources	
Pathway	**Occupations**
	Animal Nutritionist **Animal Scientist** **Aquacultural Manager** **Poultry Manager** **Veterinarian** **Veterinary Technician**
Environmental Service Systems	**Environmental Compliance Inspector** **Environmental Sampling and Analysis Technician** **Toxicologist** **Water Conservationist**
Food Products and Processing Systems	**Biochemist** **Food Scientist**
Natural Resources Systems	**Ecologist** **Fish and Game Officer** **Fisheries Technician** **Forest Manager, Forester** **Forest Technician** **Geological Technician** **Microbiologist**
Plant Systems	**Botanist** **Certified Crop Advisor** **Forest Geneticist** **Plant Breeder/ Geneticist** **Soil and Plant Scientist** **Tree Surgeon**
Power, Structural, and Technical Systems	**Agricultural Engineer**

Career Cluster: Science, Technology, Engineering and Mathematics	
Pathway	**Occupations**
Engineering and Technology	**Agricultural Engineer** **Biomedical Engineer** **Environmental Engineer**
Science and Mathematics	**Animal Nutritionist** **Animal Scientist** **Biologist** **Botanist** **Chemist** **Ecologist** **Economist** **Environmental Scientist** **Microbiologists** **Oceanographer** **Plant Biologist** **Plant Breeder and Geneticist** **Plant Pathologist** **Research Chemist** **Toxicologist** **Veterinarian** **Veterinary Assistant**