North Dakota Agriculture Education

# BIOTECHNOLOGY SYSTEMS

**Assess factors that have influenced the evolution of biotechnology in agriculture (e.g., scientific technologies, historical events, societal trends, ethical and legal implications, etc.).**

1 **Investigate and explain the relationships in the timeline of developing biotechnology applications and techniques in agriculture (e.g., major innovators, historical developments, potential applications of biotechnology, etc.).** 4.1

1 Diagram the progression of biotechnology and the evolution of scientific knowledge. 4.1.1

2 Identify the benefits and risks of biotechnology compared with alternative approaches to improving agriculture. 4.1.2

3 Identify careers, skills, and the educational preparation needed for entry level careers in biotechnology. 4.1.3

4 Analyze emerging issues and applications associated with agricultural biotechnology. 4.1.4

5 Compare and contrast the benefits and risks associated with using biotechnology to improve agriculture. 4.1.5

6 Assess personal skill sets compared to the skills needed for entry level careers in biotechnology. 4.1.6

7 Design a potential application of biotechnology to meet emerging agricultural and societal needs. 4.1.7

8 Evaluate the short-term and long-term benefits and risks of applying biotechnology to agriculture. 4.1.8

9 Create an individualized student experience that applies basic lab skills to lead to one of the identified jobs and careers. 4.1.9

2 **Evaluate the roles, scope, and implications of regulatory agencies on applications of biotechnology in agriculture and the protection of public interests (e.g., health, safety, environmental issues, etc.).** 4.2

1 Summarize the role and scope of biotechnology regulatory agencies (e.g., local, state, national, international). 4.2.1

2 Identify regulatory issues related to biotechnology in agriculture. 4.2.2

3 Explain the relationship between biotechnology regulatory agencies and the protection of public interests such as health, safety, and the environment. 4.2.3

4 Compare and contrast biotechnology regulatory systems (e.g., local, state, national, international). 4.2.4

5 Analyze the impact regulatory issues have on both the agricultural industry and on public acceptance of biotechnology in agriculture. 4.2.5

6 Examine factors and data that regulatory agencies use to evaluate the potential risks a new application of biotechnology may pose to health, safety, and the environment. 4.2.6

7 Evaluate how countries with different biotechnology regulatory systems impact trade and innovation. 4.2.7

8 Propose a plan to address a regulatory issue pertaining to biotechnology in agriculture. 4.2.8

9 Evaluate if new technologies present regulatory issues to health, safety or the environment. 4.2.9

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**3 Analyze the relationship and implications of bioethics, laws, and public perceptions on applications of biotechnology in agriculture (e.g., ethical, legal, social, cultural issues).** 4.3

1 Identify the emergence, evolution, and implications of bioethics associated with biotechnology in agriculture. 4.3.1

2 Summarize legal issues related to biotechnology in agriculture (e.g., protection of intellectual property through patents, copyright, trademarks, etc.). 4.3.2

3 Identify public perceptions of biotechnology in agriculture (e.g., social and cultural issues). 4.3.3

4 Analyze the implications bioethics may have on future advancements in biotechnology and associated science fields. 4.3.4

5 Determine the significance and impacts of legal issues related to biotechnology in agriculture. 4.3.5

6 Analyze the impact of public perceptions on the application of biotechnology in different AFNR systems. 4.3.6

7 Devise an argument for or against an ethical issue associated with biotechnology in agriculture. 4.3.7

8 Propose a solution for a legal issue associated with biotechnology in agriculture. 4.3.8

9 Design a survey to examine public perceptions of scientifically-based arguments regarding biotechnology in agriculture and reflect on the reasons why the public may support or resist significant breakthroughs using biotechnology. 4.3.9

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**Demonstrate proficiency by safely applying appropriate laboratory skills to complete tasks in a biotechnology research and development environment (e.g., standard operating procedures, record keeping, aseptic**

**4 Read, document, evaluate, and secure accurate laboratory records of experimental protocols, observations, and results.** 4.4

1 Compare and contrast common record-keeping methods used in a research and/or commercial laboratory (e.g., paper notebook, electronic notebook, etc.). 4.4.1

2 Summarize best practices for data and information security in a research and/or commercial laboratory. 4.4.2

3 Access a bioinformatics database to extract data. 4.4.3

**technique, equipment maintenance, etc.).**

4 Maintain laboratory records documented in a laboratory to ensure data accuracy and integrity (e.g., avoid bias, record any conflicts of interest, avoid misinterpreted results, etc.). 4.4.4

5 Determine when security procedures for data and information collected in a laboratory should be implemented. 4.4.5

6 Analyze data extracted from a bioinformatics database. 4.4.6

7 Propose improvements to documentation to ensure study replication, utility, and safety. 4.4.7

8 Devise a strategy for ensuring the security of data and information collected in a laboratory. 4.4.8

9 Create an application of bioinformatics to solve an agricultural issue. 4.4.9

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**5 Identify and apply standard laboratory procedures and equipment maintenance to create and maintain reliable data.** 4.5

1 Describe standard operating procedures for laboratory equipment. 4.5.1

2 Categorize laboratory equipment according to its purpose in scientific research. 4.5.2

3 Describe sterilization techniques for equipment in a laboratory (e.g., media bottles vs. laminar flow hood, etc.). 4.5.3

4 Perform ongoing maintenance of laboratory equipment according to the standard operating procedures (e.g., calibration, testing, etc.). 4.5.4

5 Operate laboratory equipment and measurement devices to get accurate and repeatable results. 4.5.5

6 Perform sterilization techniques for equipment in a laboratory using standard operating procedures. 4.5.6

7 Develop a maintenance program for laboratory equipment based upon the standard operating procedures. 4.5.7

8 Develop a proposal for new laboratory equipment or measurement devices. 4.5.8

9 Create a plan for sterilizing equipment in a laboratory according to standard operating procedures. 4.5.9

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**6 Apply standard operating procedures for the safe handling of biological and chemical materials in a laboratory.** 4.6

1 Classify different types of personal protective equipment and demonstrate how to properly utilize the equipment. 4.6.1

2 Describe aseptic techniques in the laboratory (e.g., sterile work area, sterile handling, personal hygiene, etc.). 4.6.2

3 Categorize the types of solutions that are commonly prepared in a laboratory (e.g., buffers, reagents, media, etc.). 4.6.3

4 Assess the need for personal protective equipment in a variety of situations and select the appropriate equipment to wear when working with biological and chemical materials. 4.6.4

5 Demonstrate aseptic techniques in the laboratory. 4.6.5

6 Formulate solutions using standard operating procedures (e.g. proper labeling, dilution, etc.). 4.6.6

7 Evaluate the benefits and limitations of personal protective equipment. 4.6.7

8 Create a standard operating procedure for working with biological materials based upon their classification. 4.6.8

9 Create a plan for the storage of solutions (e.g., temperature, volatility, neighboring solutions, light sensitivity, etc.). 4.6.9

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**7 Safely manage and dispose of biological materials, chemicals, and wastes according to standard operating procedures.** 4.7

1 Describe hazards associated with biological and chemical materials. 4.7.1

2 Perform waste disposal according to the standard operating procedures. 4.7.2

3 Propose a management plan to reduce laboratory waste and prevent ecological or health problems related to waste disposal. 4.7.3

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**8 Examine and perform scientific procedures using microbes, DNA, RNA and proteins in a laboratory.** 4.8

1 Differentiate types of organisms by the physical and biological properties of those organisms. (e.g., plant and animal tissue, cell cultures, microbes, etc.). 4.8.1

2 Identify the tools and techniques used to extract and purify DNA and RNA. 4.8.2

3 Summarize the role and applications of protein purification in agricultural biotechnology. 4.8.3

4 Compare and contrast proteins, enzymes, and antibodies and their relevant uses in agricultural microbiology. 4.8.4

5 Apply appropriate aseptic techniques for isolating different organisms. 4.8.5

6 Perform DNA or RNA extraction and purification techniques. (e.g., gel electrophoresis, southern blotting, etc.). 4.8.6

7 Demonstrate protein separation techniques and interpret the results. 4.8.7

8 Analyze how antibodies are formed and how they can be used in agricultural biotechnology. 4.8.8

9 Create protocols to isolate, maintain, quantify, and store cell cultures according to standard operating procedures. 4.8.9

10 Interpret data generated by extracting and purifying DNA or RNA (e.g., southern blotting, cloning, PCR, RT-PCR, etc.). 4.8.10

11 Evaluate the biochemical properties of proteins to predict potential uses. 4.8.11

12 Detect and quantify antigens by conducting an Enzyme-Linked Immunosorbent Assay (ELISA). 4.8.12

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**Demonstrate the application of**

**9 Apply biotechnology principles, techniques, and processes to modify a species.** 4.9

**biotechnology to solve problems in Agriculture, Food and Natural Resources (AFNR) systems (e.g., bioengineering, food processing, waste management, horticulture, forestry, livestock, crops, etc.).**

1 Describe the techniques used to produce transgenic organisms (e.g., microbial synthetic biology, gene knockout therapy, traditional gene insertion, etc.). 4.9.1

2 Summarize the process of transformation of cells with transgenic DNA. 4.9.2

3 Analyze the processes and techniques used to produce transgenic eukaryotes (e.g., microbial synthetic biology, gene knockout therapy, traditional gene insertion, etc.). 4.9.3

4 Transform plant or animal cells by performing a cellular transformation. 4.9.4

5 Design experiments to evaluate an existing transgenic organism. 4.9.5

6 Evaluate the results of a cellular transformation. 4.9.6

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**10 Apply biotechnology principles, techniques, and processes to enhance the production of food through the use of microorganisms and enzymes.** 4.10

1 Summarize reasons for detecting microbes. 4.10.1

2 Describe enzymes, the changes they cause, and the physical and chemical parameters that affect enzymatic reactions (e.g., food, cellulosic bioenergy, etc.). 4.10.2

3 Identify foods produced through the use of biotechnology (e.g., fermentation, etc.) to change the chemical properties of food for an intended purpose (e.g., create desirable nutritional profile, preservation, flavor, etc.). 4.10.3

4 Assess the use of biotechnology to detect microbes. 4.10.4

5 Analyze processes by which enzymes are produced through biotechnology. 4.10.5

6 Compare and contrast the effectiveness, purpose, and outcomes associated with biotechnology as well as conventional processes used in food processing. 4.10.6

7 Design an assay to detect a target microorganism in food, water, or the environment. 4.10.7

8 Conduct studies using scientific techniques to improve or discover enzymes for use in biotechnology (e.g., microbial strain selection). 4.10.8

9 Process food using biotechnology to achieve an intended purpose (e.g., preservation, flavor enhancement, etc.). 4.10.9

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**11 Apply biotechnology principles, techniques, and processes to protect the environment and maximize use of natural resources (e.g., biomass, bioprospecting, industrial biotechnology, etc.).** 4.11

1 Describe the consequences of agricultural practices on natural populations. 4.11.1

2 Summarize industrial biotechnology and the benefits and risks associated with its use in manufacturing (e.g., fabrics, plastics, etc.). 4.11.2

3 List the potential applications of bioprospecting in biotechnology and agriculture. 4.11.3

4 Analyze how biotechnology can be used to monitor the effects of agricultural practices on natural populations. 4.11.4

5 Apply the processes used in the production of molecules for use in industrial applications. 4.11.5

6 Assess the pros and cons of bioprospecting to achieve a research or product development objective. 4.11.6

7 Evaluate the impact of modified organisms on the natural environment. 4.11.7

8 Evaluate processes used in the synthesis of a molecule. 4.11.8

9 Propose opportunities to use bioprospecting after weighing the short-term and long-term impacts on the environment. 4.11.9

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**12 Apply biotechnology principles, techniques, and processes to enhance plant and animal care and production (e.g., selective breeding, pharmaceuticals, biodiversity, etc.).** 4.12

1 Identify the aims and techniques involved in the selective plant-breeding process. 4.12.1

2 Describe biotechnology processes applicable to animal health (e.g., genetic testing, etc.). 4.12.2

3 Categorize the types of pharmaceuticals developed for animals and humans through biotechnology. 4.12.3

4 Summarize the need for global biodiversity and applications of biotechnology to reduce threats to biodiversity. 4.12.4

5 Select techniques and tools used to monitor and direct plant breeding. 4.12.5

6 Assess the benefits, risks, and opportunities associated with using biotechnology to promote animal health. 4.12.6

7 Distinguish between plant-based and animal-based pharmaceuticals. 4.12.7

8 Utilize techniques to measure biodiversity in a population. 4.12.8

9 Perform plant-breeding techniques (e.g., plant tissue culture, etc.). 4.12.9

10 Design animal-care protocols to ethically monitor and promote animal systems associated with biotechnology. 4.12.10

11 Evaluate the process used to produce pharmaceuticals from transgenic organisms (e.g., hormones for animals, etc.). 4.12.11

12 Evaluate whether current threats to biodiversity will have an unsustainable impact on human populations. 4.12.12

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**13 Apply biotechnology principles, techniques, and processes to produce bioproducts (e.g., fermentation, transesterification, methanogenesis, etc.).** 4.13

1 Explain the need for bioproducts (e.g., cellulosic bioenergy, bioplastics, biofoams, biocomposites, biofuels, etc.). 4.13.1

2 Differentiate between biomass and sources of biomass. 4.13.2

3 Explain the process of fermentation and its potential applications. 4.13.3

4 Summarize the process of transesterification and its potential applications. 4.13.4

5 Describe the process of methanogenesis and its potential applications. 4.13.5

6 Analyze the impact of the production and use of bioproducts on the environment. 4.13.6

7 Assess the characteristics of biomass that make it useful for bioproduct production. 4.13.7

8 Compare the relationship between fermentation and the process used to produce alcohol from biomass. 4.13.8

9 Analyze the process used to produce biodiesel from biomass. 4.13.9

10 Analyze the process used to produce methane from biomass. 4.13.10

11 Defend how bioproducts could solve a global issue (e.g., environmental, agricultural, etc.). 4.13.11

12 Evaluate the pros and cons of the technologies used to create bioproducts from biomass. 4.13.12

13 Produce alcohol and co-products from biomass. 4.13.13

14 Produce biodiesel and co-products from biomass. 4.13.14

15 Produce methane and co-products from biomass. 4.13.15

**14 Apply biotechnology principles, techniques, and processes to improve waste management (e.g., genetically modified organisms, bioremediation, etc.).** 4.14

1. Compare and contrast the use of natural organisms and genetically-engineered organisms in the treatment of wastes. 4.14.1
2. Summarize the purpose of microorganisms in biological waste management. 4.14.2
3. Describe the role of microorganisms in industrial chemical waste treatment. 4.14.3
4. List examples of instances in which bioremediation can be applied to clean up environmental contaminants. 4.14.4
5. Analyze the process by which organisms are genetically engineered for waste treatment. 4.14.5
6. Assess the processes involved in biotreatment of biological wastes. 4.14.6
7. Compare and contrast the processes involved in biotreatment of industrial chemical wastes. 4.14.7
8. Analyze the risks and benefits of using biotechnology for bioremediation. 4.14.8
9. Conduct studies to evaluate the treatment of a waste product using a genetically engineered organism. 4.14.9
10. Evaluate the treatment of biological wastes with microorganisms. 4.14.10
11. Monitor the treatment of industrial chemical wastes with microorganisms. 4.14.11
12. Design a bioremediation project including plans to evaluate the effectiveness of the effort. 4.14.12