Minnesota Department of Education

Agriculture, Food & Natural Resources

Agriculture, Food, and Natural Resources Frameworks

Plant Systems Pathway

Plant Systems Pathway

The Plant systems pathway encompasses the study of plant life cycles, classifications, functions, structures, reproduction, media and nutrients, as well as growth and cultural practices through the study of crops, turf grass, trees, shrubs, and/or ornamental plants. Students completing a program of study in this pathway will demonstrate competence in the application of principles and techniques for the development, application, and management of plant systems in Agriculture, Food, and Natural Resource (AFNR) settings.

Experiential Learning

Experiential Learning consists of Supervised Agriculture Experience (SAE), Work-based Learning (WBL), Apprenticeship, Job Shadow, and Service Learning experiences. Experiential Learning is a required component of a total agricultural education program and intended for every student. Through their involvement in Experiential Learning activities, students are able to consider multiple careers and occupations, learn expected workplace behavior, develop specific skills within an industry, and are given opportunities to apply academic and occupational skills in the workplace or a simulated workplace environment. Through these strategies, students learn how to apply what they are learning in the classroom as they prepare to transition into the world of college and career opportunities. Table 1 contains example Supervised Agricultural Experiences defined by the National Future Farmers of America (FFA) Organization.

Table 1. Supervised Agricultural Experiences

• Agricultural Processing • Agricultural Sales • Agriscience Plant Systems Research • Diversified Agricultural Production • Diversified Crop Production • Diversified Horticulture	• Fiber and Oil Crop Production • Forage Production Forest Management and Products • Fruit Production • Grain Production • Home and/or Community Development	• Landscape Management • Nursery Operations • Specialty Crop Production • Turf Grass Management • Vegetable Production

National FFA Organization

The FFA Organization is dedicated to making a positive difference in the lives of students by developing their potential for premier leadership, personal growth, and career success through agricultural education. FFA award and degree programs recognize students for excellence in academics, career development, leadership, and community service. Career and leadership development activities encompass the entire AFNR Career Cluster and each AFNR Pathway and are available at the local chapter, regional, state, and national levels. Refer Table 2 for example FFA activities related to the Plant Systems Pathway.

Table 2. FFA Activities

Career Development Events (CDE's)	Leadership Development Events (LDE's)
• Agronomy (Crops) • Floriculture • Forestry • Nursery/Landscaping • Agricultural Sales • Soils • Agriscience Fair	• Agricultural Issues Forum • Marketing Plan • Prepared Public Speaking • Extemporaneous Speaking

Recommended Courses

Introductory Courses Number and Name	**Intermediate Courses** Number and Name	**Intermediate Courses** Number and Name	**Advanced Courses** Number and Name
• 24 Intro to Agriculture Science • 26 Agricultural Exploration • 68 Horticulture/Landscaping/ Floriculture • 25 Introduction to Agriculture	• 07 Plant Science I • 60 Horticulture I • 62 Greenhouse Operations and Management I • 64 Landscaping I • 66 Floriculture I • 69 Plant and Soil Sciences I • 77 Soil Sciences I	• 17 Aquaculture/Hydroponics • 24 Agriculture Science I • 73 Plant and Animal Science • 76 Crop Management Science • 79 Forestry Science and Management	• 25 Agriculture Science II • 78 Soil Sciences II • 70 Plant and Soil Sciences II • 61 Horticulture II • 08 Plant Science II • 63 Greenhouse Operations and Management II • 65 Landscaping II • 67 Floriculture II

Minnesota Plant Systems Standards

Minnesota Framework: MN.PS.01. Develop and implement a plant management plan for a given production goal based on current industry standards.

Performance Indicator: MN.PS.01.01. Determine the influence of environmental factors on plant growth.

Minnesota Science Academic Standards

- 9.1.1.1 Science is a way of knowing about the natural world and is characterized by empirical criteria, logical argument, and skeptical review.
- 9.1.3.1 Natural and designed systems are made up of components that act within a system and interact with other systems.
- 9.4.2.1 The interrelationship and interdependence of organisms generate dynamic biological communities in ecosystems.

MN.PS.01.01 Intro Course Benchmarks	MN.PS.01.01 Intermediate Course Benchmarks	MN.PS.01.01 Advanced Course Benchmarks
PS.01.01.01.a. Identify and summarize the three measurements of light – color, intensity and duration – that affect plant growth.	PS.01.01.01.b. Analyze and describe plant responses to light color, intensity and duration.	PS.01.01.01.c. Analyze plant responses to varied light color, intensity and duration and recommend modifications to light for desired plant growth.
PS.01.01.02.a. Identify and summarize the effects of air and temperature on plant metabolism and growth.	PS.01.01.02.b. Determine the optimal air and temperature conditions for plant growth.	PS.01.01.02.c. Design, implement and evaluate a plan to maintain optimal air and temperature conditions for plant growth.
PS.01.01.03.a. Identify and summarize the effects of water quality on plant growth, (e.g., pH, dissolved solids, etc.).	PS.01.01.03.b. Analyze and describe plant responses to water conditions.	PS.01.01.03.c. Analyze plant responses to water conditions and recommend modifications to water for desired plant growth.

Continued from Minnesota Framework: MN.PS.01

Performance Indicator: MN.PS.01.02. Prepare and manage growing media for use in plant systems.

Minnesota Science Academic Standards

- 9.1.1.1 Science is a way of knowing about the natural world and is characterized by empirical criteria, logical argument and skeptical review.

MN.PS.01.02 Intro Course Benchmarks	MN.PS.01.02 Intermediate Course Benchmarks	MN.PS.01.02 Advanced Course Benchmarks
PS.01.02.01.a. Identify the major components of growing media and describe how growing media support plant growth.	PS.01.02.01.b. Describe the physical and chemical characteristics of growing media and explain the influence they have on plant growth.	PS.01.02.01.c. Formulate and prepare growing media for specific plants or crops.
PS.01.02.02.a. Identify the categories of soil water.	PS.01.02.02.b. Discuss how soil drainage and water-holding capacity can be improved.	PS.01.02.02.c. Determine the hydraulic conductivity for soil and how the results influence irrigation practices.
PS.01.02.03.a. List and summarize the reasons for preparing growing media before planting.	PS.01.02.03.b. Prepare soil and growing media for planting with the addition of amendments.	PS.01.02.03.c. Analyze how mechanical planting equipment performs soil preparation and seed placement.

Performance Indicator: MN.PS.01.03. Develop and implement a fertilization plan for specific plants or crops.

Minnesota Academic Science Standards

- 9.1.1.1 Science is a way of knowing about the natural world and is characterized by empirical criteria, logical argument and skeptical review.
- 9.1.2.2 Engineering design is an analytical and creative process of devising a solution to meet a need or solve a specific problem.
- 9.1.3.1 Natural and designed systems are made up of components that act within a system and interact with other systems.

MN.PS.01.03 Intro Course Benchmarks	MN.PS.01.03 Intermediate Course Benchmarks	MN.PS.01.03 Advanced Course Benchmarks
PS.01.03.01.a. Summarize the impact of environmental factors on nutrient availability (e.g., moisture, temperature, pH, etc.).	PS.01.03.01.b. Assess and describe the impact environmental factors have on a crop.	PS.01.03.01.c. Devise a plan to meet plant nutrient needs based on environmental factors present.

Minnesota Framework: MN.PS.02. Apply principles of classification, plant anatomy, and plant physiology to plant production and management.

Performance Indicator: MN.PS.02.01. Classify plants according to taxonomic systems.

Minnesota Academic Science Standards

- 9.1.1.1 Science is a way of knowing about the natural world and is characterized by empirical criteria, logical argument and skeptical review.
- 9.1.1.2 Scientific inquiry uses multiple interrelated processes to pose and investigate questions about the natural world.

MN.PS.02.01 Intro Course Benchmarks	MN.PS.02.01 Intermediate Course Benchmarks	MN.PS.02.01 Advanced Course Benchmarks
PS.02.01.01.a. Identify and summarize systems used to classify plants based on specific characteristics.	PS.02.01.01.b. Compare and contrast the hierarchical classification of agricultural and ornamental plants.	PS.02.01.01.c. Classify agricultural and ornamental plants according to the hierarchical classification system.
PS.02.01.02.a. Describe the morphological characteristics used to identify agricultural and herbaceous plants (e.g., life cycles, growth habit, plant use and as monocotyledons or di-cotyledons, woody, herbaceous, etc.).	PS.02.01.02.b. Identify and describe important plants to agricultural and ornamental plant systems by common names.	PS.02.01.02.c. Identify and describe important plants to agricultural and ornamental plant systems by scientific names.

Continued from Minnesota Framework: MN.PS.02

Performance Indicator: MN.PS.02.02. Apply knowledge of plant anatomy and the functions of plant structures to activities associated with plant systems.

Minnesota Academic Science Standards

- 9.1.1.1 Science is a way of knowing about the natural world and is characterized by empirical criteria, logical argument and skeptical review.
- 9.1.3.1 Natural and designed systems are made up of components that act within a system and interact with other systems.

MN.PS.02.02 Intro Course Benchmarks	MN.PS.02.02 Intermediate Course Benchmarks	MN.PS.02.02 Advanced Course Benchmarks
PS.02.02.01.a. Identify structures in a typical plant cell and summarize the function of plant cell organelles.	PS.02.02.01.b. Compare and contrast mitosis and meiosis.	PS.02.02.01.c. Apply the knowledge of cell differentiation and the functions of the major types of cells to plant systems.
PS.02.02.02.a. Identify and summarize the components, the types and the functions of plant roots.	PS.02.02.02.b. Analyze root tissues and explain the pathway of water and nutrients into and through root tissues.	PS.02.02.02.c. Correlate the active and passive transport of minerals into and through the root system to plant nutrition.
PS.02.02.03.a. Identify and summarize the components and the functions of plant stems.	PS.02.02.03.b. Analyze and describe the difference in arrangement of vascular tissue between monocot and dicot plant stems.	PS.02.02.03.c. Evaluate the function of the xylem, phloem and cambium tissues and the impact on plant systems.
PS.02.02.04.a. Research and summarize leaf morphology and the functions of leaves.	PS.02.02.04.b. Analyze how leaves capture light energy and summarize the exchange of gases.	PS.02.02.04.c. Devise a plan for plant management practices that takes into account leaf structure and functions.
PS.02.02.05.a. Identify and summarize the components of a flower, the functions of a flower and the functions of flower components.	PS.02.02.05.b. Apply knowledge of flower structure to differentiate between the types of flowers and flower inflorescence (e.g., complete, incomplete, perfect, imperfect).	PS.02.02.05.c. Evaluate flower structures and analyze the impact of plant structure on plant breeding, production and use.
PS.02.02.06.a. Identify and summarize the functions and components of seeds and fruit.	PS.02.02.06.b. Analyze and categorize the major types of seeds and fruit.	PS.02.02.06.c. Evaluate the impact of different seed and fruit structures to plant culture and use.

Continued from Minnesota Framework: MN.PS.02

Performance Indicator: MN.PS.02.03. Apply knowledge of plant physiology and energy conversion to plant systems.

Minnesota Academic Science Standards

- 9.1.1.1 Science is a way of knowing about the natural world and is characterized by empirical criteria, logical argument and skeptical review.
- 9.1.3.1 Natural and designed systems are made up of components that act within a system and interact with other systems.
- 9.4.2.1The interrelationship and interdependence of organisms generate dynamic biological communities in ecosystems.

MN.PS.02.03 Intro Course Benchmarks	MN.PS.02.03 Intermediate Course Benchmarks	MN.PS.02.03 Advanced Course Benchmarks
PS.02.03.01.a. Summarize the importance of photosynthesis to plant life on earth and the process of photosynthesis, including the types (c3, c4, Cam), its stages (e.g., light-dependent and light independent reactions), and its products and byproducts.	PS.02.03.01.b. Apply knowledge of photosynthesis to analyze how various environmental factors will affect the rate of photosynthesis.	PS.02.03.01.c. Evaluate the impact of photosynthesis and the factors that affect it. (e.g., plant management, culture and production problems).
PS.02.03.02.a. Summarize the stages of cellular respiration including their products and byproducts.	PS.02.03.02.b. Analyze the factors that affect cellular respiration processes and rate in a crop production setting.	PS.02.03.02.c. Evaluate the impact of plant respiration on plant growth, crop management and post-harvest handling decisions.
PS.02.03.03.a. Summarize primary growth and the role of the apical meristem.	PS.02.03.03.b. Analyze plant growth and assess the process of secondary plant growth.	PS.02.03.03.c. Use the principals of primary and secondary plant growth to achieve desired characteristics of plant products. (e.g., Tissue culture, pruning, grafting, etc.).
PS.02.03.04.a. Identify and categorize the five groups of naturally occurring plant hormones and synthetic plant growth regulators	PS.02.03.04.b. Analyze and identify the plant responses to plant growth regulators and different forms of tropism.	PS.02.03.04.c. Select and defend the use of specific plant growth regulators to produce desired responses from plants.
PS.02.03.05.a. Compare and contrast the effects of transpiration, translocation and assimilation on plants.	PS.02.03.05.b. Identify and analyze the factors affecting transpiration, translocation and assimilation rate and products.	PS.02.03.05.c. Devise plans for plant management that applies knowledge of transpiration, translocation and assimilation on plant growth.

Minnesota Framework: MN.PS.03. Develop and implement a plant management plan for a given production goal based on current industry standards.

Performance Indicator: MN.PS.03.01. Demonstrate plant propagation techniques in plant system activities.

Minnesota Academic Science Standards

- 9.1.2.2 Engineering design is an analytical and creative process of devising a solution to meet a need or solve a specific problem.

MN.PS.03.01 Intro Course Benchmarks	MN.PS.03.01 Intermediate Course Benchmarks	MN.PS.03.01 Advanced Course Benchmarks
PS.03.01.01.a. Identify examples of and summarize pollination, cross-pollination and self-pollination of flowering plants.	PS.03.01.01.b. Examine and apply the process of plant pollination and/or fertilization.	PS.03.01.01.c. Select and defend the use of pollination methods and practices used to maximize crop pollination.
PS.03.01.02.a. Demonstrate sowing techniques for providing favorable conditions to meet the factors of seed germination.	PS.03.01.02.b. Handle seed to overcome seed dormancy mechanisms and to maintain seed viability and vigor.	PS.03.01.02.c. Conduct tests associated with seed germination rates, viability and vigor.
PS.03.01.03.a. Summarize optimal conditions for asexual propagation and demonstrate techniques used to propagate plants by cuttings, division, separation, layering, budding and grafting.	PS.03.01.03.b. Manage the plant environment to support asexual reproduction.	PS.03.01.03.c. Evaluate asexual propagation practices based on productivity and efficiency.
PS.03.01.04.a. Define micropropagation and discuss advantages and disadvantages associated with the practice.	PS.03.01.04.b.Summarize the main stages of the micropropagation process.	PS.03.01.04.c. Demonstrate aseptic micropropagation techniques.

Continued from Minnesota Framework: MN.PS.03

Performance Indicator: MN.PS.03.02. Develop and implement a management plan for plant production.

Minnesota Academic Science Standards

- 9.1.1.1 Science is a way of knowing about the natural world and is characterized by empirical criteria, logical argument and skeptical review.
- 9.1.2.2 Engineering design is an analytical and creative process of devising a solution to meet a need or solve a specific problem.
- 9.1.3.1 Natural and designed systems are made up of components that act within a system and interact with other systems.
- 9.4.2.1The interrelationship and interdependence of organisms generate dynamic biological communities in ecosystems.

MN.PS.03.02 Intro Course Benchmarks	MN.PS.03.02 Intermediate Course Benchmarks	MN.PS.03.02 Advanced Course Benchmarks
PS.03.02.01.a. Determine seeding rate need for specified plant population or desired quantity of finished plants.	PS.03.02.01.b. Apply pre-plant treatments required of seeds and plants and evaluate the results.	PS.03.02.01.c. Adjust and calibrate mechanized seeding and/or planting equipment for desired seed application rate.
PS.03.02.02.a. Observe and record environmental conditions during the germination, growth and development of a crop.	PS.03.02.02.b. Monitor the progress of plantings and determine the need to adjust environmental conditions.	PS.03.02.02.c. Prepare and implement a plant production schedule based on predicted environmental conditions and desired market target (e.g., having plants ready to market on a specific day such as Mother's Day, organic production, low maintenance landscape plants, etc.).
PS.03.02.03.a. Summarize the stages of plant growth and the reasons for controlling plant growth.	PS.03.02.03.b. Demonstrate proper techniques to control and manage plant growth through mechanical, cultural or chemical means.	PS.03.02.03.c. Prepare plant production schedules utilizing plant growth knowledge to get plants to their optimal growth stage at a given time.
PS.03.02.04.a. Identify and categorize structures and technologies used for controlled atmosphere production of plants.	PS.03.02.04.b. Compare and contrast the types of technologies used for controlled atmosphere production.	PS.03.02.04.c. Research, select and utilize technology for use in controlled atmosphere production.
PS.03.02.05.a. Summarize the use of hydroponic and aquaponic systems for plant production.	PS.03.02.05.b. Compare and contrast the types of systems used in hydroponic and aquaponic plant production.	PS.03.02.05.c. Research, select and create and manage a hydroponic or aquaponic plant system.

Continued from Minnesota Framework: MN.PS.03

Performance Indicator: MN.PS.03.03. Develop and implement a plan for integrated pest management for plant production.

Minnesota Academic Science Standards

- 9.1.1.1 Science is a way of knowing about the natural world and is characterized by empirical criteria, logical argument and skeptical review.
- 9.1.2.2 Engineering design is an analytical and creative process of devising a solution to meet a need or solve a specific problem.
- 9.1.3.1 Natural and designed systems are made up of components that act within a system and interact with other systems.

MN.PS.03.04 Intro Course Benchmarks	MN.PS.03.04.Intermediate Course Benchmarks	MN.PS.03.04 Advanced Course Benchmarks
PS.03.03.01.a. Identify and categorize plant pests, diseases and disorders.	PS.03.03.01.b. Identify and analyze major local weeds, insect pests and infectious and noninfectious plant diseases.	PS.03.03.01.c. Devise solutions for plant pests, diseases and disorders.
PS.03.03.02.a. Diagram the life cycle of major plant pests and diseases.	PS.03.03.02.b. Predict pest and disease problems based on environmental conditions and life cycles.	PS.03.03.02.c. Design and implement a crop scouting program.
PS.03.03.03.a. Identify and summarize pest control strategies associated with integrated pest management and the importance of determining economic threshold.	PS.03.03.03.b. Demonstrate pesticide formulations including organic and synthetic active ingredients and selection of pesticide to control specific pest.	PS.03.03.03.c. Employ pest management strategies to manage pest populations, assess the effectiveness of the plan and adjust the plan as needed.
PS.03.03.04.a. Distinguish between risks and benefits associated with the materials and methods used in plant pest management.	PS.03.03.04.b. Evaluate environmental and consumer concerns regarding pest management strategies.	PS.03.03.04.c. Examine and apply procedures for the safe handling, use and storage of pesticides including personal protective equipment and reentry interval.

Continued from Minnesota Framework: MN.PS.03

Performance Indicator: MN.PS.03.04. Apply principles and practices of sustainable agriculture to plant production.

Minnesota Academic Science Standards

- 9.1.1.1 Science is a way of knowing about the natural world and is characterized by empirical criteria, logical argument and skeptical review.
- 9.1.2.2 Engineering design is an analytical and creative process of devising a solution to meet a need or solve a specific problem.
- 9.1.3.1 Natural and designed systems are made up of components that act within a system and interact with other systems.
- 9.4.2.1The interrelationship and interdependence of organisms generate dynamic biological communities in ecosystems.

MN.PS.03.04 Intro Course Benchmarks	MN.PS.03.04 Intermediate Course Benchmarks	MN.PS.03.04 Advanced Course Benchmarks
PS.03.04.01.a. Research and summarize production methods focused on soil management (e.g., crop rotation, companion planting, cover crops, etc.).	PS.03.04.01.b. Assess and describe the short and long-term effects production methods have on soil.	PS.03.04.01.c. Devise a plan for soil management for a selected production method.
PS.03.04.02.a. Compare and contrast the alignment of different production systems (conventional and organic) with USDA sustainable practices criteria.	PS.03.04.02.b. Analyze the alignment of modern technologies used in production systems (e.g., precision agriculture, GE crops, etc.) with USDA sustainable practices criteria.	PS.03.04.02.c. Research, prepare and defend plans for a plant systems enterprise that aligns with USDA sustainable practices criteria.
PS.03.04.03.a.Compare and contrast organic and conventional production practices.	PS.03.04.03.b. Describe how organic and conventional practices impact global food security.	PS.03.04.03.c.Compare and contrast a U.S. and a foreign production system and their impact on global food security and the environment.
PS.03.04.04.a.Evaluate the water needs of different plants.	PS.03.04.04.b.Describe production practices used to minimize water inputs.	PS.03.04.04.c.Analyze a production system and develop a plan to decrease its water input.

Continued from Minnesota Framework: MN.PS.03

Performance Indicator: MN.PS.03.05 Harvest, handle and store crops according to current industry standards.

Minnesota Academic Science Standards

- 9.1.2.1 Engineering is a way of addressing human needs by applying science concepts and mathematical techniques to develop new products, tools, processes and systems.
- 9.1.2.2 Engineering design is an analytical and creative process of devising a solution to meet a need or solve a specific problem.

MN.PS.03.05 Intro Course Benchmarks	MN.PS.03.05 Intermediate Course Benchmarks	MN.PS.07.03 Advanced Course Benchmarks
PS.03.05.01.a. Identify and summarize harvesting methods and equipment.	PS.03.05.01.b. Analyze the processes used by mechanical harvesting equipment.	PS.03.05.01.c. Assess the stage of growth to determine crop maturity or marketability and demonstrate proper harvesting techniques.
PS.03.05.02.a. Research and summarize reasons for calculating crop loss and or damage.	PS.03.05.02.b. Evaluate crop yield and loss data.	PS.03.05.02.c. Make recommendations to reduce crop loss.
PS.03.05.03.a. Research and summarize how safety is ensured at each stage of the following processes: harvesting, processing and storing.	PS.03.05.03.b. Research and analyze practices used to maintain a safe product through harvest, processing, storage and shipment (e.g., Food Safety Modernization Act, Good Agricultural Practices, etc.).	PS.03.05.03.c. Research laws and apply regulations to ensure the production of plants and plant products that are safe for distribution and use.
PS.03.05.04.a. Identify and categorize plant preparation methods for storing and shipping plants and plant products.	PS.03.05.04.b. Analyze the proper conditions required to maintain the quality of plants and plant products held in storage and during shipping.	PS.03.05.04.c. Monitor and evaluate environmental conditions in storage facilities for plants and plant products.
PS.03.05.05.a. Summarize the reasons for preparing plants and plant products for distribution.	PS.03.05.05.b. Demonstrate techniques for grading, handling and packaging plants and plant products for distribution.	PS.03.05.05.c. Evaluate techniques for grading, handling and packaging plants and plant products.

Minnesota Framework: MN.PS.04. Apply principles of design in plant systems to enhance an environment (e.g. floral, forest, landscape, and farm).

Performance Indicator: MN.PS.04.01. Evaluating, identifying and preparing plants to enhance an environment.

Minnesota Academic Science Standards

- 9.1.1.1 Science is a way of knowing about the natural world and is characterized by empirical criteria, logical argument and skeptical review.
- 9.1.2.2 Engineering design is an analytical and creative process of devising a solution to meet a need or solve a specific problem.
- 9.1.3.1 Natural and designed systems are made up of components that act within a system and interact with other systems.

MN.PS.04.01 Intro Course Benchmarks	MN.PS.04.01 Intermediate Course Benchmarks	MN.PS.04.01 Advanced Course Benchmarks
PS.04.01.01.a. Identify and categorize plants by their purpose (e.g., floral plants, landscape plants, house plants, etc.).	PS.04.01.01.b. Demonstrate proper use of plants in their environment (e.g., focal and filler plants in floriculture, heat tolerant and shade plants in a landscape design, etc.)	PS.04.01.01.c. Prepare and install plant materials according to a design plan that uses the proper plants based on the situation and environment.
PS.04.01.02.a. Summarize the applications of design in agriculture and ornamental plant systems.	PS.04.01.02.b. Create a design utilizing plants in their proper environments.	PS.04.01.02.c. Evaluate a design and provide feedback and suggestions for improvement (e.g., a floral arrangement, a landscape or a landscape plan, etc.).
PS.04.01.03.a. List and describe industry standard plant preparation techniques.	PS.04.01.03.b. Create a series of plant care steps from purchase to final installation.	PS.04.01.03.c. Prepare plant materials following industry standard techniques.

Performance Indicator: MN.PS.04.02. Create designs using plants.

MN.PS.04.02 Intro Course Benchmarks	MN.PS.04.02 Intermediate Course Benchmarks	MN.PS.04.02 Advanced Course Benchmarks
PS.04.02.01.a. Research and summarize the principles and elements of design for use in plant systems.	PS.04.02.01.b. Apply principles and elements of design that form the basis of artistic impression.	PS.04.02.01.c. Analyze designs to identify use of design principles and elements.
PS.04.02.02.a. Identify and categorize tools used for design (e.g., computer landscape software, drawing tools, florist tools, etc.).	PS.04.02.02.b. Demonstrate the use of tools used for creating designs.	PS.04.02.02.c. Choose and properly use appropriate tools to create a desired design.
PS.04.02.03.a. Identify characteristics of a landscape that are analyzed during a site evaluation.	PS.04.02.03.b. Analyze a landscape site using proper site evaluation methods.	PS.04.02.03.c. Make recommendations based on a site evaluation.

Minnesota Framework: MN.PS.05. Assess factors that have influenced the evolution of biotechnology in plant systems (e.g., historical events, societal trends, ethical and legal implications, etc.).

Performance Indicator: MN.PS.05.01. Investigate and explain the relationship between past, current and emerging applications of biotechnology in plant systems (e.g., major innovators, historical developments, potential applications of biotechnology, etc.).

Minnesota Academic Science Standards

- 9.1.1.1 Science is a way of knowing about the natural world and is characterized by empirical criteria, logical argument and skeptical review.
- 9.1.2.1 Engineering is a way of addressing human needs by applying science concepts and mathematical techniques to develop new products, tools, processes and systems.
- 9.1.3.1 Natural and designed systems are made up of components that act within a system and interact with other systems.
- 9.1.3.3 Science and engineering operate in the context of society and both influence and are influenced by this context.
- 9.3.4.1 People consider potential benefits, costs and risks to make decisions on how they interact with natural systems.

MN.PS.05.01 Intro Course Benchmarks	MN.PS.05.01 Intermediate Course Benchmarks	MN.PS.05.01 Advanced Course Benchmarks
PS.05.01.01.a. Research and summarize the evolution of biotechnology in agriculture.	PS.05.01.01.b. Analyze the developmental progression of biotechnology and the evolution of scientific knowledge.	PS.05.01.01.c. Evaluate and explain how scientists use the scientific method to build upon previous findings in current and emerging research.
PS.05.01.02.a. Examine and categorize current applications and gains achieved in applying biotechnology to agriculture.	PS.05.01.02.b. Assess and summarize current work in biotechnology being done to add value to agricultural and society.	PS.05.01.02.c. Evaluate the outcomes and impacts of biotechnology on the globalization of agriculture.
PS.05.01.03.a. Distinguish between current and emerging applications of biotechnology in agriculture.	PS.05.01.03.b. Analyze and document emerging problems and issues associated with agricultural biotechnology.	PS.05.01.03.c. Design a potential application of biotechnology to meet emerging agricultural and societal needs.
PS.05.01.04.a. Compare and contrast the benefits and risks of biotechnology compared with alternative approaches to improving agriculture.	PS.05.01.04.b. Assess the benefits and risks associated with using biotechnology to improve agriculture.	PS.05.01.04.c. Evaluate the short-term and long-term benefits and risks of applying biotechnology to agriculture.

Continued from Minnesota Framework: MN.PS.05

Performance Indicator: MN. PS.05.02. Evaluate the scope and implications of regulatory agencies on applications of biotechnology in plant systems and protection of public interests (e.g., health, safety, environmental issues, etc.).

Minnesota Academic Science Standards

- 9.1.1.1 Science is a way of knowing about the natural world and is characterized by empirical criteria, logical argument and skeptical review.
- 9.1.1.2 Scientific inquiry uses multiple interrelated processes to pose and investigate questions about the natural world.
- 9.1.3.3 Science and engineering operate in the context of society and both influence and are influenced by this context.
- 9.3.4.1 People consider potential benefits, costs and risks to make decisions on how they interact with natural systems.
- 9.4.4.1 Human activity has consequences on living organisms and ecosystems.

MN.PS.05.02 Intro Course Benchmarks	MN.PS.05.02 Intermediate Course Benchmarks	MN.PS.05.02 Advanced Course Benchmarks
PS.05.02.01.a. Compare and contrast differences between regulatory systems worldwide.	PS.05.02.01.b. Assess and summarize the role and scope of agencies that regulate biotechnology.	PS.05.02.01.c. Explain and critique a decision made by a major agency that regulates agricultural biotechnology.
PS.05.02.02.a. Research and document major regulatory issues related to biotechnology in agriculture.	PS.05.02.02.b. Analyze the impact major regulatory issues have on public acceptance of biotechnology in agriculture.	PS.05.02.02.c. Critique and propose a solution for a major regulatory issue pertaining to biotechnology in agriculture.
PS.05.02.03.a. Explain the relationship between regulatory agencies and the protection of public interests such as health, safety and the environment.	PS.05.02.03.b. Research and summarize factors and data that regulatory agencies use to evaluate the potential risks a new application of biotechnology may pose to health, safety and the environment.	PS.05.02.03.c. Evaluate data to determine if new technologies present a major regulatory issue to health, safety and/or the environment.

Continued from Minnesota Framework: MN.PS.05

Performance Indicator: MN.PS.05.03. Analyze the relationship and implications of bioethics, laws and public perceptions on applications of biotechnology in plant systems (e.g., ethical, legal, social, cultural issues).

Minnesota Academic Science Standards

- 9.1.1.1 Science is a way of knowing about the natural world and is characterized by empirical criteria, logical argument and skeptical review.
- 9.1.1.2 Scientific inquiry uses multiple interrelated processes to pose and investigate questions about the natural world.
- 9.1.3.3 Science and engineering operate in the context of society and both influence and are influenced by this context.
- 9.3.4.1 People consider potential benefits, costs and risks to make decisions on how they interact with natural systems.
- 9.4.4.1 Human activity has consequences on living organisms and ecosystems.

MN.PS.05.03 Intro Course Benchmarks	MN.PS.05.03 Intermediate Course Benchmarks	MN.PS.05.03 Advanced Course Benchmarks
PS.05.03.01.a. Research and summarize the emergence, evolution and implications of bioethics associated with biotechnology, plant systems, and agriculture.	PS.05.03.01.b. Analyze the implications bioethics may have on future advancements in plant systems.	PS.05.03.01.c. Devise and support an argument for or against an ethical issue associated with biotechnology in agricultural plant systems.
PS.05.03.02.a. Research and summarize legal issues related to biotechnology in agriculture (e.g., protection of intellectual property through patents, copyright, trademarks, etc.).	PS.05.03.02.b. Determine the significance and impacts of legal issues related to biotechnology in plant systems.	PS.05.03.02.c. Propose a solution for a legal issue associated with biotechnology in plant systems.
PS.05.03.03.a. Research and summarize public perceptions of biotechnology in plant systems (e.g., social and cultural issues).	PS.05.03.03.b. Analyze the impact of public perceptions on the application of biotechnology in plants systems.	

Minnesota Framework: MN.PS.06. Demonstrate proficiency by safely applying appropriate skills to complete tasks in a biotechnology research and development environment (e.g., standard operating procedures, record keeping, aseptic technique, equipment maintenance, etc.).

Performance Indicator: MN.PS.06.01. Implement standard operating procedures for the proper maintenance, use and sterilization of equipment.

Minnesota Academic Science Standards

- 9.1.3.4 Science, technology, engineering, and mathematics rely on each other to enhance knowledge and understanding.

MN.PS.06.01 Intro Course Benchmarks	MN.PS.06.01 Intermediate Course Benchmarks	MN.PS.06.01 Advanced Course Benchmarks
PS.06.01.01.a. Identify, interpret, and implement standard operating procedures for laboratory equipment.	PS.06.01.01.b. Develop a maintenance program for laboratory equipment based upon the standard operating procedures.	PS.06.01.01.c. Perform ongoing maintenance of laboratory equipment according to the standard operating procedures (e.g., calibration, testing, etc.).
PS.06.01.02.a. Differentiate between sterilization techniques for equipment in a laboratory (e.g., media bottles vs. laminar flow hood, etc.).	PS.06.01.02.b. Create a plan for sterilizing equipment in a laboratory according to standard operating procedures.	PS.06.01.02.c. Perform sterilization techniques for equipment in a laboratory using standard operating procedures.

Performance Indicator: MN.PS.06.02. Apply standard operating procedures for the safe handling of biological and chemical materials.

Minnesota Academic Science Standards

- 9.1.3.4 Science, technology, engineering, and mathematics rely on each other to enhance knowledge and understanding.

MN.PS.06.02 Intro Course Benchmarks	MN.PS.06.02 Intermediate Course Benchmarks	MN.PS.06.02 Advanced Course Benchmarks
PS.06.02.01.a. Classify and document basic aseptic techniques in the laboratory.	PS.06.02.01.b. Demonstrate advanced aseptic techniques in the laboratory (e.g., sterile work area, sterile handling, personal hygiene, etc.).	

Minnesota Framework: MN.PS.07. Demonstrate the application of biotechnology to solve problems in plant systems (e.g., bioengineering, horticulture, forestry, crops, etc.).

Performance Indicator: MN.PS.07.01. Apply biotechnology principles, techniques and processes to create transgenic species through genetic engineering.

Minnesota Academic Science Standards

- 9.1.1.1 Science is a way of knowing about the natural world and is characterized by empirical criteria, logical argument and skeptical review.
- 9.1.2.1 Engineering is a way of addressing human needs by applying science concepts and mathematical techniques to develop new products, tools, processes and systems.
- 9.1.2.2 Engineering design is an analytical and creative process of devising a solution to meet a need or solve a specific problem.
- 9.4.3.1 Genetic information found in the cell provides information for assembling proteins which dictate expression of traits in an individual.
- 9.4.3.2 Variation within a species is the natural result of new inheritable characteristics occurring from new combinations of existing genes or from mutations of genes in reproductive cells.

MN.PS.07.01 Intro Course Benchmarks	MN.PS.07.01 Intermediate Course Benchmarks	MN.PS.07.01 Advanced Course Benchmarks
PS.07.01.01.a. Summarize biological, social, agronomic, and economic reasons for genetic modification of eukaryotes.	PS.07.01.01.b. Analyze and document the processes and describe the techniques used to produce transgenic eukaryotes (e.g., microbial synthetic biology, gene knockout therapy, traditional gene insertion, etc.).	PS.07.01.01.c. Design and conduct experiments to evaluate an existing transgenic eukaryote.
PS.07.01.02.a. Analyze the benefits and risks associated with the use of biotechnology to increase productivity and improve quality of living species (e.g., plants, animals such as aquatic species, etc.).	PS.07.01.02.b. Research and evaluate genetic engineering procedures used in the production of living species.	PS.07.01.02.c. Conduct field or clinical trials for genetically modified species.

Continued from Minnesota Framework: MN.PS.07

Performance Indicator: MN. PS.07.02. Apply biotechnology principles, techniques and processes to enhance plant care and production (e.g., selective breeding, pharmaceuticals, biodiversity, etc.).

Minnesota Academic Science Standards

- 9.1.1.1 Science is a way of knowing about the natural world and is characterized by empirical criteria, logical argument and skeptical review.
- 9.1.2.1 Engineering is a way of addressing human needs by applying science concepts and mathematical techniques to develop new products, tools, processes and systems.
- 9.1.2.2 Engineering design is an analytical and creative process of devising a solution to meet a need or solve a specific problem.
- 9.1.3.1 Natural and designed systems are made up of components that act within a system and interact with other systems.

MN.PS.07.02 Intro Course Benchmarks	MN.PS.07.02 Intermediate Course Benchmarks	MN.PS.07.02 Advanced Course Benchmarks
PS.07.02.01.a. Research and describe the aims and techniques involved in selective plant-breeding process.	PS.07.02.01.b. Choose techniques and identify tools used to monitor and direct plant breeding.	PS.07.02.01.c. Perform plant-breeding techniques (e.g., plant tissue culture, etc.).
PS.07.02.02.a. Examine and classify biotechnology processes applicable to animal health (e.g., genetic testing, etc.).	PS.07.02.02.b. Assess the benefits, risks and opportunities associated with using biotechnology to promote animal health.	PS.07.02.02.c. Design animal-care protocols to ethically monitor and promote animal systems associated with biotechnology.
PS.07.02.03.a. Research and categorize the types of pharmaceuticals developed for animals and humans through biotechnology.	PS.07.02.03.b. Distinguish the difference between plant-based and animal-based pharmaceuticals and describe their role in agriculture.	PS.07.02.03.c. Evaluate the process used to produce pharmaceuticals from transgenic organisms (e.g., hormones for animals, etc.).

Performance Indicator: PS.07.03. Apply biotechnology principles, techniques and processes to produce biofuels (e.g., fermentation, transesterification, methanogenesis, etc.).

Minnesota Academic Science Standards

- 9.1.2.1 Engineering is a way of addressing human needs by applying science concepts and mathematical techniques to develop new products, tools, processes and systems.

MN.PS.07.03 Intro Course Benchmarks	MN.PS.07.03 Intermediate Course Benchmarks	MN.PS.07.03 Advanced Course Benchmarks
PS.07.03.01.a. Differentiate between biomass and sources of biomass.	PS.07.03.01.b. Assess the characteristics of biomass that make it useful for biofuels production.	PS.07.03.01.c. Conduct a review of the technologies used to create biofuels from biomass and weigh the pros and cons of each method.