Investigating Agricultural Biotechnology
Detailed Course Outline

Unit 1 Foundations of Agricultural Biotechnology

Lesson 1.1 Introduction to Biotechnology in Agriculture

1. Biotechnology is a multidisciplinary field that harnesses biological processes, organisms, cells, and molecular components to develop technologies and products that improve human life.
    - Replicate the practices used in biotechnology by genetic engineers to create a creature (APP 1.1.1)
2. Professionals organize laboratory records to ensure compliance with Good Laboratory Practices (GLP's) and regulations.
    - Maintain Laboratory Notebooks to record procedures. (APP 1.1.2)
    - Develop and keep an Agriscience Notebook to record and store information. (APP 1.1.2)
3. Modern biotechnology has foundations in historical technologies, such as fermentation and selective breeding, while utilizing new fields, such as molecular biology, bioengineering, and bioinformatics.
    - Determine the date and significance of a biotechnological discovery. (Project 1.1.3)
    - Work collaboratively to develop a timeline of biotechnology discoveries. (Project 1.1.3)
4. Personal beliefs and scientific knowledge drive a consumer's acceptance of biotechnology.
    - Identifying personal perceptions of biotechnology applications. (APP 1.1.4)
    - Conduct a public perception survey of a biotechnology issue. (APP 1.1.5)
5. Ethical and moral questions arise from the science of genetically modifying organisms.
    - Explore personal beliefs and knowledge to gain a perspective on biotechnology applications. (APP 1.1.6)

Lesson 1.2 Safety in Biotechnology

1. Working in a biotechnology laboratory requires compliance with safety procedures and rules.
    - Demonstrate proper laboratory procedures in the appropriate order with no steps missed. (APP 1.2.1)
2. Procedures and personal protective equipment protect laboratory workers.
    - Practice donning and doffing gloves. (APP 1.2.2)
3. Lab workers use Safety Data Sheets (SDS) to ensure the proper use and cleanup of biological and chemical materials.
    - Reference SDS sheets to store, handle, and clean up chemicals accurately. (APP 1.2.3)
4. Laboratory workers must quickly identify and respond to hazards to ensure safety for all personnel and properly document the issue.
    - Respond to a hazard scenario by developing a plan of action and completing an incident report. (APP 1.2.4)
5. OSHA regulations provide guidelines to keep workplaces safe and protect workers from potential hazards.
    - Develop a presentation about OSHA regulations that regulate biotech workspaces.(APP 1.2.5)

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Lesson 1.3 Laboratory Practices

1. Scientific research generates data, often in the form of numbers. The precision of numerical data depends on the method used to generate them.
    - Complete an experiment with numerical data and evaluate the precision of data calculated using significant figures. (APP 1.3.1)
2. Proper and accurate measurement is essential for laboratory investigation.
    - Demonstrate proficiency in measuring and transferring liquids using a microbalance, cylinder, volumetric flask, micropipette, serological pipette, and droppers.(APP 1.3.2)
3. Biotechnicians use fundamental calculations in chemistry and related fields, especially molarity, pH, and dilution.
    - Mix dilated solutions based on the percentage of a substance desired. (APP 1.3.3)
    - Prepare solutions based on the desired molar concentration.(APP 1.3.4)
4. Lab workers use aseptic techniques to limit contamination.
    - Complete stations with sterilizing loops using shield plates, lids on counters, and Petri dishes to develop technical skills. (APP 1.3.5)

Unit 2: Molecular Biology and Genetic Principles

Lesson 2.1 Microbiology in Ag

1. Microorganisms, including bacteria, fungi, viruses, algae, and archaea, are foundational to biotechnology because of their diverse capabilities, adaptability, and applications.
    - Create a model of a significant microbe. (APP 2.1.1)
2. Culturing and studying microorganisms requires understanding the unique characteristics and needs of eukaryotic and prokaryotic model organisms.
    - Compare the eukaryotic and prokaryotic cell cultures. (APP 2.1.2)
3. Antibiotics are critical in agriculture for treating and preventing bacterial infections.
    - Perform a disk diffusion test to evaluate the antimicrobial properties of specific chemicals. . (APP 2.1.3)
4. Microbiology provides a scientific framework, like Koch's Postulates, for identifying the microorganisms responsible for agricultural diseases.
    - Use a model to test Koch's postulates using milk and yogurt samples. (APP 2.1.4)
5. Structural differences between Gram-positive and Gram-negative bacteria, particularly in their cell walls, influence their survival, habitats, environmental interactions, and response to antibiotics.
    - Test bacteria using a gram stain method to determine if they are gram-positive or gram-negative. (APP 2.1.5)
6. Serial dilution and optical density (OD) quantify bacterial populations in a culture are important in microbiological research.
    - Perform a serial dilution and plate count to determine bacterial populations. (APP 2.1.6)

Lesson 2.2 DNA Structure and Function

1. DNA is the genetic material found in cells. (From AFNR)
    - Explain the physical properties of a nitrogenous base, phosphate molecule, and ribose sugar.(APP 2.2.1)
2. An understanding of the biochemical structure of DNA drives biological processes.
    - Create a model of a DNA sequence using simulated materials (APP 2.2.1)

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- Investigate the physical properties of DNA by manipulating the conditions that influence its structure and transition from double helix to single strand.(APP 2.2.2)
- Draw (or diagram) the physical properties of a nitrogenous base, phosphate molecule, and ribose sugar. (APP 2.2.3)
- Research DNA replication and develop a visual representation of the replication process. (APP 2.2.4)

Lesson 2.3 Exploring Genes

1. DNA is extracted from cellular matter to be studied.
    - DNA extraction from plant and animal cells is performed.(APP 2.3.1)
    - Develop a protocol to extract DNA from a plant or animal cell. (APP 2.3.2)
2. Gel electrophoresis allows scientists to separate and analyze DNA fragments by size, which is essential for applications like gene cloning, sequencing, and genetic engineering.
    - Mix solutions and pour gel trays to prepare agarose gels. (APP 2.3.3)
    - Use gel electrophoresis to sort fragments. (APP 2.3.4)
3. Restriction enzymes are used to cut DNA to compare organisms and isolate and transfer genes and results.
    - Demonstrate the action of restriction enzyme using paper DNA strands. (APP 2.3.5)
4. Markers are used to identify the successful insertion of genes.
    - Digest a DNA sample using restriction enzymes and contact gel electrophoresis to analyze the results. (APP 2.3.6)
5. The genomes of multiple organisms can be analyzed to understand genetic variations.
    - Compare and contrast the genomes of multiple organisms using assorted bioinformatic tools (BLAST, NEBCutter, etc). (APP 2.3.7)
6. DNA profiles are created using fragments produced through Restriction Fragment Length results.
    - Solve a problem determining the culprit of a crime using restriction enzymes and gel electrophoresis. (APP 2.3.8)

Unit 3 Biotechnology Tools and Applications

Lesson 3.1 Genetic Transformers

1. Modern genetic modification techniques, such as genetic engineering and genome editing, provide precise and efficient alternatives to traditional selective breeding.
    - Compare traditional simulated breeding practices to potential genetic engineering practices. (APP 3.1.1)
2. Genetic transformation is a precise process of altering an organism's genome by introducing new DNA through genetic engineering techniques, such as recombinant DNA technology, enabling faster and more targeted improvements in agriculture and other fields compared to traditional breeding methods.
    - Simulate the steps of genetic transformation with paper models. (APP 3.1.2)
3. Transformation is used to produce proteins for synthetically increased animal and plant production.
    - Prepare agar plates and LB broth for transformation. (APP 3.1.3)
    - Transform bacterial cells to exhibit ampicillin resistance and bioluminescence. (APP 3.1.4)
4. Plasmids are used to insert the genes for desired traits into bacterial cells.
    - Use the pGLO plasmid to transform bacterial cells to exhibit desired traits. (APP 3.1.4)
    - Research how the Ti plasmid transforms a bacteria of interest for agricultural biotechnology applications. (APP 3.1.4)
5. Proteins of interest can be purified from bacterial cultures for further study.

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- Culture transformed cells and purify a protein of interest from the bacteria. (APP 3.1.5)

6. Conducting background research is important to identify what is already known about the research objective.
    - Research *Agrobacterium tumefaciens* to determine applications in the agricultural field. (APP 3.1.6)
    - Write a scientific research paper using valid resources and parenthetical citations. (APP 3.1.6)

Lesson 3.2 Genetically Modified Organisms

1. Ethical and moral questions arise from the science of genetically modifying organisms.
    - Reflect upon the term genetically modified and develop personal perceptions and beliefs pertaining to the term. (APP 4.1.1)
    - Research published perceptions of genetically modified organisms of different groups and organizations and discuss in class. (APP 4.1.1)
    - Conduct a public perception survey of genetically modified foods. (APP 4.1.4)
2. Genetic testing, such as polymerase chain reactions and lateral flow tests, is used to make production based decisions and identify genetically modified organisms.
    - Perform a lateral flow test to determine the presence of Round-Up Ready® genes in corn. (APP 4.1.2)
    - Conduct a polymerase chain reaction to determine the presence of genetic modifications in a common food item. (APP 4.1.3)
3. Organisms are genetically modified to improve agricultural products by inserting genes into cells.
    - Complete the annotated bibliography, the rough draft, and a peer review of the *A. tumefaciens* research paper. (APP 3.1.6 continuation)

Lesson 3.3 Protein Processes

1. Transcription and translation are processes that produce proteins of which all living things are made.
    - Research the processes of transcription and translation and complete a simulation of amino acid production. (Activity 3.1.1)
2. Colorimetric assays can be used to identify and determine the amount of protein in a biological sample extract.
    - Perform an experiment using a spectrophotometer to assess the protein content of milk and other high-protein drinks. (Activity 3.1.2)
    - Compare the results of Bradford assays to Biuret assays. (APP 3.1.3)
3. The presence of specific proteins in a biological sample can indicate the presence of disease, exposure to disease, or identify genetically modified products.
    - Complete an enzyme-linked immunosorbent assay to determine the presence of protein. (APP 3.1.4)

Lesson 3.4 Gene Editing

1. CRISPR-Cas9 is a powerful gene-editing tool that allows scientists to make precise changes to DNA, with applications ranging from treating genetic disorders to improving crops for more sustainable agriculture.
    - Create a graphic that outlines the steps taken in the CRISPR-Cas9 technology to edit genes. (APP 3.4.1)
    - Replicate the CRISPR-Cas9 process with a paper model. (APP 3.4.2)
2. CRISPR-Cas9 can cut a specific gene, and using homology-directed repair (HDR), a new DNA sequence can be inserted to change or disrupt the gene's function.
    - Cut bacterial chromosomal DNA at a specific location to cause a desired change. (APP 3.4.3)

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3. CRISPR-Cas9 and traditional genetic modification (GMOs) are two powerful tools for altering genetic material, each with unique methods, applications, and ethical considerations that help scientists solve real-world problems in agriculture.
    - Analyze problems that can be solved with genetic engineering or genetic editing and decide and defend the use of this technology for a particular application. (APP 3.4.4)

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