**Course Description:**

Students will use concepts, procedures, and equipment common to a professional laboratory for agricultural product development and research. Students conduct problem-based studies, and apply scientific methodology. Students will follow procedures and protocols for handling, transporting, storing, and preparing plant and animal specimens. Further, students will perform techniques including chemical separations, centrifugation, distillation and filtration. Emphasis is given to demonstrating safe, professional and ethical behavior associated with the field.

**Strand 3. Biotechnology**

Learners apply the skills and knowledge of interpreting laboratory requests, using protective clothing and hazardous material containment, specimen collection procedures, a variety of laboratory testing and techniques, and maintenance of laboratory equipment and supplies.

**Outcome: 3.1. Handling, Preparation, Transportation, Storage and Disposal**

Handle, prepare, transport, store and dispose of specimens using procedures that minimize disturbance to the test specimen. Monitor, record and maintain the integrity of equipment and instrumentation, environmental conditions of the facility and the inventory.

**Competencies**

3.1.1. Prepare and interpret labels for chemicals, supplies and equipment.

3.1.2. Use chemical references to identify hazards associated with handling and storing chemicals.

3.1.3. Neutralize acids, bases or caustic solutions for handling and disposal.

3.1.4. Sample, monitor and record the environmental conditions of the facility (e.g., air quality,

temperature, microbial contaminations).

3.1.5. Describe the purpose of common laboratory equipment.

3.1.6. Identify when to use high-efficiency particulate air (HEPA) filters and biological safety cabinets.

3.1.7. Select personal protective attire for various laboratory protocols.

3.1.8. Differentiate between primary and secondary barriers.

3.1.9. Use laboratory biosafety level criteria, based on established standard operating procedures.

3.1.10. List basic characteristics of each of the four biosafety levels for infectious agents and identify potential sources of infectious agents.

3.1.11. Adjust, calibrate and perform systems diagnostics on laboratory equipment.

3.1.12. Maintain equipment logs and determine when to perform, implement or schedule preventive maintenance and systems updates.

3.1.13. Verify expiration dates and lot numbers.

3.1.14. Implement a chemical inventory system that includes all pertinent information regarding stability, hazards and sensitivity.

3.1.15. Maintain an inventory system for products.

3.1.16. Implement procedures to monitor the distribution, consumption and pilferage of materials.

3.1.17. Maintain separate in-processing, quarantine and release areas.

*An “X” indicates that the pathway applies to the outcome.*

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| **Pathways** |  | Agribusiness and Production Systems |  | Animal Science and Management | X | Bioscience | |  | Horticulture |
|  | Natural Resource Management |  | Power Technology | |  |  | | |
| **Green Practices** |  | Green-specific |  | Context-dependent | |  | Does not apply | | |

**Outcome: 3.2. Foundations of Chemistry**

Perform a systematic and methodical application of general and organic chemistry principles to examine structures, their functions, their binding to other molecules and the methodologies for their purity and characterization.

**Competencies**

3.2.2. Use the periodic table to describe atomic structure and to characterize molecules based on functional groups.

3.2.3. Differentiate between organic and inorganic compounds.

3.2.4. Use common and chemical nomenclature for organic and inorganic materials.

3.2.5. Write names and formulas for common compounds.

3.2.6. Prepare solutions based on molarity, normality, percent weight per volume (w/v) and percent volume per volume (v/v).

3.2.7. Describe chemical bonding and bond types, including ionic and covalent and the relationships that they have with the physical state of materials.

3.2.9. Balance chemical reactions.

3.2.10. Identify materials that can be used as a catalyst.

3.2.11. Predict endothermic and exothermic characteristics of a chemical reaction.

3.2.12. Use naming systems, including common and International Union of Pure and Applied Chemistry (IUPAC) conventions.

3.2.13. Use and calibrate precision weighing and measuring techniques (e.g., analytical balance, micropipette), based on the metric system.

3.2.14. Calibrate volumetric glassware (e.g., pipettes, volumetric flasks and burettes).

3.2.15. Calculate errors in various measurements, based on data acquired using common laboratory equipment.

3.2.16. Apply standard rules for determining the number of significant figures in measurements and in the answers to corresponding calculations.

3.2.17. Convert units of measure from English to metric and within the metric system.

3.2.18. Calculate the volume, temperature and pressure of gases using the ideal gas law, Charles' Law and Boyle's Law.

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| **Green Practices** |  | Green-specific |  | Context-dependent | | |  | Does not apply | | |

**Outcome: 3.3. Microbiology Testing and Technology**

Describe the morphologies and processes of the reproduction of microorganisms.

**Competencies**

3.3.1. Use microbial taxonomy and classification systems to identify microbial organisms.

3.3.2. Compare and contrast cellular structure and functions of prokaryotic and eukaryotic cells.

3.3.3. Transform deoxyribonucleic acid (DNA) to alter bacterial metabolism, reproduction, cell structures and their functions.

3.3.4. Identify aerobic bacteria through morphological, physical and biochemical properties.

3.3.5. Obtain specimens for microbiological testing.

3.3.6. Differentiate between types of viruses.

3.3.7. Explain virulence, pathogenicity and the factors that contribute to pathogenicity.

3.3.8. Describe types and features of passive and active transport systems.

3.3.9. Describe molecular behavior and the structure of large molecules, including carbohydrates, lipids, proteins and nucleic acids.

3.3.10. Explain how chemical energy operates major cell processes (e.g., biosynthesis, movement, transport, growth).

3.3.11. Identify factors that affect and optimize rates of enzyme assay reactions.

3.3.12. Perform an enzyme-linked immunosorbent assay (ELISA) and interpret the results.

3.3.13. Perform biochemical assays of proteins, lipids, carbohydrates, nucleic acids and enzymes.

3.3.14. Perform bioassays for pathogens

3.3.15. Distinguish uses and limitations of various assays.

3.3.16. Apply quality assurance control processes within the lab setting (e.g., pre-analytic, analytic and post-analytic sources of error).

3.3.17. Perform autoclave sterilization.

3.3.18. Explain the centrifugation process.

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**Outcome: 3.4. Molecular-Genetics Technology**

Apply knowledge of nucleic acid structure and function, deoxyribonucleic acid (DNA) replication, transcription, translation, chromosome structure and remodeling and regulation of gene expression in prokaryotes and eukaryotes.

**Competencies**

3.4.2. Explain alternative forms of transmission (e.g., non-Mendelian inheritance).

3.4.4. Model the Central Dogma Theory (e.g., replication, transcription, translation).

3.4.5. Follow regulations for genetic modification (e.g., histone acetylation, ribonucleic acid [RNA] stability, co- and post-translational modifications).

3.4.6. Identify alternative types of gene expression (e.g., sex-limited, sex-linked, partial dominance, epistatic, pleiotropic).

3.4.7. Identify, isolate and manipulate peptides and proteins (i.e., primary, secondary, tertiary, quaternary).

3.4.8. Perform the steps in creating a recombinant DNA molecule.

3.4.9. Isolate and purify nucleic acids, including chromosomal and extra-chromosomal DNA molecules.

3.4.10. Compare nucleic acids, chromosomal DNA molecules and proteins using a sequence database (e.g., National Center for Biotechnology Information, Europeon Bioninformatics Institute).

3.4.11. Perform a restrictive enzyme digest and analyze the results.

3.4.12. Apply concepts of screening genetic expression, expression vectors and genetic libraries.

3.4.13. Apply the principles of nucleic acid blotting (e.g., colony transfer, Southern and Northern Blot Analysis).

3.4.14. Perform and interpret the results of a polymerase chain reaction (PCR).

3.4.15. Explain applications of Southern and Northern Blot Analysis.

3.4.16. Isolate, quantitate (e.g., Bradford assay) and characterize (e.g., Western Blot analysis) proteins.

3.4.17. Perform antibiotic resistance cloning techniques, including vector preparation, transformation and selection.

3.4.18. Perform spectroscopy of biological materials explaining the principles behind the procedures, the purpose of a blank and determine the concentration of biomolecular samples.

3.4.20. Perform gene analysis to determine the source of an isolated pathogen.

3.4.21. Identify the role of RNA in gene expression.

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| **Green Practices** |  | Green-specific |  | Context-dependent | |  | Does not apply | | |

**Outcome: 3.5. Laboratory Standard Operational Procedures**

Perform methods and techniques using protocols to conduct an experiment.

**Competencies**

3.5.1. Use an aseptic technique to collect, prepare and test samples.

3.5.2. Prepare and dispense stock reagents, buffers, media and solutions by calculating concentrations, adjusting factors such as pH and selecting purification techniques and containers.

3.5.3. Test and maintain the integrity of stains, reagents, chemicals and mounts.

3.5.4. Select and apply sterilization methods for reagents, buffers, media and solutions.

3.5.5. Perform laboratory measures by calculating and preparing a serial dilution, calculating quantities needed to perform a test analysis and calculating unit conversions and concentrations (graphing results).

3.5.6. Monitor physical properties of reagents, buffers, media and solutions for conductivity and resistivity, pH and turbidity and explain the significance of each.

3.5.7. Perform separation techniques, including chemical separations, chromatography, centrifugation, distillation and filtration and interpret the results.

3.5.8. Titrate liquids.

3.5.9. Transfer gases, liquids and solids from storage containers to equipment used in the laboratory.

3.5.10. Perform a chromatography separation of a given mixture of substances.

3.5.11. Use electrophoresis to separate nucleic acids and proteins to determine molecular weight.

3.5.12. Comply with industry-based and required regulatory quality-assurance practices (e.g., quality

control [QC], Good Laboratory Practice [GLP], Good Manufacturing Practice [GMP]) for documentation.

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**Outcome: 3.6. Culturing**

Perform experimental techniques used in microbial biology to study cell growth, manipulation and evaluation.

**Competencies**

3.6.2. Explain classification, composition and preparation of culture media and prepare media for propagation.

3.6.3. Identify bacteriologic methods necessary for the isolation and identification of organisms.

3.6.4. Operate centrifuge, microscope, compound microscope, spectrophotometer, incubator, colony counter, pipettes and other basic microbiology and analytical equipment to examine biological specimens.

3.6.5. Explain the principles of microscopy and process a specimen for light microscopy.

3.6.6. Prepare, incubate and identify colonies microscopically and macroscopically (e.g., colonial morphology, staining procedures, biochemical).

3.6.7. Isolate, propagate, maintain and harvest pure cell lines.

3.6.9. Explain the collection and handling of fungal, mycobacterial and viral specimens.

3.6.10. Describe how vectors (e.g., plasmids, transposons, viruses) are used to transform host and microorganisms.

3.6.12. Describe physical factors that affect microbial growth and identify a normal bacteria population growth curve.

3.6.13. Conduct a shelf-life study to determine physical change and biological growth.

3.6.14. Conduct a thermal death time study on an organism.

3.6.15. Calculate values of cell concentration for both batch and continuous cultivation.

3.6.16. Identify hormones used to stimulate cell growth and test for antibiotic susceptibility.

3.6.17. Explain how cell cultures can be used to assay viability and cytotoxicity.

3.6.18. Demonstrate cryopreservation techniques by freezing and thawing cells.

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**Outcome: 3.7. Bioreactor Technologies**

Describe and perform bioreactor and fermentation procedures (e.g., sterilization, microfiltration).

**Competencies**

3.7.1. Maintain, classify and analyze types and classes of bioreactors and associated materials.

3.7.2. Explain the principles and importance of sterility in industrial fermentations.

3.7.3. Explain the temperature/pressure relationship of saturated steam to sterilization.

3.7.4. Explain the effect of entrapped air on sterilization effectiveness.

3.7.5. Compare sterilization methods using dry heat versus moist heat.

3.7.6. Demonstrate sterilization by micro-filtration.

3.7.7. Explain the effect of suspended solids in fermentation media on sterilization effectiveness.

3.7.8. Describe the sources and forms of energy, the relationship between heat and temperature, how heat is transferred and the factors that affect the rates of reaction in processing.

3.7.9. Describe the functions and physical properties of simple and complex carbohydrates, lipids and proteins in the fermentation process.

3.7.10. Describe the roles of enzymes as catalysts and the factors that affect enzyme activity in the fermentation process.

3.7.11. Describe the relationship of oxygen transfer rates to mass transfer.

3.7.12. Perform applications using benchtop fermentor and bioreactor systems.

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**Outcome: 3.8. Research and Experiments**

Conduct a problem-based study, applying scientific methodology and using descriptive statistics to communicate and support predictions and conclusions.

**Competencies**

3.8.1. Identify research problems and structure a statistical experiment, simulation or study related to the problem.

3.8.2. Design a research plan, including the significance of the problem, purpose, variables, hypotheses, objectives, methods of study and a list of materials.

3.8.3. Distinguish between dependent, independent and control variables in an experiment.

3.8.4. Establish and implement procedures for systematic collection, organization and use of data.

3.8.7. Document results of the experiment in a laboratory notebook, including a statement of purpose, experimental designs, observations, results, conclusions and next steps.

3.8.10. Create, interpret and use tabular and graphical displays and describe the data.

3.8.11. Draw conclusions based on observations and data analyses, recognizing that experimental results must be open to the scrutiny of others.

3.8.12. Prepare and present findings using scientific reports.

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| **Green Practices** |  | Green-specific |  | Context-dependent | | |  | Does not apply | | |