Title: Advanced Interdiscplinary Science for Sustainable Agriculture

Length of Course: Full Year (2 semesters; 3 trimesters; 4 quarters)

Subject Area – Discipline: Laboratory Sciences ("d") – Interdisciplinary

UC Honors designation: Honors

CTE Sector: Agriculture and Natural Resources

CTE Pathway: Agriscience

Grade Level(s): 9-12

Prerequisite(s): Algebra 1 or IM 1; successful completion of life science & physical science

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Overview:

This integrated class combines an interdisciplinary approach to laboratory science and research with agricultural management principles. Using skills and principles learned in the course, students design systems and experiments to solve agricultural management issues currently facing the industry. Additionally, students will connect the products created in this class with industry activities to link real world encounters and implement skills demanded by both colleges and careers. The course culminates with an agriscience experimental research project in which students design and conduct an experiment to solve a relevant issue. Final projects will be eligible for Career Development Event competition at FFA events. Throughout the course, students will be graded on participation in intracurricular FFA activities as well as the development and maintenance of an ongoing Supervised Agricultural Experience (SAE) program.

Course Content:

Unit 1: Research Methods in Agriscience

The final unit will culminate in an agriscience experimental research project. Students will identify a problem related to the aspects of agriculture explored in this course (plant science, animal science, natural resources, and food science). After completing studies in plant science, animal science, natural resources, and food science, students will develop an agriculture problem to be solved using the scientific method. Such examples of problems identified by the student may include the effects of estrus synchronization of ovulation, a comparison of the germination rates of GMO and conventional seeds, or an investigation of perceptions of community members towards alternative agriculture practices. The research problem should be current and relevant, and may be applicable on a local, regional, national, or global level. Students will utilize the empirical method to design an experiment that will test their own authentic hypothesis using the skills and processes learned throughout the course that include dissecting published research and

studies, testing the hypothesis, collecting, synthesizing, analyzing and interpreting data, accepting or rejecting the hypothesis based upon the data, technical reading and writing, and scientific collaboration.

In this first unit, students will practice research skills in agriscience that will give them the skills needed to successfully complete the unit labs and capstone project.

Unit 1: Key Assignments

1. **Background Scholarly Research** In this assignment, students begin the work of investigation into their project. Students will read and deconstruct scholarly journal articles to identify the key components of agriscience research. The manner in which this assignment is completed can be determined by the individual teacher. Examples of student outcomes of the journal assignment could be: graphic organizer, abstract, oral presentation, visual aids, etc.
2. This assignment models the expected outcomes of all projects in the coming units.

Unit 2: Plant Systems

Students will examine the chemical and biological principles that govern plant science and crop production, using prior knowledge of plant pathology, taxonomy and biological principles to inform the unit's activities. Plant pests are present in all plant systems. Pest populations must be managed to prevent economic losses. Integrated pest management strategies are used to achieve desired results while using cost-effective and environmentally-friendly practices. Students will collect primary and secondary research regarding plant production models, chemical or biological control methods for pest management and agricultural yield expectations. Specifically in this unit, students will examine chemical irradiation methods, botanical extracts, microbial control, predator use, synthetic pesticides, etc. Through this unit, students will gather information regarding the risks and benefits of each method in regard to plant production, agricultural yields and environmental sustainability.

Unit 2: Key Assignments

1. GMO's/Organic vs. Conventional Farming Debate and TED talk

To further their understanding of accepted, conventional farming practices as well as alternative methods of production, students will distinguish between each practice, the characteristics of production that define each, and the concerns raised by society, then report their findings through visual media (TED). Genetic engineering is known as one of the great advancements of our times, but is also one of the most controversial. Often conventional farming methods and agriculture corporations are highly criticized for their creation of GMO (genetically modified organisms) products and use of chemicals. This assignment will help students understand the technologies and practices used in conventional and organic farming and be able to defend a practice or a product and support their position with scientific evidence. After instruction in conventional and organic farming, students will engage in secondary research to investigate differences between the two, the use of biotechnology and GMO's, by preparing and executing a yield differential lab that synthesizes their knowledge of biological and chemical principles. Specifically, students will calculate levels of chemical inputs and forecast environmental impacts of anticipated chemical reactions between a GMO crop, a

traditional crop and an organic crop. After the conclusion of that process, students will engage in primary research with a yield differential lab. The lab will ask students to prepare a soil sample that works for a locally-relevant crop and to plant and grow that crop in both GMO and organic forms, comparing yields at the conclusion of the lab.

Upon conclusion of their primary research, students will prepare a presentation that will highlight the results both of their secondary and primary research. The presentation should focus on the relationship between chemical use and anticipated chemical reactions in various production scenarios and expected yields from the same scenarios, with students presenting recommendations to peers or industry guests. The desired goal is for students to inform their decision with a research validated analysis of the tradeoffs associated with each production method.

For activity enhancement: Students review biased documents/media (e.g. Food Inc.) to review and discuss their inaccuracies, contrasting the results of their lab with their media review. The conclusion of this assignment will ask students to present their comparative analysis to their peers and engage in a peer review process.

Additionally, students can research scientific journal articles, laws, regulations, case studies or other scientific evidence that supports or refutes claims, then produce and submit a 4-5 minute TED talk to be reviewed by their peers . Students will select the two TED talks produced by their classmates that they feel are the most fair, balanced, and scientifically based. They will discuss their selection in an individual class blog posting.

2. Categorizing Agriculture Pests

In this activity, students will categorize pests based on biological and physical characteristics. One of the key components of an IPM plan is being able to correctly identify a pest, which is then used to determine an appropriate control method. Students will collect a weed sample (eg from home, ag dept, school), and utilizing the UC IPM website, they will learn the difference between broadleaf, sedge, grass and aquatic weeds. They will then determine what type of weed their sample is and mount it. Examples of scientific sampling methods that may be used to collect weeds include; Random Sampling, Systematic Sampling or Stratified Sampling. Students will use taxonomic classification principles in order to label the identifying characteristics that distinguish it from other weed types. Being able to identify the type of weed will assist in determining what an appropriate control is and will be utilized to create their comprehensive crop production plan. Students will then conduct a laboratory experiment using a selected chemical or biological control and report their findings via a podcast, paper or blog post.

Students will continue their study of pests by examining vertebrate and invertebrate pests, pest damage (instructor will provide samples of common pest/damage for the region) and make predictions about which pest caused the damage. Students will be able to match crop damage to the pest that caused it using indicators like mouthparts, digging and pecking. Students will be able to identify pest using mouth parts, body segments, excrement, etc. Students will create a biological dichotomous key for the identification of vertebrate and invertebrate pests. Students will research and then create a handbook that assists in identifying nematode and plant disease damage. The

dichotomous key will be added to the handbook. The knowledge gained in creating this handbook will be used as part of the IPM plan in the unit project.

3. Controlling Pests Through Integrated Pest Management

Students will demonstrate the integration of pest management techniques by designing and conducting an experiment where they compare the four methods of pest management (biological, cultural, mechanical/physical, and chemical) on a specific pest and crop, for example, snails in citrus trees or vegetables. After the conclusion of this experiment, students will construct an explanation on the effects of pest management techniques on biodiversity, ecosystem balance and agricultural productivity and include that information in their lab report. Suggested areas for experimentation might include chemical controls (soap and water), use of beneficial predators (avians or various invertebrates), cultural (tilling soil), and mechanical/cultural (physically removing the pest). One method must include a chemical control, with students describing the relationship between specific elements in the chemical control and the elements and reaction processes that facilitated the management of the pest.

4. Crop Production Plan

Based on prior knowledge and activities, students will create a comprehensive crop production calendar for a specific crop (eg row crops, trees, vines, greenhouses), organic or conventional farming methods and a specific location. The calendar will include various cultural practices, time frames on pest controls and monitoring, analysis of neighboring field plantings, fertilization, post harvest procedure, soil amendments, days to re-entry, and harvest and land preparation. In addition, students will include a solution for reducing the impacts of human activities on the environment and biodiversity through crop production practices. Students will utilize descriptions of the soil's chemical and physical profiles, chemical profiles for all soil amendments and genetic planning procedures for all plants used in the production scheme.

Related Research and Forming a Hypothesis

As they begin work on their year-long research project, students use skills in research and forming hypotheses developed in the plant systems unit to develop a hypothesis for their agriscience research project. Students will use credible sources to conduct background research on the agricultural issue they are investigating, and they will use this research to generate a testable hypothesis related to the scientific problem they have identified. The hypothesis developed by the student will be constructed with the independent and dependent variables in mind, and ultimately reviewed by the instructor.

Unit 3: Animal Systems

Each livestock species has a series of parasites or diseases that can be managed to help produce healthier livestock. This unit builds on the basic format for research methods developed through activities in Unit One and Unit Two to help students understand how animals are affected by parasites and other infectious diseases. Students will review basic livestock anatomy and physiology, livestock production systems, and the goals and objectives associated with the production of livestock as a food and fiber source.

In order to achieve production goals, the management of the livestock herd must include

an understanding of how diseases and parasites can impact livestock production in terms of growth efficiency and outcome of an animal. Students will research the basic cycles of the parasites and their prevention and how they are treated. The students will conduct experiments with pathogens, disease and infections related to livestock herds and examine information about the mode of infection and chemistry of the illness as well as the immune response of the species to the parasite or illness. Furthermore, students will propose methods for breaking the cycle of parasite and disease resistance by utilizing alternative management options outside of the traditional pharmacological treatments as part of the Parasite and Disease Management Plan (unit culminating activity).

Unit 3: Key Assignments

1. Facility Visits – In order to understand the interaction of parasite life cycles with livestock production, students will be taken to livestock production facilities to discover which type of facilities and feeding systems may have an impact on parasite infections. Additionally, students will collect fecal samples from the site to determine the presence of common pathogens and parasites in an upcoming lab. Interviews on site with producers and handlers will provide insight as to how housing and facilities will impact diseases and parasites, thereby dictating the management plans on their farms. Students will then develop a written or live recommendation to the producer regarding the management protocols and handling needs to mitigate the parasites or pathogens found a result of the experiments.

2. Survey – To foster professional contacts, students will complete a formal research survey (possibly using a Google Form Survey) which will require students to contact a variety of local facilities, producers, and veterinarians. Students will begin by engaging in secondary research to investigate major livestock conditions, diseases and parasites, with focus on the inherent biological and chemical conditions that precede or enhance the condition. Students will then use this background knowledge to develop the questions in order to examine the professional's role in diagnosing and resolving infections or conditions that may occur frequently in the local community. Students will synthesize and analyze their data to determine best practices gleaned from the survey responses.Students will select a research topic related to the results of their survey. Students will include the final results of this survey in their parasite management plan along with their research.

3. Technical Reading and Research – Taking direction from the results of their survey, students will analyze journal research and published studies and merge their survey data to create an infographic to be included in their final parasite management plan. An example of a topic could include; the use of crossbreeding in livestock to help a livestock producer achieve greater natural resistance to some parasites, the natural selection and parasite resistance to medicines or specific veterinary applications of remedies.

4. Lab Experiment 1 – Fecal Egg Counts-Practice

Providing practical, agriscience research skills, students will use the Modified McMaster's Fecal Egg Counting Protocol to perform a fecal egg count on livestock. In this pathogen experimentation the fecal egg counts will be compared to demonstrate how management affects internal parasite populations in livestock. Students will incorporate

the scientific skills learned in the first unit in this laboratory experiment. A hypothesis will be constructed to predict the outcome of the research. A McMaster's fecal egg counting slide will allow students to quantify parasite infection through the egg counting and recording process. Students will produce a formal lab report and conclusion document which includes some suggested topics for further experimentation. These suggested topics will inform the selection of the Experimental Design Topic.

5. Lab Experiment 2 – Experimental Design

Using their experiences from the first experiment, students will design and conduct a related experiment in which they investigate a parasite topic of their choice related to the final capstone project.

Examples of variables that may be tested could include:

- ➔ Livestock that have been dewormed versus those that haven't.
- ➔ Livestock that have been dry lotted after having been dewormed versus livestock that are returned immediately to graze on pasture.
- ➔ Livestock that are crossbred with breeds known to exhibit parasite resistance.
- ➔ A comparison of the effectiveness of various anthelmintics (dewormers) available to producers or commonly used on local production facilities.

A statistical analysis may be conducted to help the student determine the likelihood that the results are due to the applied variable, rather than chance. Students will revisit the original hypothesis as they draw conclusions based upon the data. A discussion of limitations to the research and further studies will be included. A formal lab report will be written and will include all parts of this study, therefore reinforcing the empirical method of scientific research. Any citations and resources should be made using APA format.

6. Final Product: Parasite/Disease Management Plan for Livestock – Components:

Using their research, surveys, and information from their visits and interviews, students will create a parasite management plan. The final product of this unit will be a written, research-based report which identifies a livestock species of interest and the disease or parasite that is affecting the livestock species of interest. After the best practices management plan is developed, students will present their portfolios to their peers and/or to local industry professionals at a formal symposium. All products should include qualitative and quantitative data recorded from the first five assignments of this unit.

Includes:

- ➔ Parasite/disease identified including biological/microbiological profile of the pest as well as a physiological analysis of the effect of the pest on the host.
- ➔ Vaccine/medication/anthelmintic- type and dosage to be administered, method of administration, withdrawal/recovery period, possible rotational schedule to prevent resistance. A chemical profile of the medication should also be included, with students specifically examining the presence of heavy metals, toxic elements and potential reactivity that require specific withdrawal periods when applied to food animals.
- ➔ Annual calendar or plan for vaccination and treatment of the animals in production.
- ➔ Facilities Design and Plan - livestock handling, pens/restraints, holding, equipment, pasture management/rotation. Specific considerations should be made for animal psychology, species-specific physiology and pest management through quality

design.

- ➔ Human and Animal Safety considerations to be made. Specifically in relation to chemicals being used in the pest management protocol, which have hazardous reactions with humans and must be stored, managed and disposed of in particular manners?
- ➔ Labor requirements
- ➔ Alternative control methods that may be considered to help prevent or diminish the impact of the parasite/disease. Which holistic or homeopathic methods are effective in managing pests for alternative agricultural production models? What are the chemical profiles and potential reaction processes of alternative medicines that could be used to manage pests?
- ➔ Industry professional to mentor any part of the development of the management plan. For example, a veterinarian may be consulted on dosage and administration or a pharmaceutical representative may be asked to provide guidance on new medications. To develop a continued connection to agricultural careers, who locally could be potentially consulted in the implementation of this plan?
- ➔ Prevention plan to deter future infestations and disease or parasite resistance. What biological, physical and chemical elements can be put into a management protocol that would enhance prevention methods?

<u>Experimental design and conducting experimentation</u>

Students continue work on their year-long agriscience project by constructing an experimental design to test the hypothesis they developed in this unit. Students will draw on the experimental design and experimentation lessons learned during both fecal egg count laboratory activities. A written experimental design should be constructed consistent with scientific protocol using a systematic approach outlined in the previous units. Students will have their experimental designs reviewed by professional contacts (industry experts, agricultural instructors, local growers/producers, researchers or university representatives). After validating the design using the peer review process, students will move to the experimentation phase of their research. Experimental designs should include replicates, control groups, and determine the variables to be controlled and how. Additionally, a determination should be made as to the type of data that will be collected and in what ways, with the emphasis placed on quantitative data or quantifying data that is qualitative in nature. Students will use their experimental design to test their hypothesis. For example, a study could be conducted to determine if administering an injection of selenium is more effective than simply providing selenium salts in the diet in an effort to prevent selenium deficiency and white muscle disease in a sheep herd. Raw data should be recorded using a field book or electronic device.

<u>Unit 4: Natural Resources</u>

Natural resources can be defined as items found on earth that are of use to humans such as fuel, food, shelter, or a source of wealth. It is what humans do with these resources and the management practices that will determine if these will be available to future generations. In this unit, students will conduct primary research to draw conclusions regarding the impacts of plant and animal systems (units 2 and 3) on natural resources. Students will create model environmental impact reports that include secondary research backing, industry needs, primary research analysis and sustainability

recommendations in watersheds located in agricultural regions. Students will identify local agriculture production areas and their relationships between land characteristics, water quality, and habitat growth and maintenance. Referencing local environments and agriculture practices, students will analyze possible sources of pollution and erosion and determine the impact of animal and plant systems, wildlife interactions, and beneficial and detrimental production practices. Students will use their knowledge to make recommendations on ecological friendly solutions on improving watersheds. Students evaluate the importance of soil and water conservation, the effects of animals, erosion, pollution, and urban sprawl on watersheds, and human impact on the environment and natural resources.

Unit 4: Key Assignments

1. Water Quality

In order to understand that natural resources like water are affected by the environment, students will locate and retrieve a sample of untreated water from local sources that have agricultural runoff, if none are nearby instructors may include local creeks, lakes, watersheds, or reservoirs, one from a source near an agriculture producing facility and one away from an agriculture producing facility. Using a standard water testing kit, the water samples will be analyzed for the various particulates and contaminants. They will record pH, lead, nitrates, presence of pesticide residue, and coliform bacteria as well as sediment levels. They will use this information to determine which pollution factors are affecting local watersheds and their source, including an analysis of possible erosion sources, chemical contaminants and biological inputs (wildlife, livestock, etc.). Following their data collection and analysis, they will use problem solving skills to make recommendations for pollutant elimination, the reporting format will be determined by the instructor (example: oral presentation, visual aide, lab write up, etc).

2. Agriculture Practices, Natural Resource Conservation, and Case Studies

Now that students have an understanding of factors that affect water quality they will be exposed to agencies that regulate the use of these resources. Local directors of the United States Department of Agriculture (USDA), Natural Resources Conservation Service (NRCS), the Resource Conservation District (RCD), or any other pertinent industry professionals will present students with information about practical applications of water conservation, limiting pollutants, and practices that reduce environmental impacts of agriculture practices. Local agriculture producers will also be invited to come and discuss their practices and how they are limiting their negative impacts on the natural resources available to them. Students will read and evaluate case studies of agriculture producing farms implementing sustainable practices. Case studies could include cover crops, owl boxes, crop rotation, and water runoff. The outcome of the visit(s) and case study will result in a reference included and cited in the future irrigation plan or environmental impact report that will be generated at the end of this unit. Both the irrigation plan or the environmental impact report should reference the data collected from assignment one.

3. Water Flow, Irrigation Plan, and Efficiency Model

Using the information and data collected in assignments one and two, students will create a plan to analyze irrigation practices and efficiency in order to identify an appropriate irrigation system. Students will also gather knowledge of adhesion, cohesion

and chemical bonding principles that govern water management through analysis of industry articles and scientific texts. Through the practice of building a water flow and efficiency model, students will identify innovative conservation approaches and irrigation methods such as scheduling irrigation rotations depending upon soil moisture, crop growing periods, availability of water, and methods of irrigation such as tape, drip, micro sprinklers, pressurized sprinklers, furrow, and flood. Sources of surface water and groundwater will be identified. Student irrigation plans will be based on a selected crop and data will be collected, analyzed, and interpreted, to form conclusions based on:

- ➔ acreage farmed
- ➔ types of crops
- ➔ methods of irrigation (to include a model demonstrating water flow and efficiency, see information below)
- ➔ sources of water
- ➔ acre feet of water for crops grown
- ➔ programs available for irrigation implementation funding or conservation
- ➔ cost effectiveness of farming versus selling water
- ➔ runoff and contamination
- ➔ environmental impact report culmination

Water flow and efficiency model:
Students will break into groups to demonstrate methods of irrigation. They are to create a "farm" of their choice (garden beds, farm plots, container created plots, etc.). Each group will be provided a set amount of water to demonstrate their method of irrigation (each group should choose different methods such as furrow, drip, micro-sprinkler, etc.). They shall record the amount of water used, soil moisture, and runoff. At the conclusion of the lab, students will be able to justify best practices of irrigation for crops grown and the impact on environment and water resources. Students will utilize knowledge of capillary action in soil, plant physiology as well as chemical bonding in water to inform their laboratory experiment. Students will present their best practices in a format to be determined by the instructor (example: oral presentation, visual aide, lab write up, etc)

Analyzing data, interpreting data and forming conclusions.
Students will determine the best methods for organizing their data using tables. The skills in analyzing and interpreting data used during the water flow and efficiency model during the Natural Resource unit will be applied to the final agriscience research project. Specifically students were asked to determine the most efficient irrigation application method during the water flow and efficiency model. Students will make similar determinations on their Agriscience research. Students will use mathematical principles to synthesize their data, calculating a mean. Furthermore, a statistical analysis of the data will help the student determine if the results are due to chance or the independent variable that was tested. Students will choose the best way to present their data using graphs they believe will most effectively demonstrate their findings, and will further summarize what each graph shows. Finally, students will interpret the data and formulate conclusions based on the results. In the written conclusion, students will use their data to either accept or reject the original hypothesis. Conclusions should be directly supported by the data and supported by previous research. Students will also identify the limitations of their research, improvements that could be made to the

experimental design, as well as future studies that may be conducted that relate the study at hand.

Unit 5: Food Systems

The purpose of this unit is to use prior knowledge of chemical and biological principles and apply them to end-stage agricultural practices in food safety and food preservation. Utilizing research skills and technical plant, animal and pest knowledge from earlier units, students will create a consumer-focused and locally-relevant food product (examples: jerky, jam, pickles). They will utilize scientifically proven food safety and preservation methods and will create a comprehensive food safety plan including a food label following FDA guidelines for presentation to be judged by industry professionals. As part of the comprehensive food safety plan students will investigate the importance of implementing Hazardous Analysis Critical Control Point (HACCP) plans in the prevention of foodborne illness. HACCP plans will identify areas of potential contamination in the food chain for a specific product's production from the raw commodities, preparation, packaging and through storage by the consumer.

Unit 5: Key Assignments

1. Foodborne Disease and Its Role in Food Safety

To begin the convergence of scientific principles and food safety, students will research a specific foodborne illness, and their findings in this research will be linked to laboratory investigations where they will determine the types of disease causing agents they collected on food samples and from the food preparation areas and tools. They will use knowledge from prior units to identify the type of disease causing agent (fungal, bacterial, viral, parasitic, noninfectious), transmission, treatment, and prevention in addition to reviewing production practices responsible for a specific outbreak of that disease. In their review of the outbreak, they will propose recommendations for prevention of future outbreaks of that type. Students will create and present a PowerPoint including their research findings; upon the conclusion of the presentations students will submit their project to a shared document to be used as a class resource in developing a comprehensive food safety and marketing plan.

2. Osmosis in Food Preparation

After learning appropriate food-handling protocols to reduce incidents of illness, students will engage in a series of chemistry-based exercises to learn the methods for preserving consumer food products safely. In particular this activity promotes student understanding of how jamming, dehydrating, and drying with salt or sugar are effective forms of food preservation, as they remove the water and change the chemical composition of food and delay the growth of microorganisms from harmful bacteria rendering the food safe for consumption. Groups of students will read a technical document on food preservation methods (e.g. smoking, canning, jamming). Students will create a graphic organizer to compare methods. Students will then conduct an experiment where they dissolve the shell of an egg and place it in various solutions over the course of a week to determine how osmosis and concentrations of solutions impacts movement through the cell membrane. Students will then apply their understanding of osmosis from this lab to a given commodity, and will be able to create a written recommendation for appropriate food preservation methods based on HACCP protocol.

They will later apply these findings to the creation of their safe food product at the end of the unit.

3. Identifying Components to HACCP

Students will create a visual display that identifies the seven principles of a HACCP plan, which is a systematic approach to the identification, evaluation, and control of food safety hazards based on the following seven principles: Principle 1: Conduct a hazard analysis, Principle 2: Determine the critical control points (CCPs), Principle 3: Establish critical limits. Principle 4: Establish monitoring procedures, Principle 5: Establish corrective actions, Principle 6: Establish verification procedures, and Principle 7: Establish record-keeping and documentation procedures. Consequently each of these principles will be researched and applied through experimentation throughout the unit, to create a comprehensive food safety plan for the food product students design for their final unit project.

4. Swabbing Hazards

After learning basic HAACP procedures, students will visit a commercial food production facility (school cafeteria, restaurant, processing site) and conduct a hazard analysis (as a basis for learning to investigate Principle 1 & 5 of a HACCP plan), swab samples of various surfaces (including but not limited to hands, door handles, tables, cutting surfaces, food preparation tools), and prepare and grow culture plates. After a period of growth, students will determine if potential disease-causing agents are present, and if so, identify the specific pathogen. Students will record their findings in a written report. As a result students will determine the critical control points for that location (Principle 2 of the HACCP plan) based on the data generated from the swabs. Students will apply this skill in the development of their product and food safety plan.

5. Chemical Properties in Preservation

Given the top 5 seasonally available commodities in a growing region, as well as common ingredients (granulated sugar, lemon, etc.) for preservation of those commodities, students will determine chemical properties of those commodities through their prior knowledge of pH, brix and water content. They will collect and record their data in a chart they design. Students will study the effects of pH on cut apple preservation (as a basis for learning to investigate Principle 3 & 4 of a HACCP plan). Each group will make a selection of a test solution based on scientific research. Students will gather data on bacterial colony counts that develop on swabs they take of samples from the cut apples. As a result groups will report to the class their findings and groups will evaluate the data. Groups will also brainstorm and determine other possible critical control limits for the sliced apple product. Students can employ several different possible methods of reporting their findings. (examples of reports include: oral presentation, visual aide, lab write up, etc)

6. Implementing Procedures and Practices

Students will begin by reviewing a locally obtained HACCP plan (as a basis for learning to investigate Principle 6 of a HACCP plan). From the plan students will annotate and 1) identify areas of critical control 2) identify scientific evidence used as expert advice to validate HACCP protocols 3) identify specific procedures and practices to implement protocol in the plant. Student findings will be recorded using a graphic organizer that will

be included in their final food safety plan (examples include: Three Circle Venn Diagram, Comparison Chart, Cause and Effect, Factors in the Cause or Sorting Organizer). Upon gathering that information, students will conduct a primary research investigation to test the HAACP principles in a controlled environment using radiation and chemical methods. Though much of the scientific research they will have read shows that appropriate temperature and time kills microorganisms, there is also a significant body of evidence that dramatic pH alterations can inhibit microorganism growth. As such, students will conduct a second research protocol within the HAACP protocol that contrasts the radiation and chemical methods of microorganism prevention in order to determine the relative efficacy of each method. Students will combine their graphic organizer with their research conclusion and present their findings in a lab report, which will also be added to their final food safety plan.

7. Food Labeling

Students will wrap up their unit by developing an infographic that highlights food allergens and their role in food labeling. Students will research to prepare the infographic, which will include symptoms, major food allergens, treatment/when to seek treatment, the relationship of livestock antibiotic withdrawal periods and what must be included in origin labeling. An analysis of several different allergen-causing foods should occur, with investigations conducted regarding the elemental makeup of each food and the chemical reactions that cause the allergic reaction, specifically drawing a relationship between the interactions of the chemical world and the microbiology of the human body. The final infographic should showcase their findings using technical nomenclature, pictures, and supporting statistics.

8. Food Safety Product and Plan

The final project for the unit will ask student to develop a physical food product such as a fruit jam, dried vegetable product, oil, herb or seasoning mix, citrus juice, etc. and create a comprehensive food safety plan for the product that includes the HAACP and labeling standards. Students will choose a commodity from their growing region and utilizing food safety principles preserve it following scientifically proven preservation methods. Students will also engage in industry-standard testing protocols to assess the chemical profile of the food product (pH level, potential toxicity, etc.) as well as engage in a multi-interval microorganism testing protocol. Students will follow FDA guidelines and use prior unit knowledge to develop an appropriate label for their food that follows legal standards as well as agricultural marketing practices. They will prepare a written and 3-5 minute visual presentation (students will choose the media) for a panel of industry professionals.

Agriscience Research Paper and Display

Throughout all units, students will gather knowledge through laboratory exercises to further develop and enhance their Agriscience Research programs. At the conclusion of the course, students will submit their research in a written paper, and it will include the following components: problem/purpose, background research, hypothesis, methodology, results/data, and discussion/ conclusion. The paper will be written using skills associated with technical and scientific writing, for example, refraining from the use of personal pronouns or keeping discussion limited to what the research and data suggest rather than personal opinion and bias. APA format will be utilized to reference

and cite sources. Students will create a visual display board, using a digital format that mirrors the use of research posters in higher education, which will also include all of the components of the paper, but in a condensed form. The peer group that reviewed the original experimental design will review the final research paper. The project and its findings will be shared with the class in an oral presentation, with the research board on display to aid in communicating the results of the research.

Course Materials:

Agriscience Fundamentals and Applications. 6th Edition. L.DeVere Burton.

Environmental Science. 7th Edition. Bernard J. Nebel and Richard T. Wright.

Introduction to Biotechnology: An Agricultural Revolution. Ray V. Herren.

FDA HACCP http://www.fda.gov/Food/GuidanceRegulation/HACCP/ucm2006801.htm

National Center for Home Canning
http://nchfp.uga.edu/publications/publications_usda.html

A Food Labeling guide
http://www.fda.gov/downloads/Food/GuidanceRegulation/UCM265446

California Public Health Department-Prodecure for Obtaining a Canning Licence
http://www.cdph.ca.gov/pubsforms/Guidelines/Documents/fdbCANgde06.pdf

Ball Canning http://www.freshpreserving.com/

Centers for Disease Control-Food Safety/ Foodborn Illness
http://www.cdc.gov/foodsafety/diseases/index.html

Food Allergens Guidance Documents & Regulatory
http://www.fda.gov/Food/GuidanceRegulation/GuidanceDocumentsRegulatoryInformation/Allergens/default.htm

Veterinary Medicines for Livestock:
www.gov.uk/managingi-livestock-veterinary-medicines

Modern Livestock and Poultry 8th Edition, Gillespie and Flanders

How to Write a Scientific Paper by Robert A. Day

Statistics for Veterinary and Animal Science by Aviva Petrie and Paul Watson

Environmental Protection Acency - Crop Production:
http://www.epa.gov/oecaagct/ag101/cropsoil.html#operations

National FFA Agriscience Fair Handbook
https://www.ffa.org/documents/agsci_handbook.pdf

National FFA Research Report Template
https://www.ffa.org/programs/awards/agrisciencefair/Pages/default.aspx