

**EL DORADO UNION HIGH SCHOOL DISTRICT
EDUCATIONAL SERVICES
Course of Study Information Page**

COURSE TITLE Biology and Sustainable Agriculture																		
DISTRICT COURSE NUMBER 0706		4-DIGIT STATE COURSE CODE (COMPLETED BY SILT) 4029																
Rationale:	<p>The Biology and Sustainable Agriculture course is an option for students in agriculture programs to fulfill the life science requirement in the El Dorado Union High School District, as well as meets the UC "d" credit for life science.</p> <p>Sustainability is based on a simple principle: Everything that we need for our survival and well-being depends, either directly or indirectly, on our environment. Sustainability creates and maintains the conditions under which humans and the biotic world can exist in productive harmony, that permit fulfilling the social, economic and other requirements of present and future generations. Sustainability is important to making sure that we have and will continue to have, the water, materials, and resources to protect human health and our environment. (adapted from http://www.epa.gov/sustainability/basicinfo.htm)</p>																	
Course Description that will be in the Course Directory:	<p>Sustainable Agriculture is a one year course designed to integrate biological science practices and knowledge into the practice of sustainable agriculture. The course is organized into four major sections, or units, each with a guiding question. Unit one addresses the question, What is sustainable agriculture? Unit two, How does sustainable agriculture fit into our environment? Unit three, What molecular biology principles guide sustainable agriculture? Unit four, How do we make decisions to maximize sustainable agricultural practices within a functioning ecosystem? Within each unit specific life science principles (including biological molecules, energy transfer through photosynthesis, cell respiration and fermentation, cell structure and function, classification, DNA structure and function, protein synthesis, genetics, evolution, and ecology), will be identified with agricultural principles and practices guiding the acquisition of this knowledge, culminating in the development of a sustainable farm model and portfolio of supporting student research.</p>																	
How Does this Course align with or meet State and District content standards?	This course meets district and state standards in the area of life science.																	
Core Subjects:	<p><i>Select up to two that apply:</i></p> <table style="width: 100%; border: none;"> <tr> <td><input type="checkbox"/> Arts</td> <td><input type="checkbox"/> Civics and Government</td> <td><input type="checkbox"/> Not Core Subject</td> </tr> <tr> <td><input type="checkbox"/> Economics</td> <td><input type="checkbox"/> History</td> <td></td> </tr> <tr> <td><input type="checkbox"/> English</td> <td><input type="checkbox"/> Mathematics</td> <td></td> </tr> <tr> <td><input type="checkbox"/> Foreign Language</td> <td><input type="checkbox"/> Reading / Language Arts</td> <td></td> </tr> <tr> <td><input type="checkbox"/> Geography</td> <td><input checked="" type="checkbox"/> Science</td> <td></td> </tr> </table>			<input type="checkbox"/> Arts	<input type="checkbox"/> Civics and Government	<input type="checkbox"/> Not Core Subject	<input type="checkbox"/> Economics	<input type="checkbox"/> History		<input type="checkbox"/> English	<input type="checkbox"/> Mathematics		<input type="checkbox"/> Foreign Language	<input type="checkbox"/> Reading / Language Arts		<input type="checkbox"/> Geography	<input checked="" type="checkbox"/> Science	
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CDE CALPADS Course Descriptors: (See Page 2 for Definitions)	<p style="text-align: center;">CTE TECH PREP COURSE INDICATORS</p> <input type="checkbox"/> Tech Prep (32) (Higher Ed) <input type="checkbox"/> Tech Prep & ROP(33) (Higher Ed) <input type="checkbox"/> ROP (30) <input checked="" type="checkbox"/> N/A	<p style="text-align: center;">CTE COURSE CONTENT CODE</p> <input type="checkbox"/> CTE Introductory (01) <input type="checkbox"/> CTE Concentrator (02) <input type="checkbox"/> CTE Completer (03) <input type="checkbox"/> Voc Subject <input type="checkbox"/> N/A	<p style="text-align: center;">INSTRUCTIONAL LEVEL CODE</p> <input type="checkbox"/> Remedial (35) <input type="checkbox"/> Honors UC-Certified (39) <input type="checkbox"/> Honors Non UC-Certified (34) <input type="checkbox"/> College (40) <input checked="" type="checkbox"/> N/A															
Length of Course:	<input checked="" type="checkbox"/> Year <input type="checkbox"/> Semester																	

Grade Level(s):	<input checked="" type="checkbox"/> 9 <input checked="" type="checkbox"/> 10 <input checked="" type="checkbox"/> 11 <input checked="" type="checkbox"/> 12	
Credit:	<input checked="" type="checkbox"/> Number of credits: 5 units each semester	<input checked="" type="checkbox"/> College Prep
	<input checked="" type="checkbox"/> Meets graduation requirements (subject Biological Science)	
	<input checked="" type="checkbox"/> Request for UC "a–g" requirements CSU/UC requirement " d "	
Prerequisites:	Completion of Algebra 1	
Department(s):	Science	
District Sites:	PHS, UMHS	
Board of Trustees COS Adoption Date:	February 8, 2005	
Textbooks / Instructional Materials:	Holt Biology, Winston, Holt, 2006, Rinehart Publishing	
Funding Source:	General	
Board of Trustees Textbook Adoption Date:	June 14, 2005	

Definitions

CALPADS	California Longitudinal Pupil Achievement Data System
CTE Technical Prep	A course within a CTE technical career pathway or program that has been articulated with a postsecondary education or through an apprenticeship program of at least 2 years following secondary instruction.
Instructional Level Code	Represents a nonstandard instructional level at which the content of a specific course is either above or below a 'standard' course instructional level. These levels may be identified by the actual level of instruction or identified by equating the course content and level of instruction with a state or nationally recognized advanced course of study, such as IB or AP.
Instructional Level Honors, UC Certified	Includes all AP courses.
Instructional Level Honors, non UC Certified	Requires Board approval.
Instructional Level College	Includes ACE courses. Equivalent to college course and content, but not an AP course. Not related to section, but to course.

EDUCATIONAL SERVICES

Course Title: Biology and Sustainable Agriculture

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EDUCATIONAL SERVICES

Department: **CTE: Agriculture**

Course Title: **Biology and Sustainable Agriculture**

Course Number: **0706**

Unit Title: **Agriculture and Agricultural Research Skills**

Content Area Standards

NGSS

HS-ETS1-1 Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.

HS-ETS1-2 Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

HS-ETS1-3 Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.

HS-LS1-2 Systems and System Models: Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales.

HS-LS1-3 Constructing Explanations and Designing Solutions: Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.

CA Agriculture Standards

C1.0 Evaluate the role of agriculture in the California economy.

C1.1 Understand the history of the agricultural industry in California.

C1.2 Describe how California agriculture affects the quality of life.

C1.3 Analyze the interrelationship of California agriculture and society at the local, state, national, and international levels.

C1.4 Research the economic impact of leading California agricultural commodities.

C1.5 Assess the economic impact of major natural resources in California.

C1.6 Distinguish between the economic importance of major agricultural exports and imports.

C1.7 Explore factors that affect food safety and producers' responsibilities to consumers.

C3.1 Describe how technology affects the logistics of moving an agricultural commodity from producer to consumer.

C3.2 Understand how technology influences factors such as labor, efficiency, diversity, availability, mechanization, and communication.

C3.5 Integrate the use of technology when collecting and analyzing data.

C13.1 State the steps of the scientific method.

C13.2 Analyze an agricultural problem and devise a solution based on the scientific method.

Unit Outline:

Driving Question: What is sustainable agriculture?

This introductory unit will focus on the biological classifications of agriculture and their associated industry sectors, what sustainability is, and how the scientific method is the driving force behind advancements and developments in sustainable biological practices within agriculture. Students develop an overview of agricultural industries and biologic practices through research projects on facets of California agriculture, and identify what sustainability and sustainable practices are through individualized lab experiments relating to current practices. Ultimately, students will be able to use the scientific method to complete an extensive laboratory experiment that is designed to evaluate potential feed source varieties for sustainable success within their local community.

Instructional Strategies:

“What is sustainable agriculture?”

Students groups will research the various biological divisions of what constitutes agriculture (plant science, animal science, forestry, horticulture, etc.). Within their research they will identify the sub categories of industry that fall within their topic, what career paths are available within each, what are currently identified as “best practices” (such as the three E’s of sustainability -- economics, ecology and equity) and what are some of the sustainability issues and biologic concerns within each of these divisions. Students will then develop a multimedia presentation to introduce their particular area of agriculture to the class and identify the most prevalent issues facing their particular field of interest.

“That’s Ag - The Science Behind Agriculture” – Categorical Based Mini-Labs:

Student groups will design and complete an inquiry based mini-lab experiment to expand on their knowledge of the particular industry sector they researched from the previous activity. Choosing a focus from one of the areas of concern or issues within their sector, students will then design and implement an experiment that tests factors contributing to the issue and potential impacts they have on the population using scientific method learned in class. Examples might include a lab on animal production and energy flow, a lab on soil degradation and plant germination, a lab on food processing practices, a lab on post-harvest preservation, etc. The labs will introduce the application of inquiry within the agriculture sectors and the importance of the implementation of research in the industry. Design protocols, data, and analysis will be submitted in lab report format. As part of their analysis, students must use their data to make suggestions on how to improve efficiency or yield, or lessen the impact of processing, relevant to their finding of their particular experiment.

Scientific Method and Sustainability Lab – “Work Like a Scientist”

In this lab students are introduced to the scientific method, the basis for all scientific decision making. The native grasses research will provide students with the foundation of scientific investigation application as well providing key research that will be used in the final unit project as well as the end of course project. Students will research the difference between native grasses versus invasive grasses including specific species. Using this knowledge they will hypothesize germination rates between these two variable groups. Students will then design and implement an experiment incorporating quantitative data collection, analysis, and draw conclusions reflective to their hypothesis, and evaluate the grasses for potential sustainability within their communities.

In addition to these instructional strategies, these learning methods can include but not be limited to direct instruction methods, multimedia instructor presentations, guided practice, individual practice, class discussion and debate, hands on interactive labs, and application of skills learned.

Assessments:**Grass Species Analysis and Community Recommendation Presentation**

As a continuation of the germination experiment, given that the two variables have differing germination rates, students can identify other measures of “success” of a potential feed crop. They will then sample the community environment for the potential factors affecting the continued growth and development of grasses. Samples would include soil testing, (pH, nutrient composition, structure and texture, and water capacity), water availability, and ambient temperatures. Combining this information with the initial background research regarding natives versus invasive, students will hypothesize on the continued success of their germinating grasses, then transplant their seeds into test plots or fodder trays, and allow for continued growth. After a predetermined amount of time, sample plots will be analyzed for percent coverage and measurements of species biomass will be completed. Using this information students will determine the most biologically suitable grass species to plant that would be the most sustainable within the local community through a written lab completed in their lab notebook and a powerpoint presentation of their hypothesis, design, data and conclusion.

In addition to the Unit Assessment, frequent checks for understanding will be used, including but not limited to warm-ups, guided practice and classwork, lab analysis questions and reports, homework, quizzes, and written chapter/unit/final exams.

Interventions: May include, but not limited to:

After-school tutoring, study groups, teacher led study sessions, online resources such as teacher notes, worksheets, instructional videos, online labs and activities, and Khan academy instruction.

EDUCATIONAL SERVICES

Department: **CTE- Agriculture**Course Title: **Biology and Sustainable Agriculture**Course Number: **0706**Unit Title: **Environment, Energy, and Agriculture****Content Area Standards**

NGSS

HS-LS1-5 Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy.

[Clarification Statement: Emphasis is on illustrating inputs and outputs of matter and the transfer and transformation of energy in photosynthesis by plants and other photosynthesizing organisms. Examples of models could include diagrams, chemical equations, and conceptual models.]

HS-LS1-6 Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules. [Clarification Statement: Emphasis is on using evidence from models and simulations to support explanations.]**HS-LS1-7** Use a model to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed resulting in a net transfer of energy.**HS-LS2-3** Construct and revise an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions.**HS-LS2-4** Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem.**HS-LS2-5** Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere.**HS-LS2-1** Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales.**HS-LS2-7** Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.**HS-LS4-6** Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.

CA Agriculture Standards

C2.1 Identify important agricultural environmental impacts on soil, water, and air.

C2.2 Explain current environmental challenges related to agriculture.

C2.3 Summarize how natural resources are used in agriculture.

C2.4 Compare and contrast practices for conserving renewable and nonrenewable resources.

C2.5 Research how new energy sources are developed from agricultural products (e.g., gascogeneration and ethanol).

C4.3 Compile the modern-day uses of animals and animal by-products.

C3.5 Integrate the use of technology when collecting and analyzing data.

C3.1 Describe how technology affects the logistics of moving an agricultural commodity from producer to consumer.

C3.2 Understand how technology influences factors of evidence consistent with scientific ideas, principles, and theories. such as labor, efficiency, diversity, availability, mechanization, and communication.

C11.1 Understand the anatomy and functions of plant systems and structures.

C11.2 Identify plant growth requirements.

C11.3 Discern between annual, biennial, and perennial life cycles.

C11.4 Examine sexual and asexual reproduction in plants.

C11.5 Understand photosynthesis and the roles of the sun, chlorophyll, sugar, oxygen, carbon dioxide, and water

in the process.

C11.6 Summarize the respiration process in the breakdown of food and organic matter.

C5.1 Identify the function of cells.

C5.2 Analyze the anatomy and physiology of cells.

Unit Outline:

Driving Question: How does sustainable agriculture fit into our environment?

While unit one examined whole systems, unit two takes a closer look at components within that system. Students will use evidence gathered from a series of laboratory exercises to be able to describe the transfer of energy from one trophic level to another as well as the cycling of nutrients and energy through ecosystems. Students will be able to draw conclusions about these biogeochemical cycles and how they apply to sustainability of production agriculture. Specifically, students will conduct primary research in the areas of photosynthesis and chemical energy creation, nutrient cycling, transpiration and water use, ecological relationships and global farming practices in order to draw biologically-sound conclusions regarding the effects of agriculture on the natural environment. The students learning will culminate in a synthesis of concepts applied to the development of a three year sustainable crop rotation plan.

Instructional Strategies:

“Bacteria at Work” - Nitrogen Fixation

Students will analyze the effects of nitrogen fixation on plants initially by examining prior studies as well as industry publications regarding the role of nitrogen in plant growth and the methods by which farmers enhance nitrogen levels in soil. This should include a thorough look at the microbiology of nitrogen-fixing bacteria, plant and root physiology, nutrient cycling and uptake in plants, chemical processes and cellular respiration in plants and fertilization methods. After garnering that background information, students will conduct an experiment that compares the effects of added nitrogen fertilizer versus nitrogen fixing bacteria on the growth of clover. Students will grow clover plants in soil with no nitrogen added, in soil with nitrogen fertilizer added, and in soil containing nitrogen-fixing bacteria (in this case, a species of rhizobia called *Rhizobium leguminosarium*, or R. *leguminosarium*). Students will monitor the nitrogen levels in each type of soil using a nitrogen testing kit. The students will observe the effects of nitrogen on the health of the clover plants by measuring the increase in biomass of each plant during the experiment. Plants should be harvested, soil washed away, and weights taken on plant material produced. Students will use the data collected to create a graph showing the relationship between nitrogen availability in the soil and crop sustainability. This allows students to not only experience agriculture’s role in the nitrogen cycle, but also provides necessary supporting data for decision making in the final end of course project.

“Morning Jolt!”- Photosynthesis Lab

Photosynthesis is the basis for the creation of chemical energy in the natural world. Plants require light in order to transform one type of energy into another, and the quantity and type of light determine the optimal photosynthesis rates. Students will conduct a laboratory exercise that examines the effects of shade on the growth of plants and the rates of photosynthesis and will develop a written memorandum to the International Coffee Growers Association regarding optimal shade levels for the growth of coffee trees, including information regarding ecological sustainability involved in the practice. The process will begin by using industry journals to examine coffee production methods; primarily comparing and contrasting industrial coffee production with shade-grown, sustainable coffee production. Students should come up with the following information: arabica coffee has the highest yields under 35 to 65% shade. In addition, growing coffee under shade also discourages weed growth, may reduce pathogen infection, protect the crop from frost, and helps to increase numbers of pollinators which results in better fruit set. However, in order to produce faster, higher yields and prevent the spread of coffee leaf rust (*Hemileia vastatrix*), many coffee plantations began to grow coffee under sunnier conditions. The fewer shade trees that are in coffee plantations, the less biodiversity there is in those plantations.

The laboratory exercise will use several small coffee plant starts (available for purchase online as seeds or a houseplant) and will grow them for a series of days under varying shade levels. Students will conduct visual assessments of plant health and growth, then conduct a traditional floating leaf disc assay protocol to assess photosynthesis levels under varying light conditions. Students will use both the previously gathered background information regarding industry practices, sustainability and plant growth as well results of the primary research to develop the memorandum regarding optimal shade levels for sustainable coffee growth.

“Move on Through” - Transpiration Lab

Students will initially conduct background research into water use in agriculture and the demands placed on farmers to be efficient and careful with this scarce natural resource. Students will then investigate transpiration as part of the hydrologic system, based on different genetic variations of plant structure (leaf type and shape, for example). Students will conduct a research exercise by examining transpiration in plants with various leaf structures. This can occur using locally-grown crops or by using exotic crops and adding a component regarding appropriate plant selection. In this lab, students will use the plant weight protocol to measure the transpiration rates of individual plants. Students give plants a predetermined amount of water, reweigh the plants, and continue weighing the plants over time to contrast weight differentials and determine water loss through transpiration. Students will monitor observable physical changes in the different plants' condition as water is depleted, collecting qualitative data and measuring the diurnal transpiration rates. Students will apply the individual plant water usage data to larger scale acreage to analyze water usage. Students will create a written case study to justify plant selection within the context of the sustainability of the hydrologic system.

Optional extension: include in the case study how trends in daily transpiration rates change if water losses were replenished through different irrigation management techniques (drip, flood, etc.).

“From Trash to Gas” - Sustainable Waste Management

Students will use both primary and secondary research to discover that food scraps, dead plants, manure, and other decaying organic matter, called biomass are a rich source of energy. Energy can be procured from biomass by turning it into a gas called biogas. The process will begin by students examining agricultural examples of biogas production (small scale composting, dairy lagoon gas extraction, codigestion, etc.) as well as the microbiological basis for biogas production, including aerobic and anaerobic fermentation, cellular respiration, lignocellulosic breakdown, etc. As part of this analysis, students will compare the amounts of biogas produced by different types of biomass. In order to quantify their findings, students will conduct an experiment with three soda bottles filled to the same volume with various types of biomass commonly used in biogas production. Bottle one will contain cow manure, bottle two will contain cow manure and household kitchen scraps, and bottle three will contain cow manure and a biological waste product of the students choosing (teacher approved). Bottles will be topped with a small balloon. Students will record the circumference of each of the balloons at the same time of day over a period of 10 days as well as record observations of the biomass inside of the bottles. Students will create a graph representing the circumference of balloons and the number of days. Students will compare graphs to determine which biomass type produced the fastest inflation of the balloon. Upon completion of the experiment, the students will then need to develop a written plan for how this naturally occurring byproduct can be harnessed to benefit a farming situation. In addition to incorporating their data, this plan should include: research on how the gas is used, the scientific processes behind biogas creation (fermentation, anaerobic digestion, etc.), biomass feedstocks that can be used to create efficient quantities of biogas, potential uses of biogas, and potential economic and sustainable benefits of instituting a biomass digester.

“Composting, Do the Rot Thing”

Students will examine the principle of composting organic material, and the process of converting complex organic matter into the basic nutrients needed by living organisms. Prior to conducting the experiment, students will use industry and extension publications to learn the processes of composting, as well as the benefits and challenges of compost production (available nutrient levels, community perceptions, hazardous materials, smell, storage, etc.). Following the background research, students will conduct a laboratory exercise that will examine the utilization of organic wastes (household) as nutrients for plants. It will allow students to investigate which waste products can be composted and best utilized by plants. Based off of prior knowledge of an ecosystem and how ecosystems regenerate as well as the interaction of food and fiber systems with natural cycles, students will justify specific nutrient requirements, as well as renewable and nonrenewable natural resources. Students will prepare three test plots, one plot with just soil, one with soil and household waste products collected by students, and one plot with animal waste products. Students will then monitor plant growth and development to graph their results. Students will create an informational, six paneled brochure that explains a waste management plan using compost. Included in the brochure should be information regarding the microbiology of compost production in addition to the practical household application of the research. Additionally, the brochure should outline the removal of organic matter to increase ecological sustainability while having the least environmental impact on the farm and community.

In addition to these instructional strategies, these learning methods can include but not be limited to direct instruction methods, multimedia instructor presentations, guided practice, individual practice, class discussion and debate, hands on interactive labs, and application of skills learned.

Assessments:

Plant, Grow, Rotate, Repeat Sustainable Crop Management Plan

Students will apply concepts of the biogeochemical cycles as well as waste management to create a 3 year sustainable crop rotation plan that produces the highest crop yields for any given location with the least environmental impact. Students must analyze current soil conditions as well as community needs when considering their crops for production. Student focus should be on nitrogen fixation of specified crops. Students will use previous knowledge of ecosystems, invasive species, and producer and consumer relationships as well as research current market prices and local demands, to assess the environmental contribution and the economical impact from each crop. When creating the 3 year crop rotations students will defend their selections and the ecological impacts of their decisions. The synthesis of the student's' research will culminate in written proposal to a local producer.

In addition to the Unit Assessment, frequent checks for understanding will be used, including but not limited to warm-ups, guided practice and classwork, lab analysis questions and reports, homework, quizzes, and written chapter/unit/final exams.

Interventions: May include, but not limited to:

After-school tutoring, study groups, teacher led study sessions, online resources such as teacher notes, worksheets, instructional videos, online labs and activities, and Khan academy instruction.

EDUCATIONAL SERVICES

Department: **CTE-Agriculture**

Course Title: **Biology and Sustainable Agriculture**

Course Number: **0706**

Unit Title: **Molecular Biology and Agriculture**

Content Area Standards

NGSS

HS-LS1-1 Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins which carry out the essential functions of life through systems of specialized cells.

HS-LS1-2 Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.

HS-LS1-3 Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.

HS-LS1-4 Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms.

HS-LS3-1 Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring.

HS-LS3-2 Make and defend a claim based on evidence that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors.

HS-LS3-3 Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.

HS-LS4-3 Apply concepts of statistics and probability to support explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait.

HS-LS4-1 Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence.

CA Agriculture Standards

C5.3 Understand various cell actions, such as osmosis and cell division.

C5.4 Compare and contrast plant and animal cells, bacteria, and viruses.

C7.1 Differentiate between genotype and phenotype and describe how dominant and recessive genes function.

C7.2 Compare genetic characteristics among cattle, sheep, swine, and horse breeds.

C7.3 Predict phenotype and genotype ratios by using a Punnett Square.

C7.4 Explain the fertilization process.

C7.5 Distinguish between the purpose and processes of mitosis and meiosis.

C8.1 Identify types of nutrients required by farm animals (e.g., proteins, minerals, vitamins, carbohydrates, fats/oils, water).

C8.2 Analyze suitable common feed ingredients, including forages, roughages, concentrates, and supplements for ruminant, monogastric, equine, and avian digestive systems.

C8.3 Understand basic animal feeding guidelines and evaluate sample feeding programs for various species, including space requirements and economic considerations.

Unit Outline:

Driving Question - What molecular biology principles guide sustainable agriculture?

In this unit, students will examine the science of agriculture and evaluate the efficiency and sustainability of current methods. Students will explore the concepts of taxonomy of plants and nomenclature of animals, cell structure, cellular division, DNA, and chromosomes. Students will apply this knowledge to evaluate desirable inheritable traits in each species to artificially select characteristics to breed more efficient and productive offspring as a part of their created breeding plan. Students will be introduced to genetic markers, genetically modified organisms, and biotechnology. With this knowledge students will examine and evaluate biotechnology, the ethics of genetic manipulation, and its implication on the sustainability of agriculture and our ability to feed a growing population. As a culminating project for the first two units students will design, conduct, and interpret their own agricultural research project on a biological issue facing agriculture and present their findings with a visual, written, and oral report.

Instructional Strategies:

“Breed For The Need”- Sustainable Breeding Evaluation

Animal genetics play a role in sustainability. An animal that is genetically predicted to become heavier muscled in a shorter period of time will utilize less pasture and nutritive resources than one that takes longer to reach the same weight. A female who produces more milk to feed her offspring will utilize less resources for both her and her progeny. Therefore, summative phenotypic traits are important to evaluate in a sustainable ecosystem in order to efficiently utilize natural resources. By analyzing these traits students can determine the probability of the trait expression in an animal’s offspring. After instruction on chromosomal physiology, multicellular organization, animal anatomy, basic heredity, and genetic expression, students will identify desirable characteristics from a group of four animals of the same species to create a sustainable breeding plan that will include: hybrid vigor, genetic efficiency and other genetic traits. Students will use three components to evaluate the group of four animals that include the farmer’s sustainability scenario, expected progeny difference data and phenotypic evaluation of the animals. First students will read an agricultural producer’s written scenario that describes the targeted phenotypic traits a farmer desires based on the environment that must sustain the health and nutrition of the specific animals while not depleting the natural resources within that biological system. The parameters of the traits the students will evaluate include milk production (the weight of the weaned offspring that was contributed to the amount of milk the mother produced), weaning weight (the weight of the offspring when removed from the mother), yearling weight (the weight of the offspring at eighteen months of age and birth weight (the weight of the offspring at birth). Next, the students will read and analyze Expected Progeny Difference (Summative phenotype expression) data. Finally, students will perform visual observations of the phenotypic traits in those four animals. Students will assess and prioritize the three analyzed components based on importance and collectively use them to place the four animals in phenotypic order from the most desirable for the environment to the least desirable according to the farmer’s sustainability scenario. Students will give an oral defense with evidence to support reasoning.

“Where Should I Make My Home ?”- Sustainable Production Plan

The students will be put into groups and collectively evaluate the same animals from the previous activity with summative phenotypic traits for each of the bio-geological growing zones in California which are desert and high desert, coastal, valley, foothills and mountains. Instruction should occur on plant taxonomy and livestock anatomical suitability (large animals in areas with poor biomass production, genetic hardiness factors, etc.) prior to the secondary research being done. Research done on each zone will provide information on the possible sustainability plans in which the four animals could be raised. Students will research the ecosystem of each area, analyzing what crops, pasture and range can be grown and the effects of climate and rainfall on the availability of nutrients for the animals’ sustainability. Based on the data accumulated from the research they will reevaluate the four animals from the previous lab including EPD data. For each zone they will place the animals in order from the one most suited and efficient to the least. Students construct a written defense for their decision in the placing of those animals in each zone based on their data and research. They will argue the merits of their placing based on the data from their zone research: native and nonnative grass and crop survivability in each zone that provides nutrition to the animals, biological merits and disadvantages of each zone on the animals. They will then use the zone information to reevaluate the EPD data and how it can be best utilized to meet the animal’s biological needs. Using the research and accumulated data students can determine a class placing for each region of California.

“Battle of the Seeds” - Biotechnology Use in Agriculture

Crop decisions made by agricultural producers are often predicated on understanding the climate, rainfall and topography needs of their growing area. These decisions often prioritize crop yield, but also must take into account the biological health of each system. The previous lab focused on evaluating the efficiency of specific animals introduced into an ecosystem where the biological components were predetermined and consistent. In this activity, students explore the introduction of new plants into predetermined, consistent ecosystems by investigating how germination, growth and efficiency of plants (crops) can be affected by genetic and environmental changes. Prior to the experiment, students should be instructed in cell division and structure as functions of organism growth, genotypic traits and variable expression, traditional hybridization methods and modern genetic manipulation. For the primary research exercise, students will set up three demonstration plots to compare growth and yield rates of plants. Half of the class will grow unweeded plots of plants, manually weed-controlled beds, and chemically controlled beds with plants that have been genetically modified to withstand the effects of a widely-used herbicide. The other half of the class will grow hybrid seed, non-hybrid seed, and genetically enhanced seed of the same plant. Upon analyzing data of plant growth and yield rates students will calculate the cost in time and money for the methods demonstrated. Students will formulate a written opinion/thesis and defend from evidence the most sustainable method of growing food based on their experiment. Students determine the statistical, economical and biological differences of genetically modified organisms as compared to natural organisms. Students will then research public concern of genetically modified organisms to prepare for a class debate. Utilizing their experimental results and research students debate the use of biotechnology and genetically modified organisms playing one of four following roles; a leader of a developing nation where hunger is a problem among their citizens, a biotechnology company specializing in producing genetically modified plants, a farmer, or a parent who primarily purchases organic produce. Students will reflect on their original opinion and write what they learned as a result of this experience.

In addition to these instructional strategies, these learning methods can include but not be limited to direct instruction methods, multimedia instructor presentations, guided practice, individual practice, class discussion and debate, hands on interactive labs, and application of skills learned.

Assessments:

“Hypothesize, Analyze, Repeat” - Formal Research Project

Labs and activities have been done in this unit that represent the common applications of biological factors such as genetic potential and variability of plants and animals, the symbiosis of animals and plants within an ecosystem and the impact of new species introduced into an established environment. Students will utilize the science of nature they learned in unit three, how that science fits into the biological systems from unit two and how those systems contribute to sustainability in unit one to develop a comprehensive agriscience experimental research project. Students will identify a problem related to agriculture that is the result of completing the first three units of the course (plant science, animal science, natural resources). 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. Specific expectations for the written research project are outlined below:

Forming a Hypothesis

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.

Experimental design and conducting experimentation

Students will construct an experimental design to test their hypothesis. 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 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, in a study of primed versus non-treated seeds, seeds would be planted in identical environments, multiple test groups would be established and compared to a control group, and the number of germinated seeds would be counted and recorded to quantify the outcome. Raw data should be recorded using a field book or electronic device.

Analyzing data, interpreting data and forming conclusions.

Students will determine the best methods for organizing their data using tables. Students will use mathematical principles to synthesize their data, calculating a mean, for example. 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.

Evidence of Performing the AgriScience Research Project

Students will submit their research in a written paper, and it will include the following components: problem/purpose, background research, hypotheses, 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.

In addition to the Unit Assessment, frequent checks for understanding will be used, including but not limited to warm-ups, guided practice and classwork, lab analysis questions and reports, homework, quizzes, and written chapter/unit/final exams.

Interventions: May include, but not limited to:

After-school tutoring, study groups, teacher led study sessions, online resources such as teacher notes, worksheets, instructional videos, online labs and activities, and Khan academy instruction.

EDUCATIONAL SERVICES

Department: **CTE-Agriculture**

Course Title: **Biology and Sustainable Agriculture**

Course Number: **0706**

Unit Title: **Agriculture's relationship with technology and the natural world.**

Content Area Standards

NGSS

HS-LS2-6 Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.

HS-ETS1-1 Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.

HS-ETS1-2 Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

HS-ETS1-3 Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.

CA Agriculture Standards

C9.1 Assess the appearance and behavior of a normal, healthy animal.

C9.2 Explain the ways in which housing, sanitation, and nutrition influence animal health and behavior.

C9.3 Analyze the causes and controls of common animal diseases.

C9.4 Summarize effective techniques for controlling parasites and explain why controlling parasites is important.

C9.5 Research the legal requirements for the procurement, storage, methods of application, and withdrawal times of animal medications, and know proper equipment handling and disposal techniques.

C11.1 Understand the anatomy and functions of plant systems and structures.

C11.2 Identify plant growth requirements.

C11.3 Discern between annual, biennial, and perennial life cycles.

C11.4 Examine sexual and asexual reproduction in plants.

C11.5 Understand photosynthesis and the roles of the sun, chlorophyll, sugar, oxygen, carbon dioxide, and water in the process.

C11.6 Summarize the respiration process in the breakdown of food and organic matter.

F5.1 Explain how basic soil science and water principles affect plant growth.

F5.2 Illustrate basic irrigation design and installation methods.

F5.3 Prepare and amend soils, implement soil conservation methods, and compare results.

F5.4 Research major issues related to water sources and water quality.

F5.5 Explain the components of soilless media and test the use of those media in various types of containers.

F9.1 Use different types of containers and demonstrate how to maintain growing containers in controlled environments.

F9.2 Operate and maintain selected hand and power equipment safely and appropriately.

F9.3 Select proper tools for specific horticultural jobs.

F9.4 Install landscape components and electrical, land, and water features.

F10.1 Utilize terms associated with landscape and design in appropriate context.

F10.2 Produce a residential design, including how to render design to scale using design technology and principles.

F10.3 Use proper landscape planting and maintenance practices.

F10.4 Prune ornamental shrubs, trees, and fruit trees

Unit Outline:

Driving Question: How do we make decisions to maximize sustainable agricultural practices within a functioning ecosystem?

Students will understand common practices in the agriculture industry that promote sustainability. They will evaluate and/or refine technological solutions that reduce impacts of human activities on natural systems by using practices that utilize cellular biology, genetics, energy cycles, biological systems, plant and animal nomenclature and how these units collectively create ecosystems that were covered in the previous units. Students will conduct production practices in the areas of animal science, horticulture, and natural resources. Students will experience how the biological systems can be changed at the cellular level, promoting the emergence of new energy cycles that produce useful, recyclable products that have a positive impact on the environment, thus decreasing the impact of agriculture on the environment and promoting sustainability. Students will investigate positive sustainable approaches to changing negative impacts agriculture has on the land by testing methods of efficiency in laboratory work. This experience will give students perspective on production costs and resource needs in relation to animal welfare, mechanization versus labor, and use of chemicals to non-use of chemicals. Students will utilize this hands-on production experience to develop their own sustainable farm as a culminating final project to illustrate the management of agricultural systems, management of natural resources, the sustainability of an ecosystem for the future while preserving biodiversity.

Instructional Strategies:**“Show Me You Care” - Practice in Animal Health Management**

Common animal production practices are done to ensure multi-system homeostasis and to foster productive animal growth and general welfare. Prior to conducting a laboratory exercise, students will engage in secondary research that seeks to correlate common livestock production practices to maintaining system health in animals. For example, castration, tail banding, hoof trimming and vaccinations prevent pathogen (viral, bacterial, fungal and parasitic) infections and thereby ensuring the health of the immune system, lymphatic system and respiratory system, among others. Shearing, clipping and dehorning are noninvasive procedures that provide recycling opportunities of animal byproducts but are also designed to maintain homeostasis and to protect vital organs throughout multiple systems (shearing reduces overall stress on the circulatory system, for example). Animal identification requires animals to have a traceable number like the scrapie tag that traces the animal to the breeder in case an animal tests positive for the genetic disease and ensure herd health (preventing disease outbreaks that can stress multiple systems).

After the conclusion of the background research, students will engage in a laboratory experience where they will conduct common livestock production procedures practiced in the United States through the application of: castration methods, dehorning practices, vaccination protocols, identification systems and shearing techniques. Students will divide into groups to demonstrate one or more of the common livestock production practices within several species of livestock and small animals. After the conclusion of each of these demonstrations, students will choose one method they demonstrated and write an explanatory position paper that correlates the production practice to physiological health in the animal, highlighting homeostatic mechanisms and system nomenclature.

“If You Root It, They Will Grow” - Sustainable Practices in Horticulture

The ability to graft, increase growth rates and clone species of plant, trees and crops is an option that can increase the number of organisms that can be planted in a shorter amount of time. Using one plant to create many or the ability to grow different varieties of fruit on one tree maximizes the efficiency of each organism within an ecosystem. The ability to utilize this technology increases species diversity while positively affecting land biomass. Students will experience a laboratory activity, conducting propagation techniques that make plants more efficient and in return contribute to the energy cycles within the ecosystem potentially maximizing sustainability of the plant and its production. This laboratory lets students use asexual propagation through the application of auxins directly onto plants used as a common practice in the horticultural industry. Students will also research the role of auxins and make predictions on its effectiveness on their assigned mother stock plant. Through teacher demonstration, students will learn the proper steps of asexual propagation and make cuttings of their plant. Each student will test the effectiveness of auxins (rooting growth hormone) with one row in a flat being a different concentration of hormone and one control. After two weeks students will collect data every three days and record the rate at which their plant cutting roots. Students will calculate the cost of hormone treatment versus the time for cuttings to root to recommend the use or non-use of auxins on their assigned plant in their lab report.

In the next step of the laboratory students will practice the proper steps of transplanting and fertilizer use as regular practice in the horticultural industry. Students will take their rooted cuttings and transplant them to a larger container. After direct instruction on types of fertilizers, students will make predictions on the most effective type of fertilizer for their rooted cuttings; liquid, slow release, and organic. Students will be assigned a growing area (landscape plot, or one gallon-containers) to conduct their experiment. Students will test each type of fertilizer with four rows of plants. One row will be the control, without fertilizer application and the other three rows will have liquid, slow release, and organic fertilizer applications. Students will take daily measurements and make final conclusions of fertilizer effectiveness for their plant. Students also compare cost of fertilizer to effectiveness to determine final recommendations in their lab report.

“It’s Easy Being Green - Growing Green Communities” - Landscaping

Students will utilize the Horticulture report and experience to create a landscape plan in groups. Students will utilize the original cuttings from the previous activity which are now grown plants. Each group will use those plants in designing a landscape for a specific area designated by the teacher that could include areas around the school and/or community. Students must consider plant growth requirements, resources such as water, soil quality, and fertilization needs. Students must address the long term needs of their landscape and write a reflection on the positive and negative aspects with recommendations for more sustainable qualities. The students will submit their designs in a written proposal to the school and or community organizations for approval. Those approved will be planted and maintained by the group for the rest of the year.

“Use Me Responsibly or Lose Me Forever” - Using Nature’s Natural Resources Students will delve deeper into natural resources conducting research on bioprospecting. They will use the knowledge gained within this unit regarding the potential to change the future through bioprospecting and the need to prevent the exploitation of those resources to preserve the biospheres for future generations. Students will read articles about the use of plants and animals in nature like coral producing a natural sunscreen named, “Sunscreen 855”. To prevent the harvest of coral in order to save the barrier reef they isolated the compound and produced it in a lab that will be the most naturally occurring sunscreen developed. Students will discuss the importance of bioprospecting, as well as how the prospect of products from plants and animals argues for the continued maintenance of biodiversity and sustainability as long as the resources are not exploited.(Biology, Prentice Hall) After the discussion students will research other types of bioprospecting happening in agriculture. They will choose one material (natural resource) being prospected and find the following information from their research: what research is being done on the material, how are they utilizing the material and how does the research and use of the material play a role in sustainability. The information accumulated on the material bioprospecting will be utilized in a flyer created by each student. The flyers will be set-up in a walking gallery where the students will use a bioprospecting rubric to score the importance of each natural resource presented as a valuable material for continued research. The students will have a class discussion about which three natural resources are the most valuable source of bioprospecting to contribute to sustainability of the human population.

Bioprospecting - “Motoring with Microbes” – Discovering Cellulose Microbes for Biofuel Efficiency

The students will then conduct a research lab on Bioprospecting for Cellulose-Degrading Microbes: Filter Paper Assay Method where Students collect samples that they predict will contain communities of cellulose-degrading microbes and test for the ability of microorganisms in their samples to break down pure cellulose (filter paper). In the process, groups collect evidence to test predictions about which environmental microbial samples will be the most effective for degrading cellulose. By comparing results across groups, students can begin to uncover patterns and develop explanations about the types of environments that support cellulose-degrading microbes. This lab method is nearly identical to that used by researchers and student results could help scientists discover new enzymes for efficient biofuel production that is key in agriculture’s ability to remain sustainable in the next century. Students will turn in a completed lab using scientific method and write an abstract of their research to send to the Great Lakes Bioenergy Research Center as part of their ongoing research on biofuel.

<https://www.glbrc.org/education/classroom-materials>

In addition to these instructional strategies, these learning methods can include but not be limited to direct instruction methods, multimedia instructor presentations, guided practice, individual practice, class discussion and debate, hands on interactive labs, and application of skills learned.

Assessments:**End of Course Project****“I Believe in the Future of Agriculture” - Sustainable Farming Project**

Students will design a solution for developing, managing, and utilizing energy and resources through the development of a completely sustainable farm on 400 acres that must include a minimum of three crops and two species of animals. A comprehensive farming portfolio will be created. The portfolio will include data and research done from each unit within the course to be used to create their farm as well as provide evidence to defend the sustainability of that farm and thus, the best representative of sustainability. The students must research genetic varieties of crops and species of animals based on genetic efficiency and commensalism. Attention to how soil nutrients and deficiencies affect vegetative reproduction, germination, plant growth and crop adaptation within an environment must be utilized in the research. Based on the data the students will determine the crops to be produced. They will research and evaluate the species of animals that will have a symbiotic relationship with the crops they have chosen above. Phenotypic and genotypic traits, hybrid vigor, commensalism, and other variables should be used to determine the two species of animals that will be best suited for the designed environment while providing for the welfare of the animals' health and nutrition. Animal welfare must be addressed in the decisions made to create a farm that is positive and biodiverse in nature. Environmental impacts based on the crops and animals raised on the farm need to be identified dealing with biological magnification, depletion of soil /plant nutrients , use of natural resources , pollution issues dealing with waste and desertification. The students will use this information as well as the data and labs from the previous units to determine the carrying capacity of livestock and acres of crops to be grown on the farm . Biological methods of reducing the identified environmental impacts will then be designed by the student, which could include methane digesters, aquaculture, CO2 collectors and irrigation water recycling. Finally, students will address the management decisions made to reduce the farm's carbon footprint over a decade of production. The portfolio and presentations will be presented to the local farm bureau as well as other agriculture associations and businesses.

In addition to the Unit Assessment, frequent checks for understanding will be used, including but not limited to warm-ups, guided practice and classwork, lab analysis questions and reports, homework, quizzes, and written chapter/unit/final exams.

Interventions: May include, but not limited to:

After-school tutoring, study groups, teacher led study sessions, online resources such as teacher notes, worksheets, instructional videos, online labs and activities, and Khan academy instruction.