The EUHSD Sustainable Agriculture Biology curriculum document identifies what students should be able to know and do in a comprehensive standards-based agricultural science course of study. The curriculum document is updated annually based on student academic achievement data, research and best practices, and input from stakeholders. The EUHSD curriculum document contains the following documents and/or information:

A. Course Description
B. Course Guidelines/Requirements - graduation credit information, transcript information, adopted materials, adopted technology, assessment outline
C. Instructional Materials References
D. Scope and Sequence Map with Essential Standards outlined by Unit
E. References to key essential design and implementation documents

The Biology and Sustainable Agriculture curriculum document, upon which this course is designed, was written by a group of California educators and industry professionals as part of the University of California Curriculum Integration (UCCI) project. UCCI is an initiative of Student Affairs, Admissions (High School Articulation Unit), at the UC Office of the President, with funding administered by the California Department of Education. The UCCI program is dedicated to supporting California high school students as they work to prepare for success in college and in life. As part of the UC’s system wide High School Articulation unit, the UCCI program focuses on assisting high schools with the development and implementation of integrated courses that unite academic study with Career Technical Education. http://ucci.ucop.edu

The EUHSD Agriculture program is designed to meet both the California Content Standards for specific disciplines and to address key California Career Technical Education standards for specific industry sector pathways. The Biology and Sustainable Agriculture course was designed as a key course within the Agriculture and Natural Resources pathway, but also serves as a foundational “d” laboratory science course in the agriculture program. The curriculum document was written to address both pathway and overarching anchor standards as well as key Next Generation Science Standards and practices.

**Escondido Union High School District – Instructional Focus**

A comprehensive course of study and/or program is designed so that all students have access to the rigorous curriculum necessary to graduate high school college and career ready. Student-Centered learning provides opportunity for collaboration, communication, and a robust learning environment and provides opportunities for all students to meet the goals of the district’s Instructional Focus at the time of this writing: “All students communicate their thinking, ideas and understanding by effectively using oral, written and/or non-verbal expression.”

**Curriculum Design Resources**

A detailed list of resources around which the EUHSD curriculum is designed is as follows:

2. [http://www.cde.ca.gov/pd/ca/sc/ngssintrod.asp](http://www.cde.ca.gov/pd/ca/sc/ngssintrod.asp) - CA Next Generation Science Standards document
Biology and Sustainable Agriculture Course Description

Biology and Sustainable Agriculture “A Biological Approach to Industry Practices” is a yearlong agriculture science course for students participating in the agriculture CTE pathways. The course was designed to integrate biological science practices and knowledge into the practice of sustainable agriculture. Students examine the definition of sustainable agriculture through a study of the environment and the conditions under which humans and the biotic world exist in productive harmony. Each unit of study is framed around an essential question explored through hands on laboratory experiences. Within each unit of study specific science principles will be identified with agricultural principles and practices guiding the acquisition of knowledge. Each semester culminates with the development of a sustainable farm model and portfolio supporting student research. **Students are expected to participate in a supervised agriculture experience program as part of their enrollment in this course.**

### Course Requirements

<table>
<thead>
<tr>
<th>Course Length: Year Long</th>
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</thead>
<tbody>
<tr>
<td>Grade Level: 9-12</td>
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<tr>
<td>UC/CSU Requirement: Approved as UC “d” lab science by UCCI.</td>
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<tr>
<td>Graduation Requirement: Meets EUHSD Biological Science Requirement or Meets EUHSD Elective Credit or CTE Requirement</td>
</tr>
<tr>
<td>Course Numbers (Semester A)</td>
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<tr>
<td>Transcript Abbreviations (Semester A)</td>
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<tr>
<td>Course Numbers (Semester B)</td>
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<td>Transcript Abbreviations (Semester B)</td>
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<td>Credits (Semester A)</td>
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<tr>
<td>Credits (Semester B)</td>
</tr>
<tr>
<td>Required Prerequisite/s: Completion or concurrent enrollment in Algebra 1 or Math 1 (Integrated)</td>
</tr>
<tr>
<td>Recommended Prerequisite/s: N/A</td>
</tr>
<tr>
<td>Board Approval Date (Curriculum): 6/21/16</td>
</tr>
<tr>
<td>Board Approval Date (Materials): 6/21/16</td>
</tr>
<tr>
<td>Technology Resource/s:</td>
</tr>
<tr>
<td>• Chromebook cart</td>
</tr>
<tr>
<td>Assessment/s:</td>
</tr>
<tr>
<td>• End of unit assessments</td>
</tr>
<tr>
<td>• Comprehensive final exam for each semester</td>
</tr>
</tbody>
</table>
## Biology and Sustainable Agriculture

### District Approved Instructional Resources

<table>
<thead>
<tr>
<th>Title</th>
<th>Edition</th>
<th>Author</th>
<th>Publisher</th>
<th>ISBN/Website</th>
<th>Use</th>
<th>©</th>
</tr>
</thead>
</table>

### Core Textbooks

| Title                                      | Edition | Author                     | Publisher                        | ISBN/Website                      | Use            |
|--------------------------------------------|---------|---------------------------|----------------------------------|-----------------------------------|----------------|--------------|
| Bioprospecting Laboratories                |         | Great Lakes Bioenergy Research Center | | | Web | 2007-2013 |
| What is Sustainability?                    |         | United States Environmental Protection Agency | | | Web | 2000-2014 |
| Great Lakes Bioenergy Research Center      |         | Michigan State University | | | Web | 2016         |
| US Environmental Protection Agency         |         | U.S. Environmental Protection Agency | | | Web | 2016         |

### Secondary Texts

<table>
<thead>
<tr>
<th>Title</th>
<th>Edition</th>
<th>Author</th>
<th>Publisher</th>
<th>ISBN/Website</th>
<th>Use</th>
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</thead>
</table>

### Supplemental Materials

<table>
<thead>
<tr>
<th>Title</th>
<th>Edition</th>
<th>Author</th>
<th>Publisher</th>
<th>ISBN/Website</th>
<th>Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bioprospecting Laboratories</td>
<td></td>
<td>Great Lakes Bioenergy Research Center</td>
<td></td>
<td></td>
<td>Web</td>
</tr>
<tr>
<td>What is Sustainability?</td>
<td></td>
<td>United States Environmental Protection Agency</td>
<td></td>
<td></td>
<td>Web</td>
</tr>
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<td>US Environmental Protection Agency</td>
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<td>U.S. Environmental Protection Agency</td>
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<td>Web</td>
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</tbody>
</table>
The Scope and Sequence Guide is a California standards based document that delineates the standards based skills students are expected to know and do in order to meet College and Career Readiness expectations outlined within the California standards for a particular course of study. Each unit of study in the Scope and Sequence document is designed to build upon the previous unit and/or prerequisite coursework in support of student mastery of specific standards based skills. The Scope and Sequence document provides the framework of understanding for key assignments, key assessments, and instructional resources and strategies that serve to assist students in meeting unit learning objectives. Teachers will meet annually to refine grade level or course expectations as well as detailed unit plans that contain specific standards based activities, key assignments, such as shorter and more sustained research projects, and standards based common unit assessments. Students in a comprehensive “d” lab based science course receiving college preparatory credit are required to participate in a curriculum that provides at least 20% of its classroom time participating in hands-on lab experiences where students interact with and demonstrate their learning and build understanding of content. Specific lab experiences are outlined within the scope and sequence document and will be reviewed on an annual basis.

The Sustainable Agricultural Science course is organized into four major sections, or units, each with a guiding question. Within each unit specific life science principles will be identified with agricultural principles and practices woven into the assignments and assessments, culminating in the development of a sustainable farm model and portfolio of supporting student research.

- Unit 1 addresses the question, “What is sustainable agriculture?”
- Unit 2 addresses the question, “How does sustainable agriculture fit into our environment?”
- Unit 3 addresses, “What molecular biology principles guide sustainable agriculture?”
- Unit 4 addresses, “How do we make decisions to maximize sustainable agricultural practices within a functioning ecosystem?”

In coursework requiring reading and writing, the following standards are not specifically stated in any one unit of study, but are the result of implementation throughout the curriculum as students participate in reading, writing, and speaking/listening standards based activities.

- By the end of grade 11, students will read and comprehend literary nonfiction in the grades 11-CCR text completely band proficiently, with scaffolding as needed at the high range. (Reading Informational Text Standard 10)
- Students will write routinely over extending time frames (time for research, reflection, and revision) and shorter time frames (a single sitting or a day or two) for a range of tasks and purposes. (Writing Standard 10)
- “To be college and career ready, students must have ample opportunities to take part in a variety of rich and structured conversations – as part of a whole class, in small groups, and with a partner – build around important content in various domains. They must be able to contribute appropriately to conversations, make comparisons and contrasts, and analyze and synthesize a multitude of ideas according to the standards of evidence appropriate to a particular discipline.” (Standards for ELA Anchor Standards for Speaking/Learning)
# Biology and Sustainable Agriculture Scope and Sequence
## Pre Unit – Introduction to Agriculture and the Agriculture Program

**Length:** 3 Weeks

### Unit Description:
All students enrolled in the EUHSD’s Agriculture pathway sequence of courses will be expected to participate in the FFA organization and activities as a vital part of the EUHSD agriculture program. This pre unit of study is designed to take approximately three weeks and covers the following essential topics:
- Introduction to Class
- Introduction to Agriculture/FFA
- Laboratory Safety and Use of Facilities

### Unit Standards

**Standards Key:**
- **HS** = High School
- **PE** = Performance Expectations
- **ETS** = Engineering & Technology
- **LS** = Life Science
- **PS** = Physical Science
- **DCI** = Disciplinary Core Ideas
- **CC** = Cross Cutting Concepts
- **SEP** = Science & Engineering Practices

**Agriculture & Natural Resources:**
- 2.5: Communicate information and ideas effectively to multiple audiences using a variety of media and formats.
- 3.6: Recognize the role and function of professional organizations, industry associations, and organized labor in a productive society.
- 4.1: Use electronic reference materials to gather information and produce products and services.
- 4.7: Demonstrate the use of appropriate tools and technology used in the Agriculture and Natural Resource sector.
- 5.4: Interpret information and draw conclusions, based on the best analysis, to make informed decisions.
- 6.2: Interpret policies, procedures, and regulations for the workplace environment, including employer and employee (student/teacher) responsibilities.
- 6.3: Use health and safety practices for storing, cleaning, and maintaining tools, equipment, and supplies.
- 6.4: Practice personal safety.
- 6.5: Demonstrate how to prevent and respond to accidents or injuries; this includes demonstrating understanding of ergonomics.

### English Language Development Bridging Strategies:
- All students should have opportunities to communicate regularly. Strategies for communication include:
  - Clearly defining the expectation for communication.
  - Model sentence frames and/or put on the board for effective communication.
  - Create strategic grouping so that EL’s have EO models in their groups.
  - Review the FFA Handbook and clarify vocabulary that may have multiple meanings or provide a completed model.
  - Demonstrate tool usage, specifically for those where injury and/or misuse could occur. Consider signs with proper use demonstrated.
  - Demonstrate safety and illustrate immediate first aide techniques.

### Learning Objectives:
- Students will be able to:
  - Identify key safety features within the lab setting and utilize key safety equipment when participating in lab activities.
  - State the requirements of participation in the FFA program and the location of key resources such as the FFA Handbook.
  - Use technology appropriately to conduct online research.
  - Synthesize ideas and present to others.
  - Practice time management skills and demonstrate an effective time management strategy.
  - Identify key classroom expectations for learning and participating in individual, small group, and large group activities.

### Instructional Resources:
- [http://www.calaged.org](http://www.calaged.org) – Website for FFA organization
- [http://www.calaged.org/sae_resources](http://www.calaged.org/sae_resources) - website for Supervised Agriculture Experience Handbook and Resources
- Lab Safety PPNT and Exam – available in UCCI Unit Resources folder

### Instructional Strategies:
- Modeling
- Grouping
| 6.6: Maintain a safe and healthful working environment. |
| 7.2: Explain the importance of accountability and responsibility in fulfilling personal, community, and workplace roles. |
| 7.3: Understand the need to adapt to changing and varied roles and responsibilities. |
| 7.4: Practice time management and efficiency to fulfill responsibilities. |
| 9.0: Work with peers to promote divergent and creative perspectives, effective leadership, group dynamics, team and individual decision making, benefits of workforce diversity, and conflict resolution as practiced in the FFA career technical student organization. |
| 10.0: Apply essential technical knowledge and skills common to all pathways in the Agriculture and Natural Resource sector, following procedures when carrying out experiments or performing technical tasks. |

### Key Unit Assignments:

- Students will participate in an introductory exploration of the historical background of the FFA organization and share their understanding with their peers. Students will utilize the FFA online website to conduct research on all of the requirements of participation in the FFA program; including a comprehensive review of the FFA Handbook Requirements. Students will set up their handbook electronically.
- Students will review all of the lab spaces within the classroom and outside spaces and identify key equipment and the safety features for operation. Students will identify the key lab safety requirements and be able to articulate the required safety features for participating in any lab or use of equipment.
- Students will review technology use requirements and create an online portfolio location, as required by the teacher, for purpose of storing and uploading their various tasks and assignments due throughout the course.

### Key Unit Assessments:

- Complete a lab and equipment safety test with 100% accuracy – may repeat until 100%.
- Creating online FFA Handbook and Portfolio – rubric for analysis to be utilized in each unit as assignments are completed.
Biology and Sustainable Agriculture Scope and Sequence
Unit 1 - Agriculture and Agricultural Research Skills
Length: 4 weeks

**Unit Description:** 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.

**Essential Question:** What is sustainable agriculture?

**Unit Standards**

**Standards Key:**
- HS = High School
- PE = Performance Expectations
- ETS = Engineering & Technology
- LS = Life Science
- PS = Physical Science
- DCI = Disciplinary Core Ideas
- CC = Cross Cutting Concepts
- SEP = Science & Engineering Practices

**Key High School Life Science Performance Expectations:**
- Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants. (HS-ETS1-1)
- 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-ETS1-2)
- Evaluate a solution to a complex real world problem based on prioritized criteria and trade-offs that account for range of constraints, including cost, safety, and reliability, and aesthetics as well as possible social, cultural, and environmental impacts. (HS-ETS1-3)

**Science and Engineering Practices:**
- Planning and Carrying Out Investigations: Planning and carrying out investigations in grades 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematics, physical, and empirical models.

**English Language Development Bridging Strategies:**
- Vocabulary definitions may need to be clarified. Provide a glossary and/or references to a glossary.
- Group according to language needs, recognizing the importance of strategic grouping for EO models.
- Provide models of PPNTS expectations, including clarifying rubric. Scaffold accordingly.
- Provide URLs for research when needed to help guide online searches. Use Wordbook or other EUHSD search engine strategies.
- Define expectations on multimedia presentation. Consider pairing for presentations and sentence frames.
- Consider modeling data analysis and/or limiting data to two or three data sets.

**Learning Objectives:**
- Students will be able to:
  - Analyze data for a specific problem or task.
  - Evaluate a real-world problem and identify pros and cons and possible impact to environment.
  - Evaluate the role of agricultural in the CA including such factors as economic, environmental, and life impact.
  - Identify major natural resources of CA.
  - Identify factors affecting food safety.
  - Create and conduct an experiment.
  - Present findings to others based on research and facts.
  - Use mathematical reasoning to explain and justify data.
  - Utilize a variety of scientific equipment.
  - Work collaboratively and independently to solve a problem.

**Instructional Resources:**
- Chrome book
- Lab Manual
- Lab Report
- WWW
- Rubrics for presentations

**Instructional Strategies:**
- Use of Content Literacy strategies when working with various text types.
- Structured collaborative discussions which may include think, pair share or other strategies.
- Sentence starters or frames for LEP students.
- Purposeful grouping
- Writing templates such as a completed lab report model.
- Constructing Explanations and Designing Solutions: Plan and conduct 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, costs, risk, time), and refine the design accordingly.

### Agriculture Standards:
- Evaluate the role of agriculture in the CA economy. (C1.0)
- Understand the history of the agricultural industry. (C1.1)
- Describe how CA agriculture affects the quality of life. (C1.2)
- Analyze the interrelationships of CA agriculture and society at the local, state, and international levels. (C1.3)
- Research the economic impact of leading CA agricultural commodities. (C1.4)
- Assess the economic impact of major natural resources in CA. (C1.5)
- Distinguish between the economic importance of major agricultural exports and imports. (C1.6)
- Explore factors that affect food safety and producer’s responsibilities to consumers. (C1.7)
- Describe how technology affects the logistics of moving an agricultural commodity from producer to consumer. (C3.1)
- Understand how technology influences factors such as labor, efficiency, diversity, availability, mechanization, and communication. (C3.2)
- Integrate use of technology when collecting and analyzing data. (C3.5)
- State the steps of the scientific method. (C13.1)
- Analyze an agricultural problem and devise a solution based on the scientific method. (C13.2)

### Reading Standards in CTE:
- Cite specific evidence from text.
- Explain central idea of text.
- Follow a multi-step procedure.
- Determine key terms and their meanings.
- Analyze relationships among concepts and key terms.
- Translate quantitative or technical information into visual form.
- Compare and contrast findings.

### Writing Standards in CTE:
- Produce clear and coherent writing.
- Use technology to produce and/or publish.
- Conduct short research to solve a problem or answer a question, including demonstrating understanding.
- Gather relevant information from multiple sources, integrate information.
- Draw evidence from text.

### Key Unit Assignments:

#### “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

### Key Unit Assessments:
- Multimedia Presentation on Sustainable Agriculture
- Lab Report – Mini lab on Industry Sector
- Lab Notebook Summary and Written Presentation on Scientific Method and Sustainability Lab including PPNT presentation
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. 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.
## Biology and Sustainable Agriculture Scope and Sequence

### Unit 2 - Environment, Energy, and Agriculture

**Length:** 10 weeks

**Unit Description:** While unit 1 examined whole systems, unit 2 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.

**Essential Question:** How does sustainable agriculture fit into our environment?

### Unit Standards

#### Key High School Life Science Performance Expectations:

- Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy. (HS-LS1-5)
- Construct and revise 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. (HS-LS1-6)
- Use a model to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules are broken and the bonds in new components are formed resulting in a net transfer of energy. (HS-LS1-7)
- Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales. (HS-LS2-1)
- Construct and revise an explanation based on evidence for cycling of matter and flow of energy in aerobic and anaerobic conditions. (HS-LS2-3)
- Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem. (HS-LS2-4)
- 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-LS2-5)
- Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity. (HS-LS2-7)

### English Language Development Standards Alignment:

- Vocabulary definitions may need to be clarified. Provide a glossary and/or references to a glossary.
- Group according to language needs, recognizing the importance of strategic grouping for ELD models.
- Sample papers and/or sample lab reports with completed data for models.
- Review APA citation criteria and provide citation builder such as Worldbook Online.
- Sample brochure including rubric.
- Create opportunities for labs that include partners or groups.
- Break down labs into segments and assess progress periodically.

### Learning Objectives:

- Students will be able to:
  - Use models to illustrate processes of photosynthesis.
  - Describe photosynthesis process using key terms and vocabulary correctly.
  - Use a model to illustrate cellular respiration bonds.
  - Construct and revise explanations as new evidence emerges.
  - Use mathematics to explain reasoning and data analysis.
  - Design and evaluate a problem and its solution.
  - Create and test a hypothesis.
  - Summarize findings and present findings.

### Instructional Resources:

- APA citation manual
- Biology textbook
- WWW and Chrome books

### Instructional Strategies:

- Grouping
- Use of literacy routines and/or charts
- Chunking text

### Reading Standards in CTE:

- Cite specific evidence from text.
- Explain central idea of text.
- Follow a multi-step procedure.
Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity. (HS-LS4-6)

**Key Disciplinary Core Ideas:**

- **LS1.C: Organization for Matter and Energy Flow in Organisms** – The sugar molecules thus formed contain carbon, hydrogen, and oxygen: their hydrocarbon backbones are used to make amino acids and other carbon-based molecules that can be assembled into larger molecules (such as proteins or DNA, used for example to form new cells. (LS1-6, LS1-7)
- **LS1.C: Organization for Matter and Energy Flow in Organisms** - As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products. (LS1-6, LS1-7)
- **LS1.C: Organization for Matter and Energy Flow in Organisms** - As a result of these chemical reactions, energy is transferred from one system of interacting molecules to another. Cellular respiration is a chemical process in which the bonds of food molecules and oxygen molecules are broken and new compounds are formed that can transport energy to muscles. (LS1-7)
- **LS1.C: Organization for Matter and Energy Flow in Organisms** - Cellular respiration also releases the energy needed to maintain body temperature despite ongoing energy transfer to surrounding environment. (LS1-7)
- **LS1.C: Organization for Matter and Energy Flow in Organisms** - The process of photosynthesis converts light energy to stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen. (LS1-5)
- **LS2.A: Interdependent Relationships in Ecosystems** – Ecosystems have carrying capacities, which are limits to the numbers of organisms and populations they can support. These limits result from such factors as the availability of living and non-living resources and from such challenges such as predation, completion, and diseases. Organisms would have the capacity to produce populations of great size were it not for the fact that environments and resources are finite. (LS2-5)
- **LS2.B: Interdependent Relationships in Ecosystems** – Photosynthesis and cellular respiration are important components of the carbon cycle, in which carbon is exchanged among the

**Writing Standards in CTE:**

- Determine key terms and their meanings.
- Analyze relationships among concepts and key terms.
- Translate quantitative or technical information into visual form.
- Compare and contrast findings.

**Determine key terms and their meanings.
- Produce clear and coherent writing.
- Write a proposal.
- Use technology to produce and/or publish.
- Conduct short research to solve a problem or answer a question, including demonstrating understanding.
- Gather relevant information from multiple sources, integrate information.
- Draw evidence from text.
<table>
<thead>
<tr>
<th>Concept</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PS3.D: Energy in Chemical Processes</td>
<td>The main way that solar energy is captured and stored on Earth is through the complex chemical process known as photosynthesis. (LS2-5)</td>
</tr>
<tr>
<td>LS2.C: Ecosystem Dynamics, Functioning, and Resilience</td>
<td>Moreover, anthropogenic changes (induced by human activity) in the environment—including habitat destruction, pollution, introduction of invasive species, overexploitation, and climate change—can disrupt an ecosystem and threaten the survival of some species. (LS2-7)</td>
</tr>
<tr>
<td>LS4.D: Biodiversity and Humans</td>
<td>Biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction). (Secondary to LS2-7)</td>
</tr>
<tr>
<td>LS4.D: Biodiversity and Humans</td>
<td>Humans depend on the living world for the resources and other benefits provided by biodiversity. But human activity is also having adverse impacts on biodiversity through overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change. Thus sustaining biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth. Sustaining biodiversity also aids humanity by preserving landscapes of recreational or inspirational value. (Secondary to LS2-7, LS4-6)</td>
</tr>
<tr>
<td>ETS1.B: Developing Possible Solutions</td>
<td>When evaluating solutions it is important to take into account a range of constraints including cost, safety, reliability and aesthetics and to consider social, cultural, and environmental impacts. (Secondary to LS2-7)</td>
</tr>
<tr>
<td>LS2.B: Cycles of Matter and Energy Transfer in Ecosystems</td>
<td>Plants or algae form the lowest level of the food web. At each link upward in a food web, only a small fraction of the matter consumed at the lowest level is transferred upward, to produce growth and release energy in cellular respiration at the higher level. Given this inefficiency, there are generally fewer organisms at higher levels of a food web. Some matter reacts to release energy for life functions, some matter is stored in newly made structures, and much is discarded. The chemical elements that make up the molecules of organisms pass through food webs and into and out of the atmosphere and soil, and they are</td>
</tr>
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combined and recombined in different ways. At each link in an ecosystem, matter and energy are conserved. (LS2-4)

- **LS4.C: Adaption** – Changes in the physical environment, whether naturally occurring or human induced, have thus contributed to the expansion of some species, the emergence of new distinct species as populations diverse under different conditions, and the decline and sometimes the extinction of some species. (LS4-5, LS4-6)

- **ETS1.B: Developing Possible Solutions** – When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics and to consider social, cultural, and environmental impacts. (LS4-6)

- **ETS1.B: Developing Possible Solutions** – Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs. (Secondary to LS4-6)

**Science and Engineering Practices:**

- **Using Mathematics and Computational Thinking:** Mathematical and computational thinking in 9-12 builds on the K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical assumptions.

- **Engaging in Argument from Evidence:** Engaging in argument from evidence in 9-12 builds from K-8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science.

**Agriculture Standards:**

- Identify important agricultural environmental impacts on soil, water, and air. (C2.1)
- Explain current environment challenges related to agriculture. (C2.2)
- Summarize how natural resources are used in agriculture. (C2.3)
- Compare and contrast practices for conserving renewable and nonrenewable resources. (C2.4)
- Research how new energy sources are developed from agricultural products. (C2.5)
- Compile the modern-day uses of animals and animal byproducts. (C4.3)
- Integrate the use of technology when collecting and analyzing data. (C3.5)
- Describe how technology affects the logistics of moving an agricultural commodity from producer to consumer. (C3.1)
- Understand how technology influences factors such as labor, efficiency, diversity, availability, mechanization, and communication. (C3.2)
- Understand the anatomy and functions of plant systems and structures. (C11.1)
- Identify plant growth requirements. (C11.2)
- Discern between annual, biennial, and perennial life cycles. (C11.3)
- Examine sexual and asexual reproduction in plants. (C11.4)
- Understand photosynthesis and the roles of the sun, chlorophyll, sugar, oxygen, carbon dioxide, and water in the process. (C11.5)
- Summarize the respiration process in the breakdown of food and organic matter. (C11.6)
- Identify the function of cells. (C5.1)
- Analyze the anatomy and physiology of cells. (C5.2)

**Key Unit Assignments:**

- **“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

**Key Unit Assessments:**

- 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. Students’ 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 economic impact from each crop.
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 that 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

When creating the 3-year crop rotations students will defend their selections and the ecological impacts of their decisions.

- Written proposal to a local producer.
- End of Unit Presentations
- Written Lab Report (Nitrogen lab, photosynthesis lab)
- Case Study Paper
- Compost Brochure
begin by students examining agricultural examples of biogas production (small scale composting, dairy lagoon gas extraction, co digestion, etc.) as well as the microbiological basis for biogas production, including aerobic and anaerobic fermentation, cellular respiration, lignocelluloses 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 feedstock’s 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.
Biology and Sustainable Agriculture Scope and Sequence  
Unit 3 - Molecular Biology and Agriculture  
Length: 12 weeks

**Unit Description:** 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 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.

**Essential Question:** What molecular biology principles guide sustainable agriculture?

### Unit Standards

**Standards Key:**  
HS = High School  
PE = Performance Expectations  
ETS = Engineering & Technology  
LS = Life Science  
PS = Physical Science  
DCI = Disciplinary Core Ideas  
CC = Cross Cutting Concepts  
SEP = Science & Engineering Practices

**Key High School Life Science Performance Expectations:**  
- 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. (LS1-1)  
- Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms. (LS1-3)  
- Use a model to illustrate the theory of cellular division (mitosis) and differentiation in producing and maintaining complex organisms. (LS1-4)  
- As questions to clarify relationships about the role of DNA and Chromosomes in coding the instructions for characteristic traits passed from parents to offspring. (LS3-1)  
- Make and defend a claim based on evidence that inheritable genetic variations may result from: (1) new genetic combinations

### English Language Development Standards

**Alignment:**

- Students may need assistance in constructing an experiment based on evidence. Teachers may wish to model and/or pair up students.  
- Provide glossary references for key terms. This unit is especially rich in terminology that may be unfamiliar.  
- When giving an oral presentation with evidence, students should have scaffold structures for the presentation, which may include an organizational scaffold for presenting ideas.  
- When writing their defense of findings based on data, provide students with a scaffold structure for their defense, including models. As students transition from presenting their argument to defending their argument, students may need assistance in compiling evidence rather than opinion.  
- Students may not be accustomed to debate procedures. Review the protocols for debate.

### Learning Objectives:

**Students will be able to:**  
- Formulate and test a hypothesis.  
- Distinguish between credible and non-credibile sources.  
- Utilize research strategies.  
- Construct an experiment using scientific protocol.  
- Use data to validate specific experimental findings.  
- Determine the best methods for organizing data.  
- Use mathematical principles to synthesize data and determine results.  
- Complete a lab report.  
- Synthesize findings both orally and in writing.  
- Write a research paper using correct citation (APA) formatting and both primary and secondary sources.  
- Present findings to others.

### Instructional Resources:

- Biology textbook  
- WWW/Internet and Chromebook

### Instructional Strategies:

- Literacy routines (including annotation skills, text type, text preview, summary, key ideas and details)  
- Oral presentation rubric and practice/review.
through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors. (LS3-2)

- Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population. (LS3-3)
- 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. (LS4-3)
- Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence. (LS4-1)

**Key Disciplinary Core Ideas:**

- **LS1.A: Structure and Function** – Systems of specialized cells within organisms help them perform the essential functions of life. (LS1-1)
- All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins, which carry out most of the work of cells. (LS1-1)
- Multicellular organisms have a hierarchical structural organization, in which any one system is made up of numerous parts and is itself a component of the next level. (LS1-2)
- Feedback mechanisms maintain a living system’s internal conditions within certain limits and mediate behaviors, allowing it to remain alive and functional even as external conditions change within some range. Feedback mechanisms can encourage (through positive feedback) or discourage (negative feedback) what is going on inside the living system. (LS1-3)

- **LS1.B: Growth and Development of Organisms** – In multicellular organism’s individual cells grow and then divide via a process called mitosis, thereby allowing the organism to grow. The organism begins as a single cell (fertilized egg) that divides successively to produce many cells, with each parent cell passing identical genetic material (two variants of each chromosome pair) to both daughter cells. Cellular division and differentiation produce and maintain a complex organism, composed of systems of tissues and organs that work together to meet the needs of the whole organism. (LS1-4)

**Reading Standards in CTE:**

- Write a proposal.
- Use technology to produce and/or publish.
- Conduct short research to solve a problem or answer a question, including demonstrating understanding.
- Gather relevant information from multiple sources, integrate information.
- Draw evidence from text.
| LS4.A: Evidence of Common Ancestry and Diversity – Genetic information provides evidence of evolution. DNA sequences vary among species, but there are many overlaps, in fact, the ongoing branching that produces multiple lines of descent can be inferred by comparing the DNA sequences of different organisms. Such information is also derivable from the similarities and differences in amino acid sequences and from anatomical and embryological evidence. (LS4-1) |
| LS4.C: Adaptation - Natural selection leads to adaptation that is, to a population dominated by organisms that are anatomically, behaviorally, and physiologically well suited to survive and reproduce in a specific environment. That is, the differential survival and reproduction of organisms in a population that have an advantageous heritable trait leads to an increase in the proportion of individuals in future generations that have the trait and to a decrease in the proportion of individuals that do not. (HS-LS4-3),(HS-LS4-4) |
| LS4.C: Adaptation - Adaptation also means that the distribution of traits in a population can change when conditions change. (HS-LS4-3) |
| LS1.A: Structure and Function - All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins, which carry out most of the work of cells. (HS-LS1-1, secondary to HS-LS3-1) (Note: This Disciplinary Core Idea is also addressed by HS-LS3-1.) |
| LS3.A: Inheritance of Traits - Each chromosome consists of a single very long DNA molecule, and each gene on the chromosome is a particular segment of that DNA. The instructions for forming species’ characteristics are carried in DNA. All cells in an organism have the same genetic content, but the genes used (expressed) by the cell may be regulated in different ways. Not all DNA codes for a protein; some segments of DNA are involved in regulatory or structural functions, and some have no as-yet known function. (HS-LS3-1) |
| LS3.B: Variation of Traits - Environmental factors also affect expression of traits, and hence affect the probability of occurrences of traits in a population. Thus the variation and distribution of traits observed depends on both genetic and environmental factors. (HS-LS3-2),(HS-LS3-3) |
| LS3.B: Variation of Traits - In sexual reproduction, chromosomes can sometimes swap sections during the process of meiosis (cell division), thereby creating new genetic combinations and thus more genetic variation. Although DNA replication is tightly regulated and remarkably accurate, errors do occur and result in mutations, which are... |
also a source of genetic variation. Environmental factors can also cause mutations in genes, and viable mutations are inherited. (HS-LS3-2)

Scientific and Engineering Practices:
- Asking Questions and Defining Problems – Asking questions and defining problems in 9-12 builds on K-8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations.
- Developing and Using Models – Modeling in 9-12 builds on K-8 experiences and progresses to using synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds.
- Analyzing and Interpreting Data – Analyzing data in 9-12 builds on K-8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data.
- Engaging in Argument from Evidence – Engaging in argument from evidence in 9-12 builds on K-8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science.

Agriculture Standards:
- Understand various cell actions, such as osmosis and cell division. C5.3
- Compare and contrast plant and animal cells, bacteria, and viruses. (C7.1)
- Compare genetic characteristics among cattle, sheep, swine, and horse breeds. (C7.2)
- Predict phenotype and genotype ratios by using a Punnett Square. (C7.3)
- Explain the fertilization process. (C7.4)
- Distinguish between the purposes and processes of mitosis and meiosis. (C7.5)
- Identify types of nutrients required by farm animals (E.g., proteins, minerals, vitamins, carbohydrates, fats/oils, water). (C8.1)
Analyze suitable common feeding ingredients, including forages, roughages, concentrates, and supplements for ruminant, monogastric, equine, and avian digestive systems. (C8.2)

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

Key Unit Assignments:

- "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 fewer 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 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

Key Unit 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:

1. 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.

2. 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
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.

3. 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.

4. 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.
Biology and Sustainable Agriculture Scope and Sequence

Unit 4 - Agriculture's Relationship with Technology and the Natural World

Length: 7 weeks

Unit Description: In unit 4, 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, and the sustainability of an ecosystem for the future while preserving biodiversity.

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

Unit Standards

Key High School Life Science Performance Expectations:
- 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. (LS2-6)
- Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants. (ETS1-1)
- Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering. (ETS1-2)
- 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, and reliability, and aesthetics as well as possible social, cultural, and environmental impacts. (ETS1-3)

Key Disciplinary Core Ideas:
- LS2.C: ECOSYSTEM DYNAMICS, FUNCTIONING AND RESILIENCE - A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions. If a modest biological or physical disturbance to an ecosystem occurs, it may return to its more or less original status (i.e., the ecosystem

English Language Development Standards

Alignment:
- Vocabulary definitions may need to be clarified. Provide a glossary and/or references to a glossary.
- Group according to language needs, recognizing the importance of strategic grouping for EO models.
- Sample papers and/or sample lab reports with completed data for models.
- Review APA citation criteria and provide citation builder such as Worldbook Online.
- Sample brochure including rubric.
- Create opportunities for labs that include partners or groups.
- Break down labs into segments and assess progress periodically.
- Sample research papers, including review of key elements of research paper/final project.

Learning Objectives:
Students will be able to:
- Engage in research on livestock production and use findings to illustrate understanding of animal health and well-being.
- Conduct lab experiments using scientific method.
- Present lab findings both orally and in summary writing.
- Demonstrate learning through completion of hands-on lab activities.
- Collect and compile data to illustrate findings.
- Summarize data in lab report.
- Work with others and independently.
- Create a design proposal using consistent design principles.
- Create a flyer using web 2.0 tools.
- Write and present a research paper.

Instructional Resources:
- Core textbook with glossary of terminology
- Lab report
- Lab materials
- Chromebooks

Instructional Strategies:
- Grouping
- Modeling effective writing
- Review rubric criteria for presentations – demonstrate presentation expectations
- Review elements of research paper, provide resources

Instructional Brochure:

Students will:

1. Engage in research on livestock production and use findings to illustrate understanding of animal health and well-being.
2. Conduct lab experiments using scientific method.
3. Present lab findings both orally and in summary writing.
4. Demonstrate learning through completion of hands-on lab activities.
5. Collect and compile data to illustrate findings.
7. Work with others and independently.
8. Create a design proposal using consistent design principles.
9. Create a flyer using web 2.0 tools.
10. Write and present a research paper.
is resilient), as opposed to becoming a very different ecosystem. Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of ecosystems in terms of resources and habitat availability. (HS-LS2-2), (HS-LS

- **LS2.C: Ecosystem Dynamics, Functioning and Resilience** - Moreover, anthropogenic changes (induced by human activity) in the environment—including habitat destruction, pollution, introduction of invasive species, overexploitation, and climate change—can disrupt an ecosystem and threaten the survival of some species. (HS-LS2-7)

- **ESS3.C: Human Impacts on Earth Systems** – The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources. (ESS3-3)

- **ETS1.B: Developing Possible Solutions** – When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider societal, cultural, and environmental impacts. (ESS3-4)

### Key Agriculture Standards:

- Assess the appearance and behavior of a normal, healthy animal. (C9.1)
- Explain the ways in which housing, sanitation, and nutrition influence animal health and behavior. (C9.2)
- Analyze the causes and controls of common animal diseases. (C9.3)
- Summarize effective techniques for controlling parasites and explain why controlling parasites is important. (C9.4)
- Research the legal requirements for the procurement, storage, methods of application, and withdrawal times of animal medications, and known proper equipment handling and disposal techniques. (C9.5)
- Understand the anatomy and functions of plant systems and structures. (C11.1)
- Identify plant growth requirements. (C11.2)
- Discern between annual, biannual, and perennial life cycles. (C11.4)
- Examine the sexual and asexual reproduction in plants. (C11.4)

### Writing Standards in CTE:

- Produce clear and coherent writing.
- Write a proposal.
- Use technology to produce and/or publish.
- Conduct short research to solve a problem or answer a question, including demonstrating understanding.
- Gather relevant information from multiple sources, integrate information.
- Draw evidence from text.

### Reading Standards in CTE:

- Cite specific evidence from text.
- Explain central idea of text.
- Follow a multi-step procedure.
- Determine key terms and their meanings.
- Analyze relationships among concepts and key terms.
- Translate quantitative or technical information into visual form.
- Compare and contrast findings.
- Understand photosynthesis and the roles of the sun, chlorophyll, and oxygen in carbon dioxide and water in the process. (C11.5)
- Summarize the respiration process in the breakdown of food and organic matter. (C11.6)
- Explain how basic soil science and water principles affect plant growth. (F5.1)
- Illustrate basic irrigation design and installation methods. (F5.2)
- Prepare and amend soils, implement soil conservation methods, and compare results. (F5.3)
- Research major issues related to water sources and water quality. (F5.4)
- Explain the components of soilless media and test the use of those media in various types of containers. (F5.5)
- Use different types of containers and demonstrate how to maintain growing containers in controlled environments. (F9.1)

**Key Unit Assignments:**

1. **“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.

2. **“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

**Key Unit Assessments:**

3. **“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, and 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 bio diverse in nature.
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 that 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 bio prospecting. They will use the knowledge gained within this unit regarding the potential to change the future through bio prospecting 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 bio prospecting, 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. After the discussion students will research other types of bio prospecting 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 bio prospecting will be utilized in a flyer created by 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.

- Lab report using scientific method and a written abstract to send to research institute.
- Class discussion on natural resources with a written summary
- Flyer on bio prospecting
- Design proposal
- Fertilization lab report
- Explanatory position paper
- Common animal production practices demonstrations
each student. The flyers will be set-up in a walking gallery where the students will use a bio prospecting 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 bio prospecting to contribute to sustainability of the human population.

- **Bio prospecting - “Motoring with Microbes” – Discovering Cellulose Microbes for Biofuel Efficiency** – The students will then conduct a research lab on Bio prospecting 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.