**Stanford NGSS Integrated Curriculum: An Exploration of a Multidimensional World**

**Unit 3: Mimicking Nature’s Design**

**Essential Question:** How does energy and matter flow within natural and designed systems?

**Total Number of Instructional Days:** 34 – 35

**Group Culminating Project:**

Create an aquaponics system that mimics a natural ecosystem

**Individual Culminating Project**

Write an instruction manual for your aquaponics system

**Lift-Off Task:**

Changing

Rivers

**Task 2:**

Matter Moves You

**Task 3:**

Cycling Matter Through Living Things

**Task 4:**

Cycling Matter Through Rocks

**Unit 3 Pop-Out**

How Science Works

(*Implement anytime during unit*)

Connect to the Culminating Project using the Project Organizer

**Task 1:**

Types of Changes

**Task 5:**

Design a Thermal Device

**Storyline for Unit 3**

Environments contain a variety of different living and non-living parts that all interact to make the environment function as a whole. In this unit, students explore how natural ecosystems function in order to design an artificial ecosystem, known as an aquaponics system, for their culminating project.

In the Lift-Off Task, students are introduced to a changing river environment, shown in an image from 200 years ago as well as an image from the present. After making their own observations, they are asked to generate a list of questions they would ask in order to learn more about how and why this river environment has changed over time. Students will return to this phenomenon and these questions throughout the unit as they seek to form a more cohesive understanding of how ecosystems function.

As students noticed changes that occurred over hundreds of years in the river environment, they were implicitly beginning to think about the chemical and physical processes involved in environmental change. In Task 1, students dig into the science behind some of these changes by learning about both physical and chemical changes. Through data analysis, they will find that looking at the properties of substances before and after the change is key to determining what type of change it is. By the end of this task, students will be able to use their scientific understanding of physical and chemical changes to help them explain real phenomena in river environments, thus paving the way to apply this knowledge in a designed setting, like their aquaponics system.

In Task 2, students continue their exploration of chemical changes with a few example reactions—combustion and cellular respiration. By analyzing these chemical reactions as molecular models, students begin to see that when molecules are broken down, they don’t just disappear; rather matter is conserved, molecules are rearranged, and energy is released in the process. This is one way matter and energy move through ecosystems. Armed with understanding of this chemical reaction, students will be able to first decide what components are needed in their aquaponics system, and then begin to conceptualize what the cycling of energy and matter looks like in their system.

Task 3 builds on ideas from Task 1 by introducing another critical chemical reaction that plays a role in the cycling of matter and flow of energy in all environments—photosynthesis. Students conduct investigations that show how photosynthesis and cellular respiration interact to allow matter to cycle and energy to flow through living organisms. By the end of this task, students should have a clear model of this cycling, so they may apply this knowledge to the design of their aquaponics system.

However, photosynthesis and cellular respiration are not the only ways matter is cycled in an ecosystem. In Task 4, students find that Earth’s materials can also be cycled through non-living components, like rocks, creating some of the changes students originally observed in the river environment in the Lift-Off Task. After simulating the rock cycle, students model the different processes that cycle Earth’s materials, including how energy drives this process. By the end of this task, students are equipped to consider how the rock cycle may play a role in their aquaponics system.

Throughout this unit, students have seen heat being absorbed and released in the chemical reactions they observed. In Task 5, students use this knowledge to approach a design problem: How can they heat a pool in the river environment so blue catfish are able to spawn? Students will use hot packs and cold packs as their inspiration, testing which chemical reactions absorb or release heat. They will then engage in the complete engineering and design process to design a heat-regulation device, which will be modified and used in their aquaponics system design.

Once students are complete with all learning tasks, they are ready to complete their culminating project. In this culminating project, the students’ job is to use what they learn about how matter cycles and energy flows through organisms and rocks in order to build a sustainable aquaponics system that mimics the properties of a river environment. After groups build their aquaponics system, students individually create an instruction manual, containing a visual model to explain how their aquaponics system functions.

**Three-Dimensional Breakdown of the Performance Expectations**

This unit was developed to align with, teach, and assess students’ understanding and skills related to these Performance Expectations. Below, we have mapped out the disciplinary core ideas, crosscutting concepts, and science and engineering practices addressed in this unit. Aspects of the dimensions that are not explicitly addressed in this unit are crossed out.

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| **Performance Expectations** | **Science and Engineering Practices** | **Disciplinary Core Ideas** | **Crosscutting Concepts** |
| **MS-LS1-6**. **Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms.** [Clarification Statement: Emphasis is on tracing movement of matter and flow of energy.] [Assessment Boundary: Assessment does not include the biochemical mechanisms of photosynthesis.] | **Constructing Explanations**   * Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students’ own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. | **LS1.C: Organization for Matter and Energy Flow in Organisms**   * Plants, algae (including phytoplankton), and many microorganisms use the energy from light to make sugars (food) from carbon dioxide from the atmosphere and water through the process of photosynthesis, which also releases oxygen. These sugars can be used immediately or stored for growth or later use.   **PS3.D: Energy in Chemical Processes and Everyday Life**   * The chemical reaction by which plants produce complex food molecules (sugars) requires an energy input (ie. from sunlight) to occur. In this reaction, carbon dioxide and water combine to form carbon-based organic molecules and release oxygen (*secondary*). | **Energy and Matter**   * Within a natural system, the transfer of energy drives the motion and/or cycling of matter. |
| **MS-LS1-7.** **Develop a model to describe how food is rearranged through chemical reactions forming new molecules that support growth and/or release energy as this matter moves through an organism.** [Clarification Statement: Emphasis is on describing that molecules are broken apart and put back together and that in this process, energy is released.] [Assessment Boundary: Assessment does not include details of the chemical reactions for photosynthesis or respiration.] | **Developing and Using Models**   * Develop a model to describe unobservable mechanisms. | **LS1.C: Organization for Matter and Energy Flow in Organisms**   * Within individual organisms, food moves through a series of chemical reactions in which it is broken down and rearranged to form new molecules, to support growth, and to release energy.   **PS3.D: Energy in Chemical Processes and Everyday Life**   * Cellular respiration in plants and animals involve chemical reactions with oxygen that release stored energy. In these processes, complex molecules containing carbon react with oxygen to produce carbon dioxide and other materials (*Secondary*). | **Energy and Matter**   * Matter is conserved because atoms are conserved in physical and chemical processes. |
| **MS-ESS2-1.** **Develop a model to describe the cycling of Earth’s materials and the flow of energy that drives this process.** [Clarification Statement: Emphasis is on the processes of melting, crystallization, weathering, deformation, and sedimentation, which act together to form minerals and rocks through the cycling of Earth’s materials.] [Assessment Boundary: Assessment does not include the identification and naming of minerals.] | **Developing and Using Models**   * Develop and use a model to describe phenomena. | **ESS2.A: Earth’s Materials and Systems**   * All Earth processes are the result of energy flowing and matter cycling within and among the planet’s systems. This energy is derived from the sun and Earth’s hot interior. The energy that flows and matter that cycles produce chemical and physical changes in Earth’s materials and living organisms. | **Stability and Change**   * Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and processes at different scales, including the atomic scale. |
| **MS-PS1-2. Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.** [Clarification Statement: Examples of reactions could include burning sugar or steel wool, fat reacting with sodium hydroxide, and mixing zinc with hydrogen chloride.] [Assessment Boundary: Assessment is limited to analysis of the following properties: density, melting point, boiling point, solubility, flammability, and odor.] | **Analyzing and Interpreting Data**   * Analyze and interpret data to determine similarities and differences in findings. | **PS1.A: Structure and Properties of Matter**   * Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it.   **PS1.B: Chemical Reactions**   * Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules and these new substances have different properties from those of the reactants. | **Patterns**   * Macroscopic patterns are related to the nature of microscopic and atomic-level structure. |
| **MS-PS1-5.** **Develop and use a model to describe how the total number of atoms does not change in a chemical reaction and thus mass is conserved**. [Clarification Statement: Emphasis is on law of conservation of matter and on physical models or drawings, including digital forms that represent atoms.] [Assessment Boundary: Assessment does not include the use of atomic masses, balancing symbolic equations, or intermolecular forces.] | **Developing and Using Models**   * Develop a model to describe unobservable mechanisms. | **PS1.B: Chemical Reactions**   * Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules and these new substances have different properties from those of the reactants. * The total number of each type of atom is conserved, and thus the mass does not change. | **Energy and Matter**   * Matter is conserved because atoms are conserved in physical and chemical processes. |
| **MS-PS1-6.** **Undertake a design project to construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes.\*** [Clarification Statement: Emphasis is on the design, controlling the transfer of energy to the environment, and modification of a device using factors such as type and concentration of a substance. Examples of designs could involve chemical reactions such as dissolving ammonium chloride or calcium chloride.] [Assessment Boundary: Assessment is limited to the criteria of amount, time, and temperature of substance in testing the device.] | **Designing Solutions**   * Undertake a design project, engaging in the design cycle, to construct and/or implement a solution that meets specific criteria and constraints. | **PS1.B: Chemical Reactions**   * Some chemical reactions release energy, others store energy. | **Energy and Matter**   * The transfer of energy can be tracked as energy flows through a designed or natural system. |
| **MS-ETS1-3. Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.** | **Analyzing and Interpreting Data**   * Analyze and interpret data to determine similarities and differences in findings. | **ETS1.B: Developing Possible Solutions**   * There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. * Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors.   **ETS1.C: Optimizing the Design Solution**   * Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process – that is, some of the characteristics may be incorporated into the new design. | **N/A** |
| **MS-ETS1-4. Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.** | **Developing and Using Models**   * Develop a model to generate data to test ideas about designed systems, including those representing inputs and outputs. | **ETS1.B: Developing Possible Solutions**   * A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. * Models of all kinds are important for testing solutions.   **ETS1.C: Optimizing the Design Solution**   * The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution. | **N/A** |

**Connections to Common Core Math and ELA Standards:**

Over the course of this unit, students will gain knowledge and skills in science, as well as in math and English-language arts. Below we list the Common Core ELA and Math standards for middle school and 7th grade that are relevant to the curriculum tasks in this unit. Within the curriculum, there are opportunities to incorporate components of the following ELA and Math Standards:

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| **Middle School Common Core ELA Standards** | | **Unit Task** |
| **Key Ideas and Details** | CCSS.ELA-Literacy.RST.6-8.1: Cite specific textual evidence to support analysis of science and technical texts. | Task 3  Project |
| CCSS.ELA-Literacy.RST.6-8.2: Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions. | Task 3 |
| CCSS.ELA-Literacy.RST.6-8.3: Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks. | Task 3  Task 4  Task 5 |
| **Integration of Knowledge and Ideas** | CCSS.ELA-Literacy.RST.6-8.7: Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). | Task 1  Task 2  Project |
| CCSS.ELA-Literacy.RST.6-8.9: Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic. | Task 3 |
| **Text Types and Purposes** | CCSS.ELA-Literacy.WHST.6-8.2: Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes. | Task 5  Project |
| **Research to Build and Present Knowledge** | CCSS.ELA-Literacy.WHST.6-8.9: Draw evidence from informational texts to support analysis, reflection, and research. | Task 3  Project |
| **Presentation of Knowledge and Ideas** | CCSS.ELA-Literacy.SL.8.5: Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest. | Task 2  Project |

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| **Middle School and 7th Grade Common Core Math Standards** | | **Unit Task** |
| **Mathematical Practice** | CCSS.MATH.MP.2: Reason abstractly and quantitatively. | Task 1  Task 2  Task 5  Project |
| CCSS.MATH.MP.4: Model with mathematics. | Task 2  Project |

**Connections to English Language Development (ELD) Standards:**

We acknowledge that language development is a key component of disciplinary understanding and helps to support more rigorous and equitable outcomes for diverse students. This curriculum thus takes into account both the receptive and productive language demands of the culminating projects and strives to increase accessibility by including scaffolds for language development and pedagogical strategies throughout learning tasks. We aim to support language acquisition through the development of concept maps; utilizing sentence frames; implementing the Critique, Correct, and Clarify technique; employing the Stronger Clearer strategy; and fostering large and small group discussions.

The California ELD Standards are comprised of two sections: the standards and a rubric. Outlined below are the standards from Section One that are met within this curriculum. For additional information, please refer to: https://www.pausd.org/sites/default/files/pdf-faqs/attachments/SS\_ELD\_7.pdf.

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| **Eighth Grade ELD Standards** | | |
| **Part I: Interacting in Meaningful Ways** | A: Collaborative | 1.Exchanging information and ideas with others through oral collaborative discussions on a range of social and academic topics |
| 2. Interacting with others in written English in various communicative forms (print, communicative technology, and multimedia) |
| 3. Offering and justifying options, negotiating with and persuading others in communicative exchanges |
| 4. Adapting language choices to various contexts (based on task, purpose, audience, and text type) |
| B: Interpretive | 5. Listening actively to spoken English in a range of social and academic contexts |
| 6. Reading closely literary and informational texts and viewing multimedia to determine how meaning is conveyed explicitly and implicitly through language |
| 7. Evaluating how well writers and speakers use language to support ideas and arguments with details or evidence depending on modality, text type, purpose, audience, topic, and content area |
| 8. Analyzing how writers and speakers use vocabulary and other language resources for specific purposes (to explain, persuade, entertain, etc.) depending on modality, text type, purpose, audience, topic, and content area |
| C: Productive | 9. Expressing information and ideas in formal oral presentations on academic topics |
| 10. Writing literary and informational texts to present, describe, and explain ideas and information, using appropriate technology |
| 11. Justifying own arguments and evaluating others’ arguments in writing |
| 12. Selecting and applying varied and precise vocabulary and other language resources to effectively convey ideas |
| **Part II: Learning About How English Works** | A: Structuring Cohesive Texts | 1. Understanding text structure |
| 2. Understanding cohesion |
| B: Expanding and Enriching Ideas | 3. Using verbs and verb phrases |
| 4. Using nouns and noun phrases |
| 5. Modifying to add details |
| C: Connecting and Condensing Ideas | 6. Connecting ideas |
| 7. Condensing ideas |

**Connections to Environmental Awareness:**

Over the course of this curriculum, students will explore content related to various environmental principles and concepts that examine the interactions and interdependence of human societies and natural systems. In accordance with the *Education and the Environment Initiative (EEI),* tasks throughout this curriculum explore many of *California’s Approved Environmental Principles and Concepts.* The principles relevant to this unit are outlined in the chart below:

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| **Unit Task** | **EEI Principle** | **EEI Concept** |
| Task 2  Task 3  Project | Principle I: The continuation and health of individual human lives and of human communities and societies depend on the health of the natural systems that provide essential goods and ecosystem services. | Concept B: The ecosystem services provided by natural systems are essential to human life and to the functioning of our economies and cultures. |
| Task 1  Task 2  Task 3  Task 4  Project | Principle III: Natural systems change in ways that people benefit from and can influence. | Concept A: Natural systems proceed through cycles and processes that are required for their functioning. |