5E Integrated STEM Lesson Plan

Lesson Title: *Terraforming Mars: Is It Possible?*

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Topic: *Ecology & Physical Science*

Targeted Grade Level: *Grade 8 to Grade 12*

Time Needed: Quarter 1: August through October; Data collection and analysis of the working vivarium ecosystems will be collected throughout the year with an analysis of collected data and modification to the systems to keep them viable completed at least quarterly until the end of the current school year.

Subject Integration: *Science, Math, Engineering, Technology, English, Intro to Business*

Justification: I chose the following areas to focus on in this Unit based on the classes offered in my facility and the two sister facilities that service intensive emotional support students. We have been moving towards integration of the Academic curricula and completing at a minimum one integrated cross-curricular project per quarter that also uses the framework for the Universal Design for Learning or Personalized Learning Academy. Finding activities that meet the State's standards but is also engaging to students who literally "hate" school is a challenge. When completing student surveys to find topics they would be interested in learning about, a few topics stood out. Space was one of the topics.

When you look at the world's population, the use of nonrenewable resources, climate change and the decrease in useable land, we have a problem. With the technology available today, the closest planet that might have potential to support life is Mars. Thus, the topic, Terraforming Mars: Is it Possible?

Science: Biology, Earth and Space Science, Environmental Science, and Physical Science are the four disciplines of science with the most relevant standards. The topic of ecology and the interaction of biotic and abiotic factors is woven throughout the unit. However, there are also components of the physical sciences embedded within the content. In Physical Science students deal mainly with force and motion in determining the best delivery system for their water features and in getting all of the necessary components to Mars to begin the process of terraforming. The Perseverance mission with MOXIE shows that it is possible to begin the process of making Oxygen on Mars a necessary element needed to sustain life. When I think about the goal to move into a more scientifically literate nation, I find that I want my

students to be able to make observations that raise questions as well as collect and understand evidence to make judgements that allow them to be productive members of society.

Math: The mathematical concepts dealt with in this unit are scale, ratios, measurement, conversion of units, calculating area, volume, and perimeter, calculating flow rates, graphing functions, and understanding debits and credits which also integrates with the Intro to Business elective. Since the students need to develop working blueprints of their water feature for the STEM Unit Project and keep expenses from their hypothetical business, they need to learn how to make scale drawings to determine how much material will be needed to construct a water feature that will fit in their designated aquarium ranging from 10 gallons to 55 gallons as well as calculate expenses and as well as calculating cost overruns from the business math side of the project.

Engineering: In engineering the students use scientific principles and mathematical reasoning to improve technologies to meet needs limited by constraints of current technologies. In the main STEM Project for this unit, the students need to design and construct a working water feature for a terrestrial or aquatic habitat. The students draw a working blueprint that is edited as they work through the build and make changes to the existing structure. As they build and test prototypes, they begin to understand the process of problem solving, critical thinking and adapting and adjusting parameters to make a working model under the constraints set for the project.

Technology: If we look at the overall definition of technology, it is how we modify the natural environment through designing things that satisfy the needs and wants of the human population. It can focus on the product or system itself or utilize computer technology. Throughout this unit the students will work with computer technology to collect data, create spreadsheets, slide shows, complete research, learn fact checking, and perform simulations to better understand the interactivity of the biotic and abiotic factors. One of the areas my students struggle with is understanding that when you do a google search on content, you must go to one or more of the recommended sites. Many of them stop on the search page and do not go further.

English: Throughout the unit, students need to use many skills learned in ELA. They need to read and comprehend scientific literature finding evidence that supports their claims. They need to be able to cite textual references in the APA format. Since they will be writing, they need to develop the skills of planning, writing with correct grammatical conventions, revising, or editing, and writing to the audience to keep them engaged during presentations. They need to be able to write a fictitious biography for their role on their team such as Zoologist, Botanist, Accountant, or Engineer/Project Manager.

Intro to Business: The students are put on teams of 4 as we work through the material. These teams are a hypothetical business that work together to research systems interactions to create their vivarium and water feature with compatible species. They need to come up with a name for their business, create a business plan, create spreadsheets to monitor cash flow, calculate payroll, and more.

Standards:

NGSS Performance Expectations:

STEM UNIT PROJECT: Construct a Vivarium modeling an ecosystem with an appropriate moving water feature that can support 4 compatible animal species (two of the animals must be isopods and springtails) with 4 compatible plant species:

Interdependent Relationships in Ecosystems

HS-LS2-1. Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales. [Clarification Statement: Emphasis is on quantitative analysis and comparison of the relationships among interdependent factors including boundaries, resources, climate and competition. Examples of mathematical comparisons could include graphs, charts, histograms, and population changes gathered from simulations or historical data sets.] [Assessment Boundary: Assessment does not include deriving mathematical equations to make comparisons.]

HS-LS2-2. Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales. [Clarification Statement: Examples of mathematical representations include finding the average, determining trends, and using graphical comparisons of multiple sets of data.] [Assessment Boundary: Assessment is limited to provided data.]

HS-LS2-6. Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions but changing conditions may result in a new ecosystem. [Clarification Statement: Examples of changes in ecosystem conditions could include modest biological or physical changes, such as moderate hunting or a seasonal flood; and extreme changes, such as volcanic eruption or sea level rise.]

HS-LS2-8. Evaluate the evidence for the role of group behavior on individual and species' chances to survive and reproduce. [Clarification Statement: Emphasis is on: (1) distinguishing between group and individual behavior, (2) identifying evidence supporting the outcomes of group behavior, and (3) developing logical and reasonable arguments based on evidence. Examples of group behaviors could include flocking, schooling, herding, and cooperative behaviors such as hunting, migrating, and swarming.]

HS-LS4-5. Evaluate the evidence supporting claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species. [Clarification Statement: Emphasis is on determining cause and effect relationships for how changes to the environment such as deforestation, fishing, application of fertilizers, drought, flood, and the rate of change of the environment affect distribution or disappearance of traits in species.]

HS-LS4-6. Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.* [Clarification Statement: Emphasis is on testing solutions for a proposed problem related to threatened or endangered species, or to genetic variation of organisms for multiple species.]

HS-ESS2-4. Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate. [Clarification Statement: Examples of the causes of climate change differ by timescale, over 1-10 years: large volcanic eruption, ocean circulation; 10-100s of years: changes in human activity, ocean circulation, solar output; 10-100s of thousands of years: changes to Earth's orbit and the orientation of its axis; and 10-100s of millions of years: long-term changes in atmospheric composition.] [Assessment Boundary: Assessment of the results of changes in climate is limited to changes in surface temperatures, precipitation patterns, glacial ice volumes, sea levels, and biosphere distribution.]

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

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

Physical Science Components:

HS-PS1-3. Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.

HS-PS2-1. Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.

HS-PS2-2. Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system

HS-PS2-4. Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects.

HS-PS3-2. Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative position of particles (objects).

HS-PS3-3. Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts:
Using Mathematics and Computational Thinking *Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking*	***LS2.A: Interdependent Relationships in Ecosystems*** *Ecosystems have carrying capacities, which are limits to the numbers of organisms and*	***Cause and Effect*** *Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-LS2-*

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 models of basic assumptions. *Use mathematical and/or computational representations of phenomena or design solutions to support explanations. (HSLS2-1)* *Use mathematical representations of phenomena or design solutions to support and revise explanations. (HS-LS2-2)* *Create or revise a simulation of a phenomenon, designed device, process, or system. (HS-LS4-6)* *Use mathematical representations of phenomena to describe explanations. (HS-PS2-2) (HS-PS2-4)* ***Engaging in Argument from Evidence***	*populations they can support. These limits result from such factors as the availability of living and nonliving resources and from such challenges such as predation, competition, and disease. Organisms would have the capacity to produce populations of great size were it not for the fact that environments and resources are finite. This fundamental tension affects the abundance (number of individuals) of species in any given ecosystem. (HS-LS2-1),(HS-LS2-2)* ***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 is resilient), as opposed to becoming a very different ecosystem. Extreme*	*8),(HS-LS4-6) (HS-LS4-5)(HS-ESS2-4)* ***Scale, Proportion, and Quantity*** *The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. (HS-LS2-1)* *Using the concept of orders of magnitude allows one to understand how a model at one scale relates to a model at another scale. (HS-LS2-2)* ***Stability and Change*** *Much of science deals with constructing explanations of how things change and how they remain stable. (HS-LS2-6),(HSLS2-7)* ***Patterns*** *Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS-PS1-3)(HS-PS2-4)*

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. *Evaluate the claims, evidence, and reasoning behind currently accepted explanations or solutions to determine the merits of arguments. (HS-LS2-6)* *Evaluate the evidence behind currently accepted explanations or solutions to determine the merits of arguments. (HS-LS2-8)* *Evaluate the evidence behind currently accepted explanations or solutions to determine the merits of arguments. (HS-LS4-5)* ***Developing and Using Models*** *Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to*	*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-LS2-6)* ***LS2.D: Social Interactions and Group Behavior*** *Group behavior has evolved because membership can increase the chances of survival for individuals and their genetic relatives. (HS-LS2-8)* ***LS4.C: Adaptation*** *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 diverge under different conditions, and the decline–and sometimes the extinction–of some species. (HS-LS4-6) (HS-LS4-5)* *Species become extinct because*	***Systems and System Models*** *When investigating or describing a system, the boundaries and initial conditions of the system need to be defined. (HS-PS2-2)* ***Energy and Matter*** *Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. (HSPS3-3)* *Energy cannot be created or destroy ed—only mov es between one place and another place, between objects and/or fields, or between systems. (HS-PS3-2)* --- **Connections to Engineering, Technology, and Applications of Science** *Influence of Science, Engineering, and Technology on Society and the Natural World* *New technologies can have deep impacts on society and the*

predict and show relationships among variables between systems and their components in the natural and designed world(s). *Use a model to provide mechanistic accounts of phenomena. (HS-ESS2-4)* ***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.* *Analyze complex real-world problems by specifying criteria and constraints for successful solutions. (HS-ETS1-1)* ***Constructing Explanations and Designing Solutions*** *Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent*	*they can no longer survive and reproduce in their altered environment. If members cannot adjust to change that is too fast or drastic, the opportunity for the species' evolution is lost. (HS-LS4-5)* ***LS4.D: Biodiversity and Humans*** *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 HS - LS2 -7), (HS-LS4-6)* ***ETS1.B: Developing Possible***	*environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology. (HS-ETS1-1) (HSETS1-3)* *Modern civilization depends on major technological systems. Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks. (HS -PS3-3)*

student-generated sources of evidence consistent with scientific ideas, principles and theories. *Evaluate a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-ETS1-3) (HS-PS3-3)* ***Planning and Carrying Out Investigations*** *Planning and carrying out investigations in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models.* *Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g.,*	***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. (secondary to HS LS2 - 7), (secondary to HS - LS4 - 6)* *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 HS-LS4-6)* ***ESS1.B: Earth and the Solar System*** *Cyclical changes in the shape of Earth's orbit around the sun, together*	

number of trials, cost, risk, time), and refine the design accordingly. (HS-PS1-3) ***Analyzing and Interpreting Data*** *Analyzing data in 9–12 builds on K–8 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.* *Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. (HSPS2-1)* ***Developing and Using Models*** *Modeling in 9–12 builds on K–8 and progresses to using, synthesizing, and dev eloping models to predict and show relationships among variables between systems and their components in the natural and designed worlds.* *Develop and use a model based on evidence to illustrate the relationships*	*with changes in the tilt of the planet's axis of rotation, both occurring over hundreds of thousands of years, have altered the intensity and distribution of sunlight falling on the earth. These phenomena cause a cycle of ice ages and other gradual climate changes. (secondary to HS - ESS2 -4)* ***ESS2.A: Earth Materials and Systems*** *The geological record shows that changes to global and regional climate can be caused by interactions among changes in the sun's energy output or Earth's orbit, tectonic events, ocean circulation, volcanic activity, glaciers, vegetation, and human activities. These changes can occur on a variety of time scales from sudden (e.g., volcanic ash clouds) to intermediate (ice ages) to very long-term tectonic cycles. (HS-ESS2-4)* ***ESS2.D: Weather and Climate***	

between systems or between components of a system (HS-PS3-2) ***Connections to Nature of Science*** *Scientific Knowledge is Open to Revision in Light of New Evidence* *Most scientific knowledge is quite durable, but is, in principle, subject to change based on new evidence and/or reinterpretation of existing evidence. (HS-LS2-2)* *Scientific argumentation is a mode of logical discourse used to clarify the strength of relationships between ideas and evidence that may result in revision of an explanation. (HSLS2-6),(HS-LS2-8)* *Scientific Knowledge is Based on Empirical Evidence* *Science arguments are strengthened by multiple lines of evidence supporting a single explanation. (HS-ESS2-4), (HSESS3-5)* ***Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena***	*The foundation for Earth's global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's re-radiation into space. (HS-ESS2-4), (secondary to HS - ESS2 - 2)* *Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate. (HS-ESS2-4)* ***ETS1.A: Defining and Delimiting Engineering Problems*** *Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. (HS-ETS1-1)* *Humanity faces major global*	

Theories and laws provide explanations in science. (HS-PS2- 1) (HS-PS2-4) *Laws are statements or descriptions of the relationships among observable phenomena. (HS-PS2-1) (HS-PS2-4)*	*challenges today, such as the need for supplies of clean water and food or for energy sources that minimize pollution, which can be addressed through engineering. These global challenges also may have manifestations in local communities. (HS-ETS1-1)* ***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. (HS-ETS1-3)* ***PS1.A: Structure and Properties of Matter*** *The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms. (HS-PS1-3)* ***PS2.B: Types of Interactions*** *Attraction and repulsion between*	

	electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects. (HS-PS1-3) ***PS2.A: Forces and Motion*** *Newton's second law accurately predicts changes in the motion of macroscopic objects. (HS-PS2-1)* *Momentum is defined for a particular frame of reference; it is the mass times the velocity of the object. (HS-PS2-2)* *If a system interacts with objects outside itself, the total momentum of the system can change; however, any such change is balanced by changes in the momentum of objects outside the system. (HS-PS2-2)* ***PS2.B: Types of Interactions*** *Newton's law of universal gravitation and Coulomb's law provide the mathematical models to describe and predict the effects of*	

	gravitational and electrostatic forces between distant objects. (HS-PS2-4) ***PS3.A: Definitions of Energy*** *Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms. (HSPS3-1) (HS-PS3-2)* *At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy . (HSPS3-2) (HS-PS3-3)* *These relationships are better understood at the microscopic scale, at which all of the different manifestations of energy can be modeled as a combination of energy*	

	associated with the motion of particles and energy associated with the configuration (relative position of the particles). In some cases, the relative position energy can be thought of as stored in fields (which mediate interactions between particles). This last concept includes radiation, a phenomenon in which energy stored in fields mov es across space. (HS-PS3-2)	

Common Core State Standards:

Math:

MP.2 Reason abstractly and quantitatively. (HS-LS2-1),(HS-LS2-2),(HS-LS2-6), (HS - LS2 - 7)

MP.4 Model with mathematics. (HS - LS2 - 1),(HS - LS2 - 2)

HSN-Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-LS2-1),(HS-LS2-2), (HS - LS2 - 7)

HSN-Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. (HS - LS2 - 1),(HS - LS2 - 2),(HS - LS2 - 7)

HSN-Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-LS2-1),(HS-LS2-2), (HS - LS2 - 7)

HSS-ID.A.1 Represent data with plots on the real number line. (HS - LS2 - 6)

HSS-IC.A.1 Understand statistics as a process for making inferences about population parameters based on a random sample from that population. (HS - LS2 - 6)

HSS-IC.B.6 Evaluate reports based on data. (HS - LS2 - 6)

ELA:

RST.9-10.8 Assess the extent to which the reasoning and evidence in a text support the author's claim or a recommendation for solving a scientific or technical problem. (HS-LS2-6), (HS - LS2 -7),(HS - LS2 - 8)

RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS - LS2 -1),(HS - LS2 -2), (HS-LS2-6),(HS-LS2-8)

RST.11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. (HS - LS2 -6),(HS - LS2 -7),(HS - LS2 - 8)

RST.11-12.8 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-LS2-6),(HS-LS2-7), (HS-LS2-8)

WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS - LS2 -1),(HS LS2 -2)

WHST.9-12.5 Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. (HS - LS4 - 6)

WHST.9-12.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.(HSLS2-7),(HS-LS4-6)

NGSS Performance Expectations: Module 1: Principles of Ecology

HS-LS1-5. Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy. [Clarification Statement: Emphasis is on illustrating inputs and outputs of matter and the transfer and transformation of energy in photosynthesis by plants and other photosynthesizing organisms. Examples of models could include diagrams, chemical equations, and conceptual models.] [Assessment Boundary: Assessment does not include specific biochemical steps.]

HS-LS1-6. Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules. [Clarification Statement: Emphasis is on using evidence from models and simulations to support explanations.] [Assessment Boundary: Assessment does not include the details of the specific chemical reactions or identification of macromolecules.]

HS-LS1-7. Use a model to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed resulting in a net transfer of energy. [Clarification Statement: Emphasis is on the conceptual understanding of the inputs and outputs of the process of cellular respiration.] [Assessment Boundary: Assessment should not include identification of the steps or specific processes involved in cellular respiration.]

HS-LS2-1. Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales. [Clarification Statement: Emphasis is on quantitative analysis and comparison of the relationships among interdependent factors including boundaries, resources, climate and competition. Examples of mathematical comparisons could include graphs, charts, histograms, and population changes gathered from simulations or historical data sets.] [Assessment Boundary: Assessment does not include deriving mathematical equations to make comparisons.]

HS-LS2-2. Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales. [Clarification Statement: Examples of mathematical representations include finding the average, determining trends, and using graphical comparisons of multiple

sets of data.] [Assessment Boundary: Assessment is limited to provided data.]

HS-LS2-5. Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere. [Clarification Statement: Examples of models could include simulations and mathematical models.] [Assessment Boundary: Assessment does not include the specific chemical steps of photosynthesis and respiration.]

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts:
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.* *Use a model based on evidence to illustrate the relationships between systems or between components of a system. (HSLS1-5),(HS-LS1-7)* *Develop a model based on evidence to illustrate the relationships between systems or components of a system. (HS-LS2-5)* ***Constructing Explanations and***	***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. (HS-LS1-5)* *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. (HS-LS1-6)* *As matter and energy flow through*	***Systems and System Models*** *Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions— including energy, matter, and information flows—within and between systems at different scales. (HS-LS2-5)* ***Energy and Matter*** *Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. (HS-LS1-5), (HS-LS1-6)* *Energy cannot be created or destroyed—it only moves between one place and another place, between objects and/or fields, or between*

Designing Solutions *Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student generated sources of evidence consistent with scientific ideas, principles, and theories.* *Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) 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. (HS-LS1-6),(HSLS2-3)* ***Using Mathematics and Computational Thinking*** *Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and*	*different organizational levels of living systems, chemical elements are recombined in different ways to form different products. (HS-LS1-6), (HS-LS17)* *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. Cellular respiration also releases the energy needed to maintain body temperature despite ongoing energy transfer to the surrounding environment.(HS-LS1-7)* ***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*	*systems.(HS-LS1-7),(HS-LS2-4)* ***Scale, Proportion, and Quantity*** *The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. (HS-LS2-1)* *Using the concept of orders of magnitude allows one to understand how a model at one scale relates to a model at another scale. (HS-LS2-2)*

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 models of basic assumptions. *Use mathematical and/or computational representations of phenomena or design solutions to support explanations. (HSLS2-1)* *Use mathematical representations of phenomena or design solutions to support and revise explanations. (HS-LS2-2)* **----------** **Connections to Nature of Science** Scientific Knowledge is Open to Revision in Light of New Evidence □ Most scientific knowledge is quite durable, but is, in principle, subject to change based on new evidence and/or reinterpretation of existing evidence. (HS-LS2-2)	*availability of living and nonliving resources and from such challenges such as predation, competition, and disease. Organisms would have the capacity to produce populations of great size were it not for the fact that environments and resources are finite. This fundamental tension affects the abundance (number of individuals) of species in any given ecosystem. (HS-LS21),(HS-LS2-2)* ***LS2.B: Cycles of Matter and Energy Transfer in Ecosystems*** *Photosynthesis and cellular respiration are important components of the carbon cycle, in which carbon is exchanged among the biosphere, atmosphere, oceans, and geosphere through chemical, physical, geological, and biological processes. (HS-LS2-5)* ***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 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-LS2-6) ***PS3.D: Energy in Chemical Processes*** *The main way that solar energy is captured and stored on Earth is through the complex chemical process known as photosynthesis. (secondary to HS - LS2 - 5)*	
Common Core State Standards: Math:		

MP.2 Reason abstractly and quantitatively. (HS-LS2-1),(HS-LS2-2),(HS-LS2-6), (HS -LS2-7)

MP.4 Model with mathematics. (HS - LS2 - 1),(HS - LS2 - 2)

HSN-Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-LS2-1),(HS-LS2-2), (HS - LS2 - 7)

HSN-Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. (HS - LS2 - 1),(HS - LS2 - 2),(HS - LS2 - 7)

HSN-Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-LS2-1),(HS-LS2-2), (HS - LS2 - 7)

ELA:

RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-LS1-6),(HS-LS2-3)

WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-LS1-6),(HS-LS23)

WHST.9-12.5 Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.(HS-LS1-6),(HS-LS2-3)

WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research. (HS-LS1-6)

SL.11-12.5 Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (HS - LS1 - 5),(HS - LS1 – 7)

NGSS Performance Expectations: Module 2: Communities, Biomes, Ecosystems

HS-LS2-2. Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales. [Clarification Statement: Examples of mathematical representations include finding the average, determining trends, and using graphical comparisons of multiple sets of data.] [Assessment Boundary: Assessment is limited to provided data.

HS-LS2-5. Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere. [Clarification Statement: Examples of models could include simulations and mathematical models.] [Assessment Boundary: Assessment does not include the specific chemical steps of photosynthesis and respiration.]

HS-LS2-7. Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.* [Clarification Statement: Examples of human activities can include urbanization, building dams, and dissemination of invasive species.]

HS-LS4-6. Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.* [Clarification Statement: Emphasis is on testing solutions for a proposed problem related to threatened or endangered species, or to genetic variation of organisms for multiple species.]

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts:
Developing and Using Models *Modeling in 9–12 builds on K–8 experiences and progresses to using,*	**LS2.A: Interdependent Relationships in Ecosystems** □ Ecosystems have carrying	**Systems and System Models** □ Models (e.g., physical, mathematical, computer models) can

synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds. *Develop a model based on evidence to illustrate the relationships between systems or components of a system. (HS-LS2-5)* ***Using Mathematics and Computational Thinking*** *Mathematical and computational thinking in 9-12 builds on 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 models of basic assumptions.* *Use mathematical representations of phenomena or design solutions to*	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 nonliving resources and from such challenges such as predation, competition, and disease. Organisms would have the capacity to produce populations of great size were it not for the fact that environments and resources are finite. This fundamental tension affects the abundance (number of individuals) of species in any given ecosystem. (HS-LS21),(HS-LS2-2) **LS2.B: Cycles of Matter and Energy Transfer in Ecosystems** □ Photosynthesis and cellular respiration are important components of the carbon cycle, in which carbon is exchanged among the biosphere, atmosphere, oceans, and geosphere through chemical, physical, geological, and biological processes. (HS-LS2-5) **LS2.C: Ecosystem Dynamics,**	be used to simulate systems and interactions— including energy, matter, and information flows—within and between systems at different scales. (HS-LS2-5) **Cause and Effect** □ Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-LS2-8),(HS-LS4-6) **Scale, Proportion, and Quantity** □ Using the concept of orders of magnitude allows one to understand how a model at one scale relates to a model at another scale. (HS-LS2-2) **Stability and Change** Much of science deals with constructing explanations of how things change and how they remain stable. (HS-LS2-6),(HSLS2-7)

support and revise explanations. (HS-LS2-2) Create or revise a simulation of a phenomenon, designed device, process, or system. (HS-LS4-6) ***Constructing Explanations and Designing Solutions*** *Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.* *Design, evaluate, and refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-LS2-7)* ***----------*** ***Connections to Nature of Science*** *Scientific Knowledge is Open to Revision in Light of New Evidence*	**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 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-LS2-6) □ 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)	

Most scientific knowledge is quite durable, but is, in principle, subject to change based on new evidence and/or reinterpretation of existing evidence. (HS-LS2-2)	**LS4.C: Adaptation** □ 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 diverge under different conditions, and the decline–and sometimes the extinction–of some species. (HS-LS4-6) **LS4.D: Biodiversity and Humans** □ Biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction). (secondary to HS - LS2 - 7) □ 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. (s econdary to HS - LS2 -7), (HS-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. (secondary to HS LS2 - 7), (secondary to HS - LS4 - 6) □ 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 HS-LS4-6)	

Common Core State Standards:

Math:

MP.2 Reason abstractly and quantitatively. (HS-LS2-1),(HS-LS2-2),(HS-LS2-6), (HS-LS2-7)

MP.4 Model with mathematics. (HS - LS2 - 1),(HS - LS2 - 2)

HSN-Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-LS2-1),(HS-LS2-2), (HS-LS2-7)

HSN-Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. (HS-LS2-1),(HS-LS2-2),(HS-LS2-7)

HSN-Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-LS2-1),(HS-LS2-2), (HS-LS2-7)

ELA:

RST.9-10.8 Assess the extent to which the reasoning and evidence in a text support the author's claim or a recommendation for solving a scientific or technical problem. (HS-LS2-6), (HS-LS2-7),(HS-LS2-8)

RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS - LS2 -1),(HS - LS2 -2), (HS-LS2-6),(HS-LS2-8)

RST.11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. (HS-LS2-6), (HS-LS2-7),(HS-LS2-8)

RST.11-12.8 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-LS2-6),(HS-LS2-7), (HS-LS2-8)

WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-LS2-1),(HS-LS2-2)

WHST.9-12.5 Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. (HS - LS4 - 6)

WHST.9-12.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.(HSLS2-7),(HS-LS4-6)

NGSS Performance Expectations: Module 3: Population Ecology

HS-LS2-2. Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales. [Clarification Statement: Examples of mathematical representations include finding the average, determining trends, and using graphical comparisons of multiple sets of data.] [Assessment Boundary: Assessment is limited to provided data.]

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts:
Using Mathematics and Computational Thinking *Mathematical and computational thinking in 9-12 builds on 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 models of basic assumptions.* *Use mathematical representations of phenomena or design solutions to support and revise explanations. (HS-LS2-2)* ---------- ***Connections to Nature of Science*** *Scientific Knowledge is Open to Revision in Light of New Evidence* *Most scientific knowledge is quite*	**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 nonliving resources and from such challenges such as predation, competition, and disease. Organisms would have the capacity to produce populations of great size were it not for the fact that environments and resources are finite. This fundamental tension affects the abundance (number of individuals) of species in any given ecosystem. (HS-LS21),(HS-LS2-2) **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	Scale, Proportion, and Quantity □ Using the concept of orders of magnitude allows one to understand how a model at one scale relates to a model at another scale. (HS-LS2-2)

durable, but is, in principle, subject to change based on new evidence and/or reinterpretation of existing evidence. (HS-LS2-2)	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 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-LS2-6)	

Common Core State Standards:

Math:.

MP.2 Reason abstractly and quantitatively. (HS-LS2-1),(HS-LS2-2),(HS-LS2-6), (HS - LS2 - 7)

MP.4 Model with mathematics. (HS - LS2 - 1),(HS - LS2 - 2)

HSN-Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-LS2-1),(HS-LS2-2), (HS - LS2 - 7)

HSN-Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. (HS - LS2 - 1),(HS - LS2 - 2),(HS - LS2 - 7)

HSN-Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-LS2-

1),(HS-LS2-2), (HS - LS2 – 7)

ELA:

RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS - LS2 -1),(HS - LS2 -2), (HS-LS2-6),(HS-LS2-8)

WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS - LS2 -1),(HS LS2 -2)

NGSS Performance Expectations: Module 4: Biodiversity and Conservation

HS-LS2-2. Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales. [Clarification Statement: Examples of mathematical representations include finding the average, determining trends, and using graphical comparisons of multiple sets of data.] [Assessment Boundary: Assessment is limited to provided data.]

HS-LS2-7. Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.* [Clarification Statement: Examples of human activities can include urbanization, building dams, and dissemination of invasive species.]

HS-LS4-5. Evaluate the evidence supporting claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species. [Clarification Statement: Emphasis is on determining cause and effect relationships for how changes to the environment such as deforestation, fishing, application of fertilizers, drought, flood, and the rate of change of the environment affect distribution or disappearance of traits in species.] The

HS-LS4-6. Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.* [Clarification Statement: Emphasis is on testing solutions for a proposed problem related to threatened or endangered species, or to genetic variation of organisms for multiple species.]

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts:
Using Mathematics and Computational Thinking *Mathematical and computational thinking in 9-12 builds on 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 models of basic assumptions.)* *Use mathematical representations of phenomena or design solutions to support and revise explanations. (HS-LS2-2)* *Create or revise a simulation of a phenomenon, designed device, process, or system. (HS-LS4-6)* ***Constructing Explanations and Designing Solutions***	**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 nonliving resources and from such challenges such as predation, competition, and disease. Organisms would have the capacity to produce populations of great size were it not for the fact that environments and resources are finite. This fundamental tension affects the abundance (number of individuals) of species in any given ecosystem. (HS-LS21),(HS-LS2-2) **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	**Cause and Effect** □ Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HSLS4-2),(HS-LS4-4),(HS-LS4-5)(HS-LS$-6) **Scale, Proportion, and Quantity** □ Using the concept of orders of magnitude allows one to understand how a model at one scale relates to a model at another scale. (HS-LS2-2) **Stability and Change** □ Much of science deals with constructing explanations of how things change and how they remain stable. (HS-LS2-6),(HSLS2-7)

Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. *Design, evaluate, and refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-LS2-7)* ***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 or historical episodes in science.* *Evaluate the evidence behind currently accepted explanations or solutions to*	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 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-LS2-6) 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) **LS4.C: Adaptation** Changes in the physical environment, whether naturally occurring or human induced, have thus contributed to the expansion of	

determine the merits of arguments. (HS-LS4-5) --- ***Connections to Nature of Science*** *Scientific Knowledge is Open to Revision in Light of New Evidence* *Most scientific knowledge is quite durable, but is, in principle, subject to change based on new evidence and/or reinterpretation of existing evidence. (HS-LS2-2)*	some species, the emergence of new distinct species as populations diverge under different conditions, and the decline–and sometimes the extinction–of some species. (HS-LS4-6) (HS-LS4-5) □ Species become extinct because they can no longer survive and reproduce in their altered environment. If members cannot adjust to change that is too fast or drastic, the opportunity for the species' evolution is lost. (HS-LS4-5) **LS4.D: Biodiversity and Humans** □ Biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction). (secondary to HS-LS2-7) □ Humans depend on the living world for the resources and other benefits provided by biodiversity. But human 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. (s econdary to HS - LS2 -7), (HS-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. (secondary to HS-LS2-7), (secondary to HS-LS4-6) □ 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. (HS-LS4-6)	

Common Core State Standards:

Math:

MP.2 Reason abstractly and quantitatively. (HS-LS2-1),(HS-LS2-2),(HS-LS2-6), (HS - LS2 - 7)

MP.4 Model with mathematics. (HS - LS2 - 1),(HS - LS2 - 2)

HSN-Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-LS2-1),(HS-LS2-2), (HS - LS2 - 7)

HSN-Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. (HS - LS2 - 1),(HS - LS2 - 2),(HS - LS2 - 7)

HSN-Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-LS2-1),(HS-LS2-2), (HS - LS2 - 7)

ELA:

RST.9-10.8 Assess the extent to which the reasoning and evidence in a text support the author's claim or a

recommendation for solving a scientific or technical problem. (HS-LS2-6), (HS-LS2-7),(HS-LS2-8)

RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS - LS2 -1),(HS - LS2 -2), (HS-LS2-6),(HS-LS2-8)

RST.11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. (HS - LS2 -6),(HS - LS2 -7),(HS - LS2 - 8)

RST.11-12.8 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-LS2-6),(HS-LS2-7), (HS-LS2-8)(HS-LS4-5)

WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS - LS2 -1),(HS LS2 -2)

WHST.9-12.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.(HSLS2-7),(HS-LS4-6)

WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research. (HS - LS4 -1), (HS-LS4-2), (HS - LS4 -3), (HS-LS4-4),(HS-LS4-5)

Measurable Student Learning Objectives:

STEM Unit Project: Sustainable Habitat Engineering Phase One

Students will research and identify the biotic and abiotic factors influencing ecosystems and construct a water feature for a vivarium with compatible plant and animal species.

Phase one: Summative Assessment: Student groups will present their ecosystems in an oral presentation and demonstration of their ecosystem earning 80% or better on the average rubric score of the 5 evaluators for the group and individual scores.

Note: Once the vivarium is constructed the students will enter phase two of the project doing long term data tracking and analysis scoring 80% or higher on observations and analysis of the biogeochemical cycles. (Phase two is not described or outlined here)

Engage Formative Assessment: Students will write a minimum of 2 sentences in the What I know and a minimum of 2 sentences in the What I want to learn columns of their KW chart.

Explore Formative Assessment: Students will list and describe 5 of the 7 characteristics of life.

Explain Formative Assessment: Students will earn 16 out of 20 points on the rubric for Building a Vivarium daily work. Alternate give for ES students 14 out of 24 points on the rubric for Building a vivarium daily work for ES students. Parameters may be changed as students learn how to self-regulate. Use individual behavior support plans for further customization.

Note: 80% or higher is recommended for gen ed classes. I use 60% as mandated by my program for special needs students.

Elaborate Formative Assessment: The student will earn 80% of the teacher or para observed sections per day.

Note: not all of the sections on the rubric will be used every day.

Evaluate: Students will earn an average of 80% of the group and individual points on the rubric for their presentations to the 5 members of the expert panel.

Physical Science:

Module 1: Force and Motion

Students will learn the connections between force, motion, energy in a system in accordance with Newton's three laws of motion. Mastery will be shown by earning an 80% or better on the summative assessment.

Life Science, Earth Science, and Environmental Science

Module 1: Principles of Ecology

Students will learn the connections between organisms, the flow of energy through the system, and the cycling of abiotic and biotic materials. Mastery will be shown by earning an 80% or better average on the summative assessment.

Module 2: Communities, Biomes, and Ecosystems

Students will learn that abiotic factors drive the ability of community members to interact in terrestrial and aquatic biomes. Mastery will be shown by earning an 80% or better average on the summative assessment.

Module 3: Population Ecology

Students will learn about the factors that influence populations of organisms, and the impact of humans on those populations. Mastery will be shown by earning an 80% or better average on the summative assessment.

Module 4: Biodiversity and Conservation

Students will learn about the threats to biodiversity from climate change, pollution, and other human impacts. Mastery will be shown by earning an 80% or better average on the summative assessment.

Nature of STEM: When I'm thinking about the question does this unit fit the nature of STEM, I need to answer a few key questions. The first, does this unit have my students know, use and interpret scientific explanations and observations of the natural world as well as explore possible solutions to problems facing my students' reality? The second, Will my students generate and evaluate evidence? Thirdly, can my students participate productively in scientific practices and be able to have evidence-based discussions in the community and with peers and staff? I believe this unit does that. The students are asked to make vivariums (models of a specific ecosystem), track the viability of their system and report their findings. The content helps them to make judgements based on the core knowledge explored in the modules. The STEM project's first presentation is at the end of the first quarter where hopefully the students will have a working ecosystem model. As the year progresses, they will make observations and collect data on the health of their ecosystem making modifications when the biotic and abiotic factors are out of balance periodically presenting their findings and modifications.

The students will also consider the problem of getting their system to Mars and beginning the terraforming process outside of a biodome. They will explore the three Newtonian laws to develop their model of transport.

Engaging Context/Phenomena: In this Unit, students will attempt to answer the question: Terraforming Mars: Is it Possible? A time lapsed video clip from the NASA conceptual Image Lab will be shown of Mars billions of years ago and its transformation to what it is today as determined by the data collected from recent NASA robotic rovers and satellites. The storyline presented to the students in a mission format is as follows:

Good Morning (or afternoon), students. Evidence shows the Earth is running out of space and resources to support the human population. Your mission, should you choose to accept involves researching and constructing a model of one of the ecosystems on Earth and propose a plan to recreate that ecosystem on Mars. Can Mars be terraformed, or are there other methods that could be used for humans to colonize the Red Planet?

Data Integration: Once the vivariums, are constructed the students will collect data from their systems via the use of probe ware and visual observations of the system. They will also analyze data provided from the NASA Mars Exploration Program. Students will evaluate the differences in the data collected by the Mars Exploration program and the data collected by the USGS global ecosystems from their project in the Geosciences and Environmental Change Science Center. Students need to analyze the biome and ecosystem parameters to meet the needs of the animals and plants in their systems.

Differentiation of Instruction: The primary disability within the classrooms at my facility is Emotional Disturbance. Many have secondary disabilities of Autism Spectrum Disabilities, Specific Learning Disabilities, Speech and Language disabilities, and English as a second language with Spanish being their primary mode of communication. Because of the behavioral issues for all of the students an intensive positive behavior support plan is completed for each student. Classroom management is key to the success of failure of a given daily activity or hands-on project or Lab. For the students to participate in hand-on activities, they need to follow strict guidelines and classroom expectations. What this looks like in my classroom is a modified version of CHAMPS combined with Behavior Management through Adventure and the group process. Safety is paramount. Most of the students work hard to follow classroom expectations to earn those hands-on experiences. However, there have been outliers where behaviors are so severe that the class as a whole loses the ability to engage in fun stimulating activities. Here's where the group process takes over. The students' call a group to confront their peer. If the peer's negative behavior continues the student's vote their peer off the island. When the class has earned the activity, that student voted off the island is intercepted during class switch by behavior support staff,

my para-educator or personal care assistant and taken to one of the quiet rooms or reflection room with an alternate assignment. The student can earn his way back on the island by following specific classroom expectations.

A second strategy I use to differentiate instruction with the ES population is different colored pencils or markers. Each student is assigned a specific color of pencil or marker. There are two reasons for this. One, I can see who is participating by the color they write with and two, I can tell who is throwing writing implements for attention.

English as a Second Language students: This is dependent on the level of English acquisition by each individual student. Since most of my ESL students are Spanish speakers, I use a lot of cognates. I'm also lucky in that my para-educator is fluent in Spanish. She has been able to explain concepts to the student in Spanish. I was fortunate enough to secure to grants for new curriculum. The students have the choice of using the online text in Spanish or in English. I encourage them to use the text to speech feature and listen to the text in Spanish and in English. The English text has the glossary in the text in two columns, English on the right and Spanish on the left.

Specific Learning Disabilities: For those who struggle with reading text, I use text to speech, book share or other resources. These students may also be given shorter vocabulary assignments. I'll give them the must know words instead of the whole list for the specific module. I also use alternate print material at different Lexile levels that presents the same content but at a lower reading level. These students will also receive guided notes with page numbers and maybe even the paragraph to guide them to the correct place in the text and minimizes the frustration in finding evidence for their answers.

All of the students may use a calculator for any math calculations. For some students, I make step by step instructions with pictures to help them use different calculator functions then the standard four operations.

Real-life Connection: There are several real-life connections to this lesson. The first is the understanding of Ecology and the biotic and abiotic factors that support life. The Earth can only support a finite number of species with the natural resources available. The current human population is approaching 8 billion people. Is there a carrying capacity for humans? Ecosystems are finely tuned and are directly impacted by human interaction. If humans continue on their present course, will we eventually have to consider moving to another planet?

Possible Misconceptions:

STEM Unit Project: Each different ecosystem or biome has the same amount of water. Some students will try to put a large waterfall and pool in a desert habitat.

Principles of Ecology: From teaching this section in the past, I've noticed that many students believe that food chains end with the apex predator. Another possible misconception is how the water cycle works. Since many of the students do not think globally, they have difficulty understanding that when water evaporates it has to go somewhere. They struggle to understand that the earth is essentially a closed system. Evaporated water will come back down to the ground somewhere in the world.

Communities, Biomes, Ecosystems: In this module some possible misconceptions include the idea that climax communities do not change. Students struggle with the concept of a never-ending cycle. Many students use weather and climate synonymously. They also believe that deserts are always hot. Introducing the concept of high deserts that can get extremely cold usually brings on quite a debate.

Population Ecology: Populations can increase indefinitely. The students do not understand carrying capacity. They also believe humans do not have the same needs as other organisms to survive.

Biodiversity and Conservation: When an ecosystem is disturbed by human intervention, the animals and plants will all die.

Force and Motion: Many students struggle to understand force, motion, and energy. A common preconception is that distance and displacement are the same. Another, the height of a distance time graph is its slope. As far as force is concerned, students may think that if there is no motion there is no force acting on the object/s. They also may think that force and momentum is interchangeable. Students may also think mechanical advantage and efficiency are the same as well as energy can be converted into something other than a different form of energy.

Lesson Procedure:

5E Model STEM Unit Project	5E Objectives
Engage: **Terraforming Mars: Is**	**Note: The STEM Unit project is designed to be completed interspersed with the four module lessons in Life Science and 1 module Physical Science. There will be notes in the procedure to direct you to each new phase as students gain new or deeper understanding of the biotic**

It Possible?	**and abiotic characteristics necessary to support life as well as the physics necessary to get people to Mars.** **Procedure:** In this Performance Task: The night before Unit begins the teacher places the phenomena question, "Terraforming Mars: Is it Possible?" on the Driving Question Bulletin Board. Teacher prepares "Mission Folders" for each student with mission storyline, performance task, job descriptions, rubrics for evaluation. Groups of 4 students are color coded. Folders for each class are stored milk crates for easy access. Before each class begins the teacher places the folder and a pack of sticky notes on the pods of worktables. As students enter the classroom they are directed to their assigned group. Teacher shows time-lapsed video clip from NASA Conceptual Image Lab on what Mars looked like billions of years ago and how it transformed into the planet it is today at https://svs.gsfc.nasa.gov/20201 Teacher presents storyline for the question: Terraforming Mars: Is It Possible? Teacher tells students, "NASA is planning on sending humans to Mars. What things must the space agency bring to the Red Planet or make there in order to support a colony of astronauts?" Teacher gives think time to the students to collaborate with their teammates, look through their folders, write ideas on their sticky notes, and put their sticky notes on the Driving Question Board. Students and Teacher discuss the feasibility of terraforming Mars or other ideas the students might have for humans to exist on Mars. Teacher plays video clip of Neil deGrasse Tyson explaining terraforming up to the point where he states the amount of CO_2 on the planet. Teacher asks What is carbon dioxide? What are three facts about the gas? Teacher hands out article and GIST graphic organizer: *The Perseverance Rover spilt CO_2 on Mars to make breathable air* (Grossman, 2021) Students fill in the Title of the article on the GIST go.

	Step 1: Students preview the article looking at headings, subheadings, and graphic elements. Step 2: Compile a list of words, phrases and key vocabulary Step 3: Students read the text and answer these questions while reading: • What is the MOXIE instrument and what is its job? • In what way is MOXIE like "an electrical tree," according to Michael Hecht? • Where is most of the oxygen on Mars found? • How did MOXIE get to Mars and when did it arrive? • How successful was the first MOXIE test on Mars? What powered it? At full production, how much of its product can MOXIE make? • MOXIE is a small device. What is the primary goal of a full-scale version? For instance, what do NASA scientists see as the most important need for its product gas? Step 4: Students summarize the text in exactly 20 words. Teacher: Play the rest of Tyson's Star Talk. After watching the rest of the clip, have the students do some research on traveling to the Red Planet. Student can use *Science News for Students* as a resource on NASA's planned missions for human exploration of Mars. Based on what you learn, list the pros and cons of being part of such a mission. Identify how force and motion will affect the success of the mission. If given a chance, would you rather take part as part of the ground crew or part of the space crew? Explain your decision. Transition to Explore: Play from 50 seconds through 2 minutes 47 seconds of Mars Season1

	Episode 1 Novo Mundo. **Modifications:** Students may not know what terraforming is. Teacher may wish to group students with intellectual disabilities or ESL students in groups with peers who would be good at mentoring. In emotional support classrooms, teacher needs to be cognizant of the behavior needs of students and carefully group students to minimize negative behaviors such as intimidation and bullying. **Standards Addressed:** HS-ETS1-1; ELA: *WHST.9-12.7* **Formative/Summative Assessments** *KW of a KWL chart exit ticket to see where the students are in their thinking.* **Resources** 10 colored pencils and dry erase markers with key for each student , Dry erase erasers 1 for each pod of tables, Teacher computer, Projector, Sticky notes (one pack per table), 2' x 3' Whiteboards 1 for each pod of tables, Mission folders 4 for each pod; each pod a different color, Mission storyline, Performance project rubric, Student computers, KW exit tickets, Student computers, Milk crate (1 for each class with each class being a different color)
Explore: **Characteristics of Life** **Mars versus Earth**	**Procedure:** Teacher will collect 10 living and non-living items and place them in brown bags. Teacher will show each item to the students and ask is the item living or non-living. Students answer. Teacher asks, "How do you know?" Have students collaborate in their groups and list evidence for living or non-living on their white board in their specified color. Detailed instructions for the activity are found at https://drive.google.com/drive/folders/1evy1L2ARmj_0gpBsGvtAbvDxN8hf7F5O?usp=sharing Teacher will hand out the Activity 2: Part A: If you went to Mars beginning on page 38 of the Mars activities pdf found at: https://mars.nasa.gov/classroom/pdfs/MSIP-MarsActivities.pdf To assist students in completing the table on page 39, the t*eacher will show the slide show from* https://mars.nasa.gov/imagine/students/ and explore what it will take to live on Mars. This interactive explains the Martian resources and environmental constraints as well as some of the

	characteristics for life. Part B: Teacher will walk the students through the procedure. Students will explore soil mixtures to determine if life is present. Students are not given the procedure. They are working on following verbal instructions and honing their observation skills. Once students have observed their samples. Discuss which samples the students thought were living and why? At the end of this activity, move to the engage of the Principles of Ecology Section and work through the end of Module 2 Communities biomes and ecosystems. Once they complete these two modules, they will be ready to explore and decide as a team which ecosystem they would like to model. Concurrently the English Teacher will be working on APA citations and students writing their biographies for their role on their teams and then revising them to make a biography slide for their presentations. The math teachers will be teaching students how to make perspective drawings with isometric dot paper, measuring in metric, and calculating area and volume so they will be prepared to purchase materials for the build phase in the Elaborate section. The business teacher will have each student group come up with a business name and create a logo for their business. Teacher will have the students learn how to create a budget and prepare a spreadsheet adding in appropriate debits and credits and calculate payroll costs. In Computer Technology, the teacher will work with the students on creating slide presentations and how to integrate the slides created in the other disciplines to make a cohesive presentation. Computer technology teacher will also work with different platforms for presentation and discuss the difference in using those platforms. Example: Prezi versus tradition slide show. **Modifications** *ESL students may need to have vocabulary pre-taught.* **Standards Addressed** HS-LS4-5, HS-ETS1-3, *MP.2, MP.4, HSN-Q.A., HSN-Q.A.2, HSN-Q.A.3, HSS-ID.A.1, HSS-IC.A.1, HSS-IC.B.6, RST.9-10.8, RST.11-12.1, RST.11-12.7, RST.11-12.8, WHST.9-12.2, WHST.9-12.5, WHST.9-12.7 Standards include what will be addressed by the other teachers as the students prepare for the Evaluate part of this performance task.* **Formative/Summative Assessments** Exit ticket: have students list 5 of the 7 characteristics of life.

	Resources *Enough copies for each student in class of If you went to Mars activity student pages found at* https://mars.nasa.gov/classroom/pdfs/MSIP-MarsActivities.pdf on pages 38, 39, 43 and 44 sand or sandy soil sample, three glass vials, baby food jars, or beakers for soil per group, sugar- 5 ml (sugar will be added to all soil samples), instant active dry yeast- 5 ml added to 50 ml of soil, Alka-Seltzer tablets crushed- 1 tablet added to 50 ml of soil, hot water - enough to cover the top of the soil in all jars (not hot enough to kill the yeast!), cups for distributing the water, magnifying lens, pencils, teacher computer, projector. 10 samples of living and nonliving organisms. One whiteboard per table group. Colored dry erase markers, dry erasers1 per table, copies of worksheets for each student.
Explain	**Procedure:** Teacher shows video clips on build methods for students that explain the safety techniques, reasons for specific materials, materials appropriate for different habitats. Youtube has several good videos to choose from depending on the experience level of students and the materials and tools available for use.Total chaos uses the fewest materials and technical equipment such as soldering irons, foam saws etc. https://www.youtube.com/watch?v=C49FDaxI5PQ This is another video with more detail and minimum tools with more safety tips embedded. https://www.youtube.com/watch?v=ekftaXc5E5g The next two video clips give good details but use more technical equipment that may not be in every classroom. These tools are more difficult to use and less safe if safety is a big concern with your population of students. Foam And Lizards: https://www.youtube.com/watch?v=kHWG8243Q3s The second videographer has his in three parts: https://www.youtube.com/watch?v=TCTfdcbwAco ; https://www.youtube.com/watch?v=n5p9NDXscF8 https://www.youtube.com/watch?v=0i289PArFLU Note: all four videographers have additional videos with good hints and tips on building techniques and steps. Following watching the video clip, Students will discuss with their group mates how they would like to build their model. They begin drawing their plans and taking their measurements. Students will decide which aquarium will best fit their needs, what kind of ecosystem they want to build and begin researching. Each student should be assigned a particular section to research based on their jobs as assigned for their businesses. Example: The zoologist will research animals that can be kept in

	vivariums compatible with the ecosystem chosen. (two of the animals chosen must be isopods and springtails to maintain the health of the system). The botanist researches plants. Accountant/project manager and Engineer research and develop the blue print with measurements and develop the budget for the project. All students collaborate on the design and final print given to the teacher for approval. Students take notes and cite research for their particular area. Students write their portion of the proposal. (this can be completed over multiple days depending on the level of the students and the length of the class?) Teacher during the research phase moves randomly around the classroom monitoring student activity, asking questions, reminding students to keep on task. If there is a para-educator in the classroom the paraeducator can monitor students on Hapara, Lanschool or other system monitoring. They can also move around the classroom redirecting students as necessary. As students are researching, they create the slides that will be integrated into the final presentation. **Modifications** The first two video choices are better for use in intensive emotional support classrooms or with students who have multiple or physical impairments that effect coordination. They are more forgiving in the techniques demonstrated. Note: my class sizes are a maximum of 10 students unless our sister facilities also reach maximum capacity. At that point the maximum size of each classroom is 12 students. My students also struggle with attendance. It is very rare that the full compliment of students are in school at the same time. My group sizes can be modified to take an average of class attendance per day. **Standards Addressed:** HS-LS2-1, HS-LS2-2, HS-LS2-6, HS-LS2-8, HS-LS4-5, HS-LS4-6, HS-ESS2-4, HS-ETS1-1, HS-ETS1-3, *MP.2, MP.4, HSN-Q.A.1, HSN-Q.A.2, HSN-Q.A.3, RST.9-10.8, RST.11-12.1, RST.11-12.7, RST.11-12.8, WHST.9-12.2, WHST.9-12.5, WHST.9-12.7* **Formative/Summative Assessments:** Teacher uses rubric to assess and approve student proposals and designs. Use rubric on shared drive: https://drive.google.com/drive/folders/1evy1L2ARmj_0gpBsGvtAbvDxN8hf7F5O?usp=sharing Alternate rubric on shared drive: this is modified for the use in intensive emotional support classrooms using trauma based strategies to improve student engagement.

	Resources: Student laptops, paper for notetaking or google doc, large sheets of graph paper for blue prints, teacher laptop, projector, Youtube videos as in procedure section. Pencils, pens, whiteboards on each table for collaboration, colored dry erase marker color coded to student.
Elaborate	**Procedure:** Students begin the build **Modifications** *(What student needs must be addressed? How can you make each experience accessible for ALL learners?)* **Standards Addressed** *(Which standards are being explicitly taught in this section?)* **Formative/Summative Assessments** *(How will you assess in each phase?)* **Resources** *(List all resources and materials used in this part of the lesson.)*
Evaluate *Oral presentation and demonstration of performance task.*	**Procedure:** One week prior to presentations, Teacher will provide rubric to experts for review and field any questions before presentation day. Experts will arrive at predetermined time before first classes presentation. When students arrive in class, they will greet the panel of experts. Students will gather their materials needed for their presentation. If student computers can be linked to the projection system, students may use one of their computers to present. If not, the students will provide the teacher with a flash drive containing their material or share their google slides for presentation. Students will present and demonstrate their models to the panel. Once their presentation is concluded the question phase will ensue. Experts and teacher will ask pertinent questions to the students about their choices and understanding of the parameters and environmental constraints. Students will be provided with feedback and suggestions to improve their models. **Modifications:** Some students may have difficulty with public speaking, especially to strangers.

	Standards Addressed: HS-LS2-1, HS-LS2-2, HS-LS2-6, HS-ETS1-1, HS-ETS1-3 **Formative/Summative Assessments** Students will be evaluated by a panel of community experts in the fields of engineering, biology, botany, business as well as their teacher through the use of an explicit rubric attached at https://drive.google.com/drive/folders/1evy1L2ARmj_0gpBsGvtAbvDxN8hf7F5O?usp=sharing They will also receive positive feedback on what they did well and suggestions for improvement as they begin the data collection and sustainability phase of the performance task. **Resources** *Community experts willing to volunteer their time to evaluate student projects, enough copies of rubric to give one to each expert and the teacher to complete for each groups project. Blue pens, computer connected to projector, student slide presentation on flash drive, student working models and completed vivariums, water for community experts, note pads for each expert to take notes on presentation.*
5E Model **Force, Motion, and Energy**	**5E Objectives**
Engage *In this module the students will seek to answer the question: What do we need to know about force, motion and energy to get to Mars?*	**Note:** This module is composed of four phases. The first phase launches the Module and gives the phenomena question for students to understand and describe the principles of motion. They will explore velocity, momentum and acceleration. The second phase explores the forces action on objects to create motion in accordance with Newton's three laws of motion. The third phase explores the flow of energy in a mechanical system and explores the concept of conservation of energy. **Procedure:** **Pre-Assessment Simplified Force Concept Inventory:** Teacher explains that the students will be completing an inventory to see what they understand about force and motion. Explain that they will receive 30 points whether they are correct or incorrect. If they just guess they will only receive 15 points for at least attempting the inventory. Sleeping and refusing will earn a 0%. Explain that for those who really try, read each question, and

	attempt to find the correct answer will receive a special treat. Those who just guess will not receive the special treat and have an alternate assignment to complete on the day of the treat. Students who need assistance with reading the questions can request that adaptation. Students may use objects in the room to visualize what is happening. Teacher hands out inventory and pencils. Teacher, Para, BSA and PCA wander around room reminding those who are guessing of the expectations and incentive. **Phase one: Teacher has students log on to Chromebooks and go to https://phet.colorado.edu/en/simulations/moving-man Allow the students to freely explore the sim for 10 minutes before working through the lesson plan for *The Moving Man* (Loblein, 2021, pp. 5-27)** **Phase Two: Primary Source Starter: The Crumpled Glider** T: Show video clip *Being the Wright Brothers* 2 minutes 30 seconds https://www.youtube.com/watch?v=6NVqB-WK0yY T: State to students the objective of understanding the process of analyzing primary resources, and introduce the concept of primary resources (project slide of primary resource) and a choice of one of the two graphic organizers See think Wonder or Observe Reflect Question. Hand out graphic organizers and pencils. Have students put names on their papers and guide them to the see or observe columns on their papers. Reiterate the importance of not working ahead. (5 minutes) S: choose 1 graphic organizer; put name on paper T: Give students the guiding question: What is the price of success? How does the concept of force apply to aeronautics or flight? Project slide of the crumpled glider to the students and pass out a copy of the photograph to each student. Have students observe the phot for 2 minutes without writing anything down. Ask What do you see? What details stand out? What do you notice first? What people and objects are shown? How are they arranged? What is the physical setting? What if any words do you see? What other details do you see? Remind them to not write anything at this point just observe deeply. S: observe photograph. (2 minutes)

	T: After 2 minutes, have the students write their observations. Remind them to only write what they see, not their analysis. Give two minutes. S: Writes observations (2 minutes) T: Have students complete a think pair share with a partner. Have one person per group share their observations with the class. (2 minutes per group) T: Have students move to the think or reflect column on their GO. Encourage students to generate and test hypothesis about the crumpled glider photo. Use the crumpled glider for this section. Why do they think the image was made? What's happening in the image? What happened a minute before the picture was taken? What happened a minute after the picture was taken? When do you think the image was made? Who do you think was the audience for this image? What tools were used to create this? What can you learn from examining this image? What's missing from this image? If someone made this today, what would be different? What would be the same? S: Students fill in the think or reflect column on the GO (2 minutes) S: Repeat the procedure with the Kitty Hawk #30 and First Flight Photos. Compare and contrast the three photos placing them in order chronologically. T&S Discuss the think/reflect column as a class. Speculate why Wilbur and Orville persisted in spite of Otto Lilienthal's death and their multiple failures to produce a flying machine and financial difficulties. T: Guide students to the last column. Have students ask 3 questions under the topic, What do you wonder about? Who? What? When? Where? Why? and How? S: Write 3 questions they wonder about. T: Collect GO. Hand out exit ticket. S: write one force that caused the glider to crumple. **Phase Three:** Students collaboratively define evidence and inference. Students consider different meanings of the word energy.and learn what energy means in science. Use lesson plan from *Mars*

	Mission Ops Manual pp. 9 – 19. (Rutzke et. al., 2018) **Modifications ESL** use cognates and pre-teach vocabulary *Emerging level: Use pointing and gesturing to pictures and concrete examples.* **Standards Addressed** HS-PS1-3, HS-PS2-1, HS-PS2-2, HS-PS2-4, HS-PS3-2, HS-PS3-3 **Formative/Summative Assessments** **Exit tickets with multiple choice question addressing concepts from daily work with similar wording to the SFCI.** **Phase one: Name that motion simulation from the Physics Classroom** **Resources** *one copy of SFCI for every student. PDF document shared with students who wish to complete online. Copies of the materials from Loblein's activity for The Moving Man simulation, Graphic organizers, Photos of the crumpled glider, and Wright's airplane. Exit tickets*
Explore *Plan for students to engage in hands-on activities that are designed to facilitate conceptual change.*	**Procedure:** **Phase One:** Show Introduction to Newton's First Law of Motion from Classroom Combo: Rolling with Newton's Laws. The combo allows students to see how mass interacts with acceleration and force. Newton's laws apply to launching a rocket and also traveling to Mars. A key concept students learn is impulse, or a force applied for a specific time period. It might result in a change in velocity. It will help students apply their knowledge to develop a model for going to Mars and then the return trip. Use the activity for the Newton Car (Miller, pp.58 – 62, 2012) and videos at the following URL: https://www.nasa.gov/stem-ed-resources/rolling-with-newtons-laws.html (May, 2021)

	Phase Two: Rocket Activity: POP Can Hero Engine (Miller, pp. 42 – 47, 2012) **Phase Three: Mission to Mars Mission 2: Exploring energy, (May, pp. 20 – 23, 2021)** **Guiding questions: How does the use and energy in our classroom compare to outer space? What is the difference between the meaning of energy in everyday use and in science?** Play youtube video https://SGP6YOPnhe4 Hand out student spec sheet Energy in Science. After completing Think pair share discussions have students play the PBS Energy game at: https://www.pbs.org/wgbh/nova/labs/lab/energy/1/2/ (Miller, 2012) **Modifications: Lower students, Provide students with check list to mark as they complete each step and have teacher initial before moving to next step. Have car premade for students instead of having them build them.** **Standards Addressed:** HS-PS2-1, HS-PS2-2, HS-PS2-4 **Formative/Summative Assessments Exit tickets for each section with key concept.** **Resources:** copies of Newton car student worksheets, pencils, projector, computer, videos, -1 1 X 3 X 8 in. board* -3 1/4" diameter by 2 1/2" long dowels (or wood screws) -Wood glue, rubber bands, string or thread, masking tape, straws, weight set, scissors, triple beam balance, rulers, plastic bottle or film canister, 4 pop cans for each student, water, plastic dish pans, string, large nails, copper float, tubing, Bunsen burner, thumb screw, string, fire blanket and extinguisher, goggles, aprons, student spec sheet mission 1 and 2, Chromebooks
Explain *Facilitate opportunities for students to explain their understanding of*	**Procedure:** **Phase One:** PhET simulation Force and Motion Activity 1 and 2 (Loblein, pp. 69 – 90, 2021) Have students spend 10 minutes exploring the PhET on their Chromebooks. Hand out Student directions Forces and Motion activity (Loblein, 2021)

concepts and processes and make sense of new concepts.	Have students complete the simulation lab. Go through clicker questions together. Have students Think Pair Share for each question. Then decide as a group the correct answer. **Phase Two: 321 Puff and Heavy lifting activity (Miller, pp. 48 – 57, 2012)** Have students complete each activity. Give them a graphic organizer following the engineering cycle. Have students complete each step and get signed off by teacher or para before moving to next section of the lab. Teacher asks probing questions to have students verbalize why they are making their rockets in that manner. **Phase Three: Mission 3 Energy Flows Model for running a car (May, pp. 29 – 31, 2021)** Teacher asks the students if having music, games, and ways of communicating and staying up to date with Earth would be important? Ask how someone on Mars might charge their personal devices? Think Pair Share and discuss as a group. Launch into Teach Engineering Lab to build a wind turbine. Follow the directions at the URL: https://www.teachengineering.org/activities/view/cub_energy2_lesson07_activity2 **Complete Data Analysis Lab Solar Power: When and Where is Best? (Regents of the University of Colorado, 2012)** Follow the directions at the following URL**:** **https://www.teachengineering.org/lessons/view/cub_solarenergy_lesson01** Teacher shows power point. Students and teacher work through Data integration worksheet together. **Modifications** Create a graphic organizer with all tables for data entry for lower functioning students with guiding questions that have two choice to describe the force and motion. **Standards Addressed:** HS-PS1-3, HS-PS2-1, HS-PS2-2, HS-PS2-4, HS-PS3-2, HS-PS3-3 **Formative/Summative Assessments** *Exit tickets with key take aways.* **Resources** *student materials from Force and Motion Activity 1 and 2, student materials for Rocket educator guide, different kinds of colored paper, markers, colored pencils, pencils, tape, scissors, balloons, glue, straws, binder clips, paper clips, fishing line, sandwich bags, 3 oz paper cups,*

	balloon hand pumps, wooden spring clothespins, wind turbine worksheet for each student, solar power energy estimation worksheet. • small DC toy motor; available online • 2 pieces of thin electrical wire with alligator clips, each about 50 cm or 20 inches long • rubber band • stiff ruler • cylindrical-shaped cork, at least 2 cm or ¾ inch in diameter; alternative to cork: Styrofoam ball • 4 paperclips • scotch tape • scissors • 4 pieces of cardboard, each 3 x 5 cm • (optional) safety goggles or glasses • Wind Turbine Worksheet, one per team For the entire class to share: • 1 or 2 small electric fans or hair dryers • DC voltmeter; available online
Elaborate *Provide applications of concepts and opportunities to challenge and deep ideas; build on or extend understanding and skills.*	**Procedure:** **Phase One: Rocket Activity Rocket Races (Miller, pp. 63 – 69, 2012)** Follow directions in Nasa Rocket Educator Guide **Phase Two: Rocket Activity Foam Rocket or Pop Rocket (Miller, pp. 70 – 92, 2012)**depending on class ability. Low functioning does pop rocket, higher foam rocket. Teacher builds pop rocket launcher. Follow directions in NASA Rocket Educator Guide.

	Phase Three:Solar Water Heat it Up Activity (Regents of University of Colorado, 2012) Using the directions at the following URL: https://www.teachengineering.org/activities/view/cub_solarenergy_lesson01_activity1 Students design, build and test their own solar water heater. Complete Mission 4: Engineering an energy solution for personal devices. Use microbits and small solar panels oto come up with a solution. Watch TED video *Your kids might live on Mars* Follow plans from Mission to Mars (May, pp. 32 – 36, 2021). **Modifications** To challenge students more, provide additional options for tubing, including 1/2" PVC and ¼" clear tubing. These additional options help students learn about trade-offs in flow rate of water through the device and the amount of time the water is exposed to solar energy for heating. Keep in mind that if students use varied tubing sizes, you need multiple hosing adapters in order to connect the hosing to the solar water heaters and garden fountain pumps.(Regents of University of Colorado, 2012) **Standards Addressed** HS-PS1-3, HS-PS2-1, HS-PS2-2, HS-PS2-4, HS-PS3-2, HS-PS3-3 **Formative/Summative Assessments** *Exit tickets with key take aways from days lesson.* **Resources** *Materials budget sheet each student, efficiency analysis sheet, final budget and efficiency worksheet, water pump, plastic hose, pvc pipe, dishwasher hose, brass fittings, multimeter, Mindstorms, strawbees, CD blanks, Student data collection sheet for rocket racers, balsa wood, card board, paints, markers, straws, balloons, rocket race design sheet, keys to gym, tape, glue, wheel collets, dowel rods, student materials for pop rocket and foam rocket, aquarium airline hose and connectors, tape measure, tangent guide, calculator, duct tape,foam water heater insulation tubing, rubber bands, meter stick, tacks,*
Evaluate	**Procedure:** Teacher explains that the students will be completing the *Simplified Force Concept Inventory* to see what they have learned about force and motion. Explain that they will receive 30 points whether they are correct or incorrect. Their assessment grade will be calculated on the percent improvement from the Pre-Instruction *Simplified Force Concept Inventory*. If they just guess

Assess students knowledge, skills and abilities.	they will only receive 15 points for at least attempting the inventory. Sleeping and refusing will earn a 0%. Explain that for those who really try, read each question, and attempt to find the correct answer will receive a special treat. Those who just guess will not receive the special treat and have an alternate assignment to complete on the day of the treat. Students who need assistance with reading the questions can request that adaptation. Students may use objects in the room to visualize what is happening. Teacher hands out inventory and pencils. Teacher, Para, BSA and PCA wander around room reminding those who are guessing of the expectations and incentive. **Modifications:** Readers for students who need assistance reading questions. Manipulatives for students needing a more visual reference. **Standards Addressed** HS-PS2-1, HS-PS2-2, HS-PS2-4, **Formative/Summative Assessments *The Simplified Force Concept Inventory* (Jackson, 2009)** **Resources** *One SFCI per student, pencils,*
5E Model **Principles of Ecology**	**5E Objectives**
<u>Engage</u> *In this module the students will seek to answer the question: Why would this bird build a nest in a tree with thorns?*	**Note:** This module is composed of four phases. The first phase launches the Module and gives the phenomena question for students to understand the principles of ecology. The second phase explores organisms and their relationships with a focus question of: “What relationships among organisms might exist with a bird nest built in a thorny tree?” The third phase explores the flow of energy in an ecosystem. The focus question is: “How does energy flow through an ecosystem?” The fourth and last phase of this module explores the cycling of Matter. The focus question is “How does matter flow through and ecosystem?” The second through fourth phase support the first encounter the phenomena in phase one. **Procedure:** **Phase one:** Teacher pre-lesson: posts the new encounter the phenomena question on the guiding questions board: “Why would this bird build a nest in a tree with thorns?” Students enter classroom

	and take assigned seats with pod members for this Unit. Teacher shows video clip about weaver birds at the following link: https://www.youtube.com/watch?v=pvGpXnu7AxI Students collaborate together and write their ideas for what they think will be answered in this module on sticky notes and post underneath the guiding question on the Driving Question Board. As students collaborate, they put their questions, ideas and thinking on the table pod whiteboard in their representative colors. Give students Claim, Evidence, Reasoning print or online version depending on students' comfort in using technology. An example is provided on the shared drive:https://drive.google.com/drive/folders/1evy1L2ARmj_0gpBsGvtAbvDxN8hf7F5O?usp=sharing Students write their claim for the driving question for this module. **Phase Two:** Teacher prelesson: posts the new focus question on the driving question board: "What relationships of organisms might exist with a bird nest build in a thorny tree. Teacher can show an enlarged picture of the students' sticky note questions from the Encounter the Phenomena Question for this Module. Have the students go to the driving question board and determine which questions they think will be answered in this phase. **Phase Three:** Teacher pre-lesson: posts the new encounter the phenomena question on the guiding questions board: "How does energy flow through an ecosystem?" Students enter classroom and take assigned seats with pod members for this Unit. Teacher hands out T-chart for students and also has T-chart on whiteboard with the headings: biotic factors and abiotic factors. Students fill in T-chart as they watch the following video clip. Teacher shows video clip about phytoplankton abundance in Svalbard, Norway at the following link: https://www.youtube.com/watch?v=ko96I_e72OQ Start the clip at 22:09 stop at 27:09 Think, Pair, Share: students compare their T-charts with shoulder partner. Then share their collection of biotic and abiotic factors on the classroom whiteboard. Students collaborate together and write their ideas for what they think will be answered in this module on sticky notes and post underneath the guiding question on the Driving Question Board.

	As students collaborate, they put their questions, ideas and thinking on the table pod whiteboard in their representative colors. Give students Claim, Evidence, Reasoning print or online version depending on students' comfort in using technology. An example is provided on the shared drive:https://drive.google.com/drive/folders/1evy1L2ARmj_0gpBsGvtAbvDxN8hf7F5O?usp=sharing Students write their claim for the driving question for this module. **Phase four:** **Modifications ESL** use cognates and pre-teach vocabulary *Emerging level: Use pointing and gesturing to pictures and concrete examples.* **Standards Addressed** HS-LS2-2. **Formative/Summative Assessments** *(How will you assess in each phase?)* **Resources** *one copy of claim evidence reasoning graphic for every student. PDF document shared with students who wish to complete online.*
Explore *Plan for students to engage in hands-on activities that are designed to facilitate conceptual change.*	**Procedure:** **Phase One:** Teacher will prepare one transparent container with a piece of overripe fruit for each table pod times the number of classes. Students will write observations on the observation graphic in their mission folders. Once initial observations are made the teacher will add about 5 fruit flies to each container and states, "I'm adding a POPULATION of fruit flies to this system." Students will write observations of the containers. Each day when students arrive, they will write observations. This continues for 1 week. At the end of the week, students will write a summary paragraph analyzing their observations and any changes that occurred. In this paragraph they need to discuss

	whether or not this would be a reasonable way to study a real population. **Phase Two:** Have students design Quadrats to explore habitat size and species diversity in a local natural area. Teacher tells students their table groups need to design a simple tool to complete an investigation of a local natural habitat that has an area of 1 square meter. Materials on the materials table consist of ½ "PVC pipe, 90 degree elbow connectors, vinyl coated steel cable, thimbles, clamps, 3/8" dowels, nylon parachute cord. The tool needs to be lightweight and easy to carry in a daypack. After students complete their quadrats take students to predetermined area within walking distance from the school or plan a field trip to a local state park or natural area. Have student groups work together to collect random samples of the area. Students have notebooks to log the number of different plant and animal species found in the area as well as count how many of each type of plant or small animals that fit in quadrat area. Students will also spend 15 minutes observing the area writing any observations of larger plants or animals that don't fit in the quadrat but are within visual distance of the designated area. Students may use cameras or cell phones to take pictures of different plant and animal species in area for later identification. Teacher provides students with plant and animal taxonomy guides from the local game, park and fish or ag office. Teacher guides students in the collection of data by asking, "What types of organisms have you observed?" and "What are some interesting characteristics of these organisms?" Have students discover the biosphere and construct a definition. **Phase Three:** Algae Balls: Investigating Photosynthesis teacher and student materials can be found at: https://www.massbioed.org/educators/curriculum/16-investigating-photosynthesis-with-algae-balls and also on shared google drive: https://drive.google.com/drive/folders/1evy1L2ARmj_0gpBsGvtAbvDxN8hf7F5O?usp=sharing **Phase Four:** **Modifications** *(What student needs must be addressed? How can you make each experience accessible for ALL learners?)* **Standards Addressed:** HS-LS1-5, HS-LS1-7 **Formative/Summative Assessments**

	Resources: **Phase one:** Drosophila melanogaster, over ripe piece of fruit, glass or clear plastic container, Observations graphic organizer; **Phase two:** ½ " pvc thin wall pipe, vinyl coated cable, 90 degree pvc elbow connectors, thimbles, clamps, nylon parachute cord, 3/8" wooden dowels, meter sticks, tape measures, rulers, pencils, student lab observation notebooks, permission slips for outing, cell phones or cameras for taking pictures of plants and animals, local taxonomy guides. **Phase three:** Copies of student materials found in shared drive for each student. 75 1 mL graduated transfer pipet • 45 small beakers or disposable plastic cups • 15 tea strainers (or 20cm x 20cm plastic screen) • 90 2.0 mL (or larger) tubes • 15 plastic spoons • 15 microcentrifuge tube racks • Lamp (15 watt spiral fluorescent bulb will work) • Sodium alginate • Calcium chloride • Baking soda (sodium bicarbonate) • Cresol red • Thymol blue • Ethanol • Freshly boiled distilled water (1500 mL) • Concentrated liquid freshwater algae suspension (Chlorella or Chlamydomonas) Optional Supplies/equipment • Platform shaker • Color Standards • 9 X 5 mL glass vials with lids (for the color standards) • Boric acid • Sodium tetraborate decahydrate or sodium borate (Borax) • dH2O Student groups need: 6 graduated transfer pipettes • 2 small beakers or paper cups • Tea strainer or mesh filter • Plastic spoon • 6 2.0 mL microcentrifuge tubes • Sodium alginate • Calcium chloride • 1X hydrocarbonate indicator solution (orange) • dH2O • Permanent marker
Explain *Facilitate opportunities for students to explain their understanding of concepts and processes and make sense of new concepts.*	**Procedure:** **Phase One:** **Phase Two:** Teacher set up teacher account at https://ecolearn.gse.harvard.edu/ to be able to use ecoMUVE, ecoMOBILE, ecoXPT, and ecoMOD software. The software still works on Firefox browser platform. Use the e-teachers guide to have students explore organisms and their relationships. Students use the student version of the software to simulate organism interaction. Students collect data and analyze from the virtual environment. **Phase Three:** Data Analysis of phytoplankton in Svalbard. Teacher hands out data analysis activity found: https://drive.google.com/drive/folders/1evy1L2ARmj_0gpBsGvtAbvDxN8hf7F5O?

	usp=sharing **Phase Four:** **Modifications** *(What student needs must be addressed? How can you make each experience accessible for ALL learners?)* **Standards Addressed** *(Which standards are being explicitly taught in this section?)* **Formative/Summative Assessments** *(How will you assess in each phase?)* **Resources** *(List all resources and materials used in this part of the lesson.)*
Elaborate *Provide applications of concepts and opportunities to challenge and deep ideas; build on or extend understanding and skills.*	**Procedure:** **Phase Two:** Show video clip from https://ecolearn.gse.harvard.edu/ Have students answer the following questions: Why are there so many living organisms on the Earth, and so many different species? How do the characteristics of abiotic factors influence the organisms living in that area? Optional: Have the students complete the virtual ecology lab at: https://www.learner.org/series/the-habitable-planet-a-systems-approach-to-environmental-science/ecology-lab/ **Modifications** *(What student needs must be addressed? How can you make each experience accessible for ALL learners?)* **Standards Addressed** *(Which standards are being explicitly taught in this section?)* **Formative/Summative Assessments** *(How will you assess in each phase?)* **Resources** *(List all resources and materials used in this part of the lesson.)*
	Procedure: *(What happens during this phase? What is the teacher doing? What is the student doing?)*

Evaluate *Assess students knowledge, skills and abilities.*	**Modifications** *(What student needs must be addressed? How can you make each experience accessible for ALL learners?)* **Standards Addressed** *(Which standards are being explicitly taught in this section?)* **Formative/Summative Assessments** *(How will you assess in each phase?)* **Resources** *(List all resources and materials used in this part of the lesson.)*
5E Model **Communities, Biomes, Ecosystems**	**5E Objectives**
Engage *Phenomena Question: Why would you grow a garden in a city?*	**Procedure:** *(What happens during this phase? What is the teacher doing? What is the student doing?)* **Modifications** *(What student needs must be addressed? How can you make each experience accessible for ALL learners?)* **Standards Addressed** *(Which standards are being explicitly taught in this section?)* **Formative/Summative Assessments** *(How will you assess in each phase?)* **Resources** *(List all resources and materials used in this part of the lesson.)*
Explore *Plan for students to engage in hands-on activities that are designed to facilitate conceptual change.*	**Procedure:** *(What happens during this phase? What is the teacher doing? What is the student doing?)* **Modifications** *(What student needs must be addressed? How can you make each experience accessible for ALL learners?)* **Standards Addressed** *(Which standards are being explicitly taught in this section?)*

	Formative/Summative Assessments *(How will you assess in each phase?)* **Resources** *(List all resources and materials used in this part of the lesson.)*
Explain *Facilitate opportunities for students to explain their understanding of concepts and processes and make sense of new concepts.*	**Procedure:** *(What happens during this phase? What is the teacher doing? What is the student doing?)* **Modifications** *(What student needs must be addressed? How can you make each experience accessible for ALL learners?)* **Standards Addressed** *(Which standards are being explicitly taught in this section?)* **Formative/Summative Assessments** *(How will you assess in each phase?)* **Resources** *(List all resources and materials used in this part of the lesson.)*
Elaborate *Provide applications of concepts and opportunities to challenge and deep ideas; build on or extend understanding and skills.*	**Procedure:** *(What happens during this phase? What is the teacher doing? What is the student doing?)* **Modifications** *(What student needs must be addressed? How can you make each experience accessible for ALL learners?)* **Standards Addressed** *(Which standards are being explicitly taught in this section?)* **Formative/Summative Assessments** *(How will you assess in each phase?)* **Resources** *(List all resources and materials used in this part of the lesson.)*
	Procedure: *(What happens during this phase? What is the teacher doing? What is the student doing?)*

Evaluate *Assess students knowledge, skills and abilities.*	**Modifications** *(What student needs must be addressed? How can you make each experience accessible for ALL learners?)* **Standards Addressed** *(Which standards are being explicitly taught in this section?)* **Formative/Summative Assessments** *(How will you assess in each phase?)* **Resources** *(List all resources and materials used in this part of the lesson.)*
5E Model **Population Ecology**	**5E Objectives**
Engage *Phenomena Question: "Why are bee populations declining?"*	**Procedure:** *(What happens during this phase? What is the teacher doing? What is the student doing?)* **Modifications** *(What student needs must be addressed? How can you make each experience accessible for ALL learners?)* **Standards Addressed** *(Which standards are being explicitly taught in this section?)* **Formative/Summative Assessments** *(How will you assess in each phase?)* **Resources** *(List all resources and materials used in this part of the lesson.)*
Explore *Plan for students to engage in hands-on activities that are designed to facilitate conceptual change.*	**Procedure:** *(What happens during this phase? What is the teacher doing? What is the student doing?)* **Modifications** *(What student needs must be addressed? How can you make each experience accessible for ALL learners?)* **Standards Addressed** *(Which standards are being explicitly taught in this section?)*

	Formative/Summative Assessments *(How will you assess in each phase?)* **Resources** *(List all resources and materials used in this part of the lesson.)*
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Elaborate *Provide applications of concepts and opportunities to challenge and deep ideas; build on or extend understanding and skills.*	**Procedure:** *(What happens during this phase? What is the teacher doing? What is the student doing?)* **Modifications** *(What student needs must be addressed? How can you make each experience accessible for ALL learners?)* **Standards Addressed** *(Which standards are being explicitly taught in this section?)* **Formative/Summative Assessments** *(How will you assess in each phase?)* **Resources** *(List all resources and materials used in this part of the lesson.)*
	Procedure: *(What happens during this phase? What is the teacher doing? What is the student doing?)*

Evaluate *Assess students knowledge, skills and abilities.*	**Modifications** *(What student needs must be addressed? How can you make each experience accessible for ALL learners?)* **Standards Addressed** *(Which standards are being explicitly taught in this section?)* **Formative/Summative Assessments** *(How will you assess in each phase?)* **Resources** *(List all resources and materials used in this part of the lesson.)*
5E Model **Biodiversity and Conservation**	**5E Objectives**
Engage *Phenomena Question: What happens to the Ecosystem if the River is Destroyed?*	**Procedure:** *(What happens during this phase? What is the teacher doing? What is the student doing?)* **Modifications** *(What student needs must be addressed? How can you make each experience accessible for ALL learners?)* **Standards Addressed** *(Which standards are being explicitly taught in this section?)* **Formative/Summative Assessments** *(How will you assess in each phase?)* **Resources** *(List all resources and materials used in this part of the lesson.)*
Explore *Plan for students to engage in hands-on activities that are designed to facilitate conceptual change.*	**Procedure:** *(What happens during this phase? What is the teacher doing? What is the student doing?)* **Modifications** *(What student needs must be addressed? How can you make each experience accessible for ALL learners?)* **Standards Addressed** *(Which standards are being explicitly taught in this section?)*

	Formative/Summative Assessments *(How will you assess in each phase?)* **Resources** *(List all resources and materials used in this part of the lesson.)*
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Teacher Background: Here is the link to a shared folder with resources for the Performance Task and supporting lessons for this unit: https://drive.google.com/drive/folders/1evy1L2ARmj_0gpBsGvtAbvDxN8hf7F5O?usp=sharing

I have included a power point from the initial rendition of this particular unit on the shared drive to show the process and engagement of students. Every class had 100% engagement. Some of the hardest workers and best designs were from special needs students.

References:

Biggs, A., Hagins, W. C., Holliday, W. G., Lundgren, L. V., MacKenzie, A. H., Rogers, W. D., … Kapicka, C. (2020). *Inspire Biology*. New York, United States: McGraw-Hill Education. Pages 20A – 123.

ecolearn. (2019, May 13). Retrieved April 26, 2020, from https://ecolearn.gse.harvard.edu/

Ecosystems. (2020, February 20). Retrieved April 26, 2020, from https://www.learner.org/series/the-habitable-planet-a-systems-approach-to-environmental-science/ecosystems/

Gipson, L. (2016, August 24). *Aeronautics for introductory physics (grades 9-college)*. NASA. https://www.nasa.gov/aeroresearch/resources/k-12/introductory-physics

Grossman, L. (2021, May 24). *The Perseverance rover split CO2 on Mars to make breathable air*. Science News for Students. https://www.sciencenewsforstudents.org/article/nasa-perseverance-rover-mars-oxygen-breathable-air

Jackson, J. (2009). *PhysPort assessments: Simplified force concept inventory*. PhysPort. https://www.physport.org/assessments/assessment.cfm?I=72&A=SFCI

Lederle, C. (2011a, November 15). *Primary source starter: The Wright Brothers' Crumpled glider*. Teaching with the Library of Congress. https://blogs.loc.gov/teachers/2011/11/primary-source-starter-the-wright-brothers%e2%80%99-crumpled-glider-2/

Lentz, M. (2013, November 13). Mars Transition. Retrieved April 23, 2020, from https://svs.gsfc.nasa.gov/20201

Loblein, T. (2021, October 13). *PhET interactive simulations*. PhET. https://phet.colorado.edu/en/contributions/view/3031

Mars Education Program Jet Propulsion Laboratory Arizona State University. (2011, June 6). Mars Activites: Teacher Resources and Classroom Activities. Retrieved April 22, 2020, from https://mars.nasa.gov/classroom/pdfs/MSIP-MarsActivities.pdf

MassBioEd. (2019, June 21). Investigating Photosynthesis with Algae Balls / MassBioEd. Retrieved April 23, 2020, from https://www.massbioed.org/educators/curriculum/16-investigating-photosynthesis-with-algae-balls

May, S. (2021, June 22). *Classroom combo: Rolling with newton's laws*. NASA. https://www.nasa.gov/stem-ed-resources/rolling-with-newtons-laws.html

Miller, D.: (2012, July 30). *Rockets educator guide*. NASA. https://www.nasa.gov/stem-ed-resources/rockets.html

NASA. (2011, June 6). Imagine Mars: Student. Retrieved April 22, 2020, from https://mars.nasa.gov/imagine/students/

Regents of the University of Colorado. (2021, November 23). *Wind power! Designing a wind turbine*. TeachEngineering.Org. https://www.teachengineering.org/activities/view/cub_energy2_lesson07_activity2

Rutzke, C. J., Baxter-Lauffer, H., & Burt, N. (2018). *Physical science—Mars Mission Operations Manual*. NASA. https://www.nasa.gov/sites/default/files/atoms/files/physicalscience-marsmissionopsmanual.pdf

StarTalk. (2019). Terraforming Mars with Neil deGrasse Tyson [Video]. In *YouTube*. https://www.youtube.com/watch?v=7XdkKMhAdnA

The Physics Classroom. (2017, August). *Physics simulation: Name that motion*. The Physics Classroom. https://www.physicsclassroom.com/Physics-Interactives/1-D-Kinematics/Name-That-Motion

Vernet, M. (2019, September 27). Influence of Phytoplankton Advection on the Productivity Along the Atlantic Water Inflow to the Arctic Ocean. Retrieved April 23, 2020, from https://www.frontiersin.org/articles/10.3389/fmars.2019.00583/full