Unit Synopsis

Students are introduced to an anchoring phenomena of a "fifty year old bio bottle." Students create a preliminary design of a Bio Bottle, which will "make visible" what their baseline understanding is of what is needed for life to exist in a contained environment.
Students then begin to identify the key components of an ecosystem- abiotic and biotic factors. Students test a specific abiotic factor and the effect that factor has on bean germination. Students then revise their model of their bio bottle, to include necessary abiotic components.
Focus then turns to the biotic factors of an ecosystem- consumers, producers, and decomposers. Students recognize the importance of all three kinds of organisms in an ecosystem. As students acquire continued understanding of the necessary components of an ecosystem, they again modify their original model of their bio bottle. Students show understanding of the relationship among key components of an ecosystem through formative assessments.
Student attention then turns to producers, and the process in which they attain energy- photosynthesis. Students again return to their bio bottle design and ensure that their bottle will contain enough producers and access to sunlight for photosynthesis to occur.
Photosynthesis on the molecular level is then explored, in addition to the law of conservation of matter.
Students then identify how matter, specifically atoms of key elements, flow from producers to consumers, and throughout an ecosystem. Students also recognize that states of matter change as matter flows through an ecosystem. Students again return to their model of their bio bottle and trace the flow of at least one form of matter through their bottles' ecosystem.
The interactions of all components of an ecosystem are then identified. Predator- prey relationships and over- population are explored. The vital role of bees as pollinators is explored. Students identify that anyone one change in an ecosystem often impacts the entire ecosystem. Students are challenged to identify the components necessary for a healthy ecosystem, as well as identifying factors that may place an ecosystem at risk.The culminating review with final revisions to the students' bio bottles are then completed. Students' culminating challenge is the actual creation of their bio bottle, accompanied by a written defense of why each biotic and biotic factor was included in their final design.
(Note: If this unit occurs at the start of the year, students can continue to evaluate the success of their bio bottle design for the remainder of the year. Successful bio bottles can be kept in the classroom for the following year!

Suggested Time Frame:
40-45 hours

Anchoring Phenomenon/Design Problem:
Design Challenge: Creation of a Bio Bottle

Unit Driving Question:
What are the constraints to make a successful bio bottle?

Culminating Performance Task:
Students use revised models to construct a Bio Bottle

NGSS Performance Expectation(s): (Hyperlinks will bring reader to NGSS Evidence Statements)

- MS-LS1-6. Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms.
  - [Clarification Statement: Emphasis is on tracing movement of matter and flow of energy.]
  - [Assessment Boundary: Assessment does not include the biochemical mechanisms of photosynthesis.]
- MS-LS2-1. Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.
  - [Clarification Statement: Emphasis is on cause and effect relationships between resources and growth of individual organisms and the numbers of organisms in ecosystems during periods of abundant and scarce resources.]
- MS-LS2-2. Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.
  - [Clarification Statement: Emphasis is on predicting consistent patterns of interactions in different ecosystems in terms of the relationships among and between organisms and abiotic components of ecosystems. Examples of types of interactions could include competitive, predatory, and mutually beneficial.]

- MS-LS2-3. Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.
  - [Clarification Statement: Emphasis is on describing the conservation of matter and flow of energy into and out of various ecosystems, and on defining the boundaries of the system.]
  - [Assessment Boundary: Assessment does not include the use of chemical reactions to describe the processes.]

- MS-LS2-4. Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.
  - [Clarification Statement: Emphasis is on recognizing patterns in data and making warranted inferences about changes in populations, and on evaluating empirical evidence supporting arguments about changes to ecosystems.]

- MS-LS2-5. Evaluate competing design solutions for maintaining biodiversity and ecosystem services. *
  - [Clarification Statement: Examples of ecosystem services could include water purification, nutrient recycling, and prevention of soil erosion. Examples of design solution constraints could include scientific, economic, and social considerations.]

- MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

- MS-ETS1-2. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

Three Dimensions that form the Foundation for these NGSS Performance Expectations:

Science & Engineering Practices:	Disciplinary Core Ideas:	Crosscutting Concepts:
Constructing Explanations and Designing Solutions • Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. • Construct an explanation that includes qualitative or quantitative relationships between variables that predict phenomena. **Analyzing and Interpreting Data.** • Analyze and interpret data to provide evidence for phenomena. **Developing and Using Models** • Develop a model to describe phenomena. **Engaging in Argument from Evidence** • Construct an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.	**LS1.C: Organization for Matter and Energy Flow in Organisms** • Plants, algae (including phytoplankton), and many microorganisms use the energy from light to make sugars (food) from carbon dioxide from the atmosphere and water through the process of photosynthesis, which releases oxygen. These sugars can be used immediately or stored for growth or later use. **LS2.A: Interdependent Relationships in Ecosystems** • Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors. • In any ecosystem, organisms and populations with similar requirements for food, water, oxygen, or other resources may compete with each other for limited resources, access to which consequently constrains their growth and reproduction. • Growth of organisms and population increases are limited by access to resources. • Similarly, predatory interactions may reduce the number of organisms or eliminate whole	**Energy and Matter** • Within a natural system, the transfer of energy drives the motion and/or cycling of matter. • The transfer of energy can be tracked as energy flows through a natural system. **Cause and Effect** • Cause and effect relationships may be used to predict phenomena in natural or designed systems. **Patterns** • Patterns can be used to identify cause and effect relationships. **Stability and Change** • Small changes in one part of a system might cause large changes in another part.

• Evaluate competing design solutions based on jointly developed and agreed-upon design criteria. **Asking Questions and Defining Problems** • Define a design problem that can be solved through the development of an object, tool, process or system and includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions.	populations of organisms. Mutually beneficial interactions, in contrast, may become so interdependent that each organism requires the other for survival. Although the species involved in these competitive, predatory, and mutually beneficial interactions vary across ecosystems, the patterns of interactions of organisms with their environments, both living and nonliving, are shared. **LS2.B: Cycle of Matter and Energy Transfer in Ecosystems** • Food webs are models that demonstrate how matter and energy is transferred between producers, consumers, and decomposers as the three groups interact within an ecosystem. Transfers of matter into and out of the physical environment occur at every level. Decomposers recycle nutrients from dead plant or animal matter back to the soil in terrestrial environments or to the water in aquatic environments. The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem. **LS2.C: Ecosystem Dynamics, Functioning, and Resilience** • Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations. • Biodiversity describes the variety of species found in Earth's terrestrial and oceanic ecosystems. The completeness or integrity of an ecosystem's biodiversity is often used as a measure of its health. **LS4.D: Biodiversity and Humans** • Changes in biodiversity can influence humans' resources, such as food, energy, and medicines, as well as ecosystem services that humans rely on—for example,	

	water purification and recycling. *(secondary)* **PS3.D: Energy in Chemical Processes and Everyday Life** ● The chemical reaction by which plants produce complex food molecules (sugars) requires an energy input (i.e., from sunlight) to occur. In this reaction, carbon dioxide and water combine to form carbon-based organic molecules and release oxygen. *(secondary)* **ETS1.A: Defining and Delimiting Engineering Problems** ● The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions. **ETS1.B: Developing Possible Solutions** ● There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem.	

Possible Common Core State Standards Connections:
ELA/Literacy -

- RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts. (MS-LS1-6)(MS-LS2-1)(MS-LS2-2)(MS-LS2-4)(MS-ETS1-1)(MS-ETS1-2)
- RST.6-8.2 Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions. (MS-LS1-6)
- RST.6-8.7 Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). (MS-LS2-1)
- RST.6-8.8 Distinguish among facts, reasoned judgment based on research findings, and speculation in a text. (MS-LS2-5)
- RST.6-8.9 Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic. (MS-ETS1-2)

- RI.8.8 — Trace and evaluate the argument and specific claims in a text, assessing whether the reasoning is sound and the evidence is relevant and sufficient to support the claims. (MS-LS2-4)(MS-LS2-5)
- WHST.6-8.1 — Write arguments to support claims with clear reasons and relevant evidence. (MS-LS2-4)
- WHST.6-8.2 — Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content. (MS-LS1-6) (MS-LS2-2)
- WHST.6-8.8 — Gather relevant information from multiple print and digital sources, using search terms effectively; assess the credibility and accuracy of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation. (MS-ETS1-1)
- WHST.6-8.7 — Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration. (MS-ETS1-2)
- WHST.6-8.9 — Draw evidence from informational texts to support analysis, reflection, and research. (MS-LS1-6)(MS-LS2-2)(MS-LS2-4)(MS-ETS1-2)
- SL.8.1 — Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 8 topics, texts, and issues, building on others' ideas and expressing their own clearly. (MS-LS2-2)
- SL.8.4 — Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence, sound valid reasoning, and well-chosen details; use appropriate eye contact, adequate volume, and clear pronunciation. (MS-LS2-2)
- SL.8.5 — Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest. (MS-LS2-3)

Mathematics -
- MP.4 — Model with mathematics. (MS-LS2-5)
- MP.2 — Reason abstractly and quantitatively. (MS-ETS1-1)(MS-ETS1-2)
- 7.EE.3 — Solve multi-step real-life and mathematical problems posed with positive and negative rational numbers in any form (whole numbers, fractions, and decimals), using tools strategically. Apply properties of operations to calculate with numbers in any form; convert between forms as appropriate; and assess the reasonableness of answers using mental computation and estimation strategies. (MS-ETS1-1)(MS-ETS1-2)

PROGRESSION OF LEARNING

Learning Sequence 1: Student Engagement with the Anchoring Phenomenon
- Learning Sequence Driving Question: What are the constraints to make a successful bio bottle?
- Learning Sequence 1
- Relationship to Anchoring Phenomena/Design Problem:
  - This sequence introduces the anchor phenomenon. Students will build their understanding of this phenomenon through several learning sequences.
- Student Expected Outcomes:
  - Students will define the criteria and constraints of the bio bottle.
  - Students will develop a model to describe the bio bottle.

Learning Sequence 2
- Learning Sequence Driving Question: What are the components of a thriving ecosystem?
- Learning Sequence 2
- Relationship to Anchoring Phenomena/Design Problem:
  - Students identify the abiotic and biotic factors in the bio bottle.
- Student Expected Outcomes:
  - Students will use evidence and reasoning to describe how the stability of an ecosystem is dependent upon the biological and physical components.
  - Students will identify patterns of change of the earth's ecosystem through the use of qualitative and quantitative data.

Learning Sequence 3
- Learning Sequence Driving Question: How does energy move through an ecosystem?
- Learning Sequence 3
- Relationship to Anchoring Phenomena/Design Problem:
  - Students obtain information to identify producers, consumers, and decomposers in their biosphere to help understand what is needed in a bio bottle.
- Student Expected Outcomes:
  - Students will explain how organisms and their populations are dependent on their interactions with other living things as energy and matter flow through an ecosystem.

- Students will create a model to show the movement of energy from producers to consumers and the cycling of matter.

Learning Sequence 4
- Learning Sequence Driving Question: What is the primary source of energy for most organisms?
- Learning Sequence 4
- Relationship to Anchoring Phenomena/Design Problem:
  - Students learn how the living things within the bio bottle will acquire mass, and how the bottle will suit the needs of the plant to allow for biomass production.
- Student Expected Outcomes:
  - Students will recognize that the laws of conservation of energy and matter are demonstrated in the chemical reaction of photosynthesis.
  - Students will identify the key role of sunlight as the initial source of energy in most ecosystems.

Learning Sequence 5
- Learning Sequence Driving Question: How does matter move through an ecosystem?
- Learning Sequence 5
- Relationship to Anchoring Phenomena/Design Problem:
  - In this learning sequence, students learn how matter moves between organisms in an ecosystem, through the interdependent chemical reactions of photosynthesis and respiration. Students will also identify that states of matter change as matter flows through an ecosystem such as a bio bottle.
- Student Expected Outcomes:
  - Students will create a model to describe how matter, made of atoms, and energy move through an ecosystem as it cycles into and out of living.and nonliving parts of an ecosystem.
  - Students will create a model of a food web to demonstrate how matter, made of atoms, and energy move through an ecosystem.

Learning Sequence 6
- Learning Sequence Driving Question: How do interactions of organisms affect movement of energy?
- Learning Sequence 6
- Relationship to Anchoring Phenomena/Design Problem:
  - Students learn about the interconnectedness of a food web, apply it to their bio bottle and identify potential competition for resources.
- Student Expected Outcomes:
  - Students will analyze and interpret patterns of predator and prey relationships to make predictions for the future.
  - Students will analyze and interpret data from multiple sources to identify the cause and effect of changes in predator/ prey populations.
  - Students will organize and interpret data to determine if small changes in resources may constrain the growth and reproduction of organisms in the ecosystem.

Learning Sequence 7
- Learning Sequence Driving Question: How are ecosystems dynamic and always changing?
- Learning Sequence 7
- Relationship to Anchoring Phenomena/Design Problem:
  - Students apply the concepts of a healthy ecosystem to developing a successful bio bottle.
- Student Expected Outcomes:
  - Students will identify and describe evidence to support the claim that interactions between organisms can be beneficial and may vary across ecosystems.
  - Students will define the boundaries of their biosphere model based on observable patterns of a successful ecosystem.

Learning Sequence 8
- Learning Sequence Driving Question: What are disruptions in an ecosystem and how do they affect humans?
- Learning Sequence 8
- Relationship to Anchoring Phenomena/Design Problem:
  - In a closed system as well as in an open system, how do abiotic and biotic factors impact one another?
- Student Expected Outcomes:
  - Students will analyze and interpret data to show that ecosystem characteristics change over time.
  - Students will use evidence and reasoning to make a claim that the impact of small changes in one part of an ecosystem can cause a larger change in another part of the ecosystem.
  - Students will use the systematic method to evaluate competing design solutions based on scientific evidence.

- Students will apply their model to demonstrate that humans can impact an ecosystem.

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Assessments:

- **Culminating Performance Task**
    - Students use revised models to build bio bottles.
        - Bio Bottles
        - Culminating Activity Handout
- **Grade 7 Assessment Tasks and Rubrics**
- **2019-2020 - G3-G8 Interim Assessment Blocks (IABS) by CREC Bundle**

Additional Resources:

- EPIC! Digital Library - G7 U2A List
    - Includes ebooks and videos
    - Must have an educator user account for free access