ED II Lab #22: OCEAN, Giver of Life

EDII Lab #22 combines Disciplinary Core Ideas (DCIs) from the physical, life, and earth and space sciences as well as aspects of engineering design through the study of the planet's oceans. The core ideas include the vast biodiversity of the oceans and the myriad ways in which humans impact ocean habitats, how this biodiversity is explored, the concept of resilience in relation to human impact, and the chemistry of salinity and buffers. The wide variety of DCIs covered in this lab support the integration of all 7 Crosscutting Concepts – patterns; cause and effect; scale, proportion, and quantity; systems and systemic models; energy; structure and function; and stability and change (indicated by color below). Students learn about these ideas and concepts through engaging in a variety of scientific practices. They have multiple opportunities to derive and analyze information regarding biodiversity and human impact issues from technical reports and interactive media. They also get an in-depth look into how a large-scale scientific endeavor, in this case the Census of Marine Life, gets underway and evolves while providing never-before compiled data required to address human-impact issues. They use a variety of diagrammatic models to better understand food webs and energy flow though ecosystems, the nature of pH and how buffers work, and atomic structure. Through their study of salinity and buffering, students apply the mole concept, providing them with the opportunity to apply mathematical skills relevant to scientific investigation. In the third lab of Level II, students continue to take on more responsibility for writing components of the lab, which allows them to deepen their understanding of concepts and practices through synthesizing and re-presenting relevant material. They conduct a titration of a water sample and then design a method of "acidification" in order to model this phenomenon.

NRC Framework Disciplinary Core Ideas (DCI) and Crosscutting Concepts Related to the Lab

Crosscutting Concepts Color Key

■ = Patterns	■ = Energy and matter
■ = Cause and effect	■ = Structure and function
■ = Scale, proportion, and quantity	■ = Stability and change
■ = Systems and systemic models	Brackets [ ] denote additional cross-cutting concepts

<u>NOTE</u>: Where the NGSS Performance Expectations align to <u>both</u> our lab and the Framework DCI, we include the Performance Expectations parenthetically [i.e., (MS-PS1-1)]. This follows the same convention that Achieve follows in their documents.

Physical Sciences	Life Sciences	Earth and Space Sciences	Engineering Design
Matter and Its Interactions: Structure and Properties of Matter (PS1.A) Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons. (HS-PS1-1) The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states. (HS-PS1-1) The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms. (HS) [This lab also connects this DCI to Structure and Function.] **Matter and Its Interactions: Chemical Reactions (PS1.B)** In many situations, a dynamic and condition-dependent balance between a reaction and the reverse reaction determines the numbers of all	**From Molecules to Organisms: Structures and Processes: Structure and Function (LS1.A)** Systems of specialized cells within organisms help them perform the essential functions of life. (HS) Multicellular organisms have a hierarchical structural organization, in which any one system is made up of numerous parts and is itself a component of the next level. (HS) Feedback mechanisms maintain a living system's internal conditions within certain limits and mediate behaviors, allowing it to remain alive and functional even as external conditions change within some range. Feedback mechanisms can encourage (through positive feedback) or discourage (negative feedback) what is going on inside the living system. (HS) **From Molecules to Organisms: Structures and Processes: Organization for Matter and Energy Flow in Organisms (LS1.C)** The process of photosynthesis converts light energy to stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen. (HS) As matter and energy flow through different organizational levels of living	**Earth's Systems: Earth Materials and Systems (ESS2.A)** Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. (HS) 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) **Earth's Systems: The Roles of Water in Earth's Surface Processes (ESS2.C)** The abundance of liquid water on Earth's surface and its unique combination of physical and chemical	**Engineering Design: Defining and Delimiting Engineering Problems (ETS1.A)** Humanity faces major global 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) 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)

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types of molecules present. (HS) [This lab also connects this DCI to Patterns.] The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions. (HS) [This lab also connects this DCI to Energy and Matter.] **Motion and Stability: Forces and Interactions: Types of Interactions (PS2.B)** 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-PS1-1) [This lab also connects this DCI to Structure and Function.] **Energy: Definitions of Energy (PS3.A)** At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. (HS) [This lab also connects this DCI to	systems, chemical elements are recombined in different ways to form different products. (HS) **Matter and Energy in Organisms and Ecosystems: Cycles of Matter and Energy Transfer in Ecosystems (LS2.B)** Photosynthesis and cellular respiration (including anaerobic processes) provide most of the energy for life processes. (HS) Plants or algae form the lowest level of the food web. At each link upward in a food web, only a small fraction of the matter consumed at the lower level is transferred upward, to produce growth and release energy in cellular respiration at the higher level. Given this inefficiency, there are generally fewer organisms at higher levels of a food web. Some matter reacts to release energy for life functions, some matter is stored in newly made structures, and much is discarded. The chemical elements that make up the molecules of organisms pass through food webs and into and out of the atmosphere and soil, and they are combined and recombined in different ways. At each link in an ecosystem, matter and energy are conserved. (HS) Photosynthesis and cellular respiration are important components of the	properties are central to the planet's dynamics. These properties include water's exceptional capacity to absorb, store, and release large amounts of energy, transmit sunlight, expand upon freezing, dissolve and transport materials, and lower the viscosities and melting points of rocks. (HS) **Earth's Systems: Weather and Climate (ESS2.D)** 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) Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate. (HS) [This lab also connects this DCI to Energy and Matter.]	

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Systems and Systemic Models.] **Energy: Conservation of Energy and Energy Transfer (PS3.B)** Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. (HS) **Energy: Energy in Chemical Processes and Everyday Life (PS3.D)** The main way that solar energy is captured and stored on Earth is through the complex chemical process known as photosynthesis. (HS) **Waves and Their Applications in Technologies for Information Transfer: Wave Properties (PS4.A)** The wavelength and frequency of a wave are related to one another by the speed of travel of the wave, which depends on the type of wave and the medium through which it is passing. (HS) **Waves and Their**	carbon cycle, in which carbon is exchanged among the biosphere, atmosphere, oceans, and geosphere through chemical, physical, geological, and biological processes. (HS) **Ecosystems: Interactions, Energy, and Dynamics: Ecosystem Dynamics, Functioning, and Resilience (LS2.C)** 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) 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)	Current models predict that, although future regional climate changes will be complex and varied, average global temperatures will continue to rise. The outcomes predicted by global climate models strongly depend on the amounts of human-generated greenhouse gases added to the atmosphere each year and by the ways in which these gases are absorbed by the ocean and biosphere. (HS) **Earth's Systems: Biogeology (ESS2.E)** The many dynamic and delicate feedbacks between the biosphere and other Earth systems cause a continual co-evolution of Earth's surface and the life that exists on it. (HS) **Earth and Human Activity: Human Impacts on Earth Systems (ESS3.C)** The sustainability of human societies and the biodiversity that supports them requires responsible	

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Applications in Technologies for Information Transfer: Electromagnetic Radiation (PS4.B) **Waves and Their Applications in Technologies for Information Transfer: Information Technologies and Instrumentation (PS4.C)** Multiple technologies based on the understanding of waves and their interactions with matter are part of everyday experiences in the modern world (e.g., medical imaging, communications, scanners) and in scientific research. They are essential tools for producing, transmitting, and capturing signals and for storing and interpreting the information contained in them. (HS)	**Biological Evolution: Unity and Diversity: Adaptation (LS4.C)** Natural selection leads to adaptation, that is, to a population dominated by organisms that are anatomically, behaviorally, and physiologically well suited to survive and reproduce in a specific environment. That is, the differential survival and reproduction of organisms in a population that have an advantageous heritable trait leads to an increase in the proportion of individuals in future generations that have the trait and to a decrease in the proportion of individuals that do not. (HS) 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) 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) [This lab also connects this DCI to Systems and Systemic Models.]	management of natural resources. (HS) Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude ecosystem degradation. (HS) **Earth and Human Activity: Global Climate Change (ESS3.D)** Though the magnitudes of human impacts are greater than they have ever been, so too are human abilities to model, predict, and manage current and future impacts. (HS-ESS3-5) Through computer simulations and other studies, important discoveries are still being made about how the ocean, the atmosphere, and the biosphere interact and are modified in response to human activities. (HS)	

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	Biological Evolution: Unity and Diversity: Biodiversity and Humans (LS4.D) Biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction). (HS) 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. (HS) [This lab also connects this DCI to Stability and Change.]		

NRC Framework Science and Engineering Practices Related to the Lab

Asking questions and defining problems	Developing and using models	Planning and carrying out investigations	Analyzing and interpreting data
Ask questions: • that arise from careful observation of phenomena, or unexpected results, to clarify and/or seek additional information. • that arise from examining models or a theory, to clarify and/or seek additional information and relationships. • to clarify and refine a model, an explanation, or an engineering problem. Ask questions that can be investigated within the scope of the school laboratory, research facilities, or field (e.g., outdoor environment) with available resources and, when appropriate, frame a hypothesis based on a model or theory.	Evaluate merits and limitations of two different models of the same proposed tool, process, mechanism or system in order to select or revise a model that best fits the evidence or design criteria. Develop and/or use multiple types of models to provide mechanistic accounts and/or predict phenomena, and move flexibly between model types based on merits and limitations. Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system. Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems.	Plan an investigation or test a design individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems. Consider possible confounding variables or effects and evaluate the investigation's design to ensure variables are controlled. Select appropriate tools to collect, record, analyze, and evaluate 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. Consider limitations of data analysis (e.g., measurement error, sample selection) when analyzing and interpreting data.

NRC Framework Science and Engineering Practices Related to the Lab

Using mathematics and computational thinking	**Constructing explanations and designing solutions**	**Engaging in argument from evidence**	**Obtaining, evaluating, and communicating information**
Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations. Apply techniques of algebra and functions to represent and solve scientific and engineering problems. Apply ratios, rates, percentages, and unit conversions in the context of complicated measurement problems involving quantities with derived or compound units (such as mg/mL, kg/m3, acre-feet, etc.).	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. Apply scientific reasoning, theory, and/or models to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion. Apply scientific reasoning, theory, and/or models to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion.	Compare and evaluate competing arguments or design solutions in light of currently accepted explanations, new evidence, limitations (e.g., trade-offs), constraints, and ethical issues. Evaluate the claims, evidence, and/or reasoning behind currently accepted explanations or solutions to determine the merits of arguments. Respectfully provide and/or receive critiques on scientific arguments by probing reasoning and evidence, challenging ideas and conclusions, responding thoughtfully to diverse perspectives, and determining additional information required to resolve contradictions.	Critically read scientific literature adapted for classroom use to determine the central ideas or conclusions and/or to obtain scientific and/or technical information to summarize complex evidence, concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms. Compare, integrate and evaluate sources of information presented in different media or formats (e.g., visually, quantitatively) as well as in words in order to address a scientific question or solve a problem. Gather, read, and evaluate scientific and/or technical information from multiple authoritative sources, assessing the evidence and usefulness of each source. Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (i.e., orally, graphically, textually, and mathematically).