Okeanos Explorer Education Materials Collection, Volume 1: Why Do We Explore?
Next Generation Science Standards Performance Expectations

Lesson: To Boldly Go (MS)

No Performance Expectations

Science and Engineering Practices:

Asking Questions and Defining Problems

- Ask questions to identify and/or clarify evidence and/or the premise(s) of argument.

Developing and Using Models

- Develop a model to predict and/or describe phenomena.

Using Mathematics and Computational Thinking

- Use mathematical representations to describe and/or support scientific conclusions and design solutions.

Obtaining, Evaluating, and Communicating Information

- Critically read scientific texts adapted for classroom use to determine the central ideas and/or obtain scientific and/or technical information to describe patterns in and/or evidence about the natural and designed world(s).
- Communicate scientific and/or technical information (e.g. about a proposed object, tool, process, system) in writing and/or through oral presentations.

Crosscutting Concepts:

Patterns

- Graphs, charts and images can be used to identify patterns in data.

Systems and System Models

- Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy, matter, and information flows within systems.

Structure and Function

- The observed function of natural and designed systems may change with scale.

Connections to Engineering, Technology, and Applications of Science

Influence of Science, Engineering and Technology on Society and the Natural World

- Technologies extend the measurement, exploration, modeling, and computational capacity of scientific investigations.
- All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural environment.
- The uses of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus technology use varies from region to region and over time.

Connections to Nature of Science

Science is a Human Endeavor

- Advances in technology influence the progress of science and science has influenced advances in technology.

Okeanos Explorer Education Materials Collection, Volume 1: Why Do We Explore?
Next Generation Science Standards Performance Expectations

Lesson: Journey to the Unknown (MS)

No Performance Expectations

Science and Engineering Practices:

Asking Questions and Defining Problems

- Ask questions that arise from careful observation of phenomena, models, or unexpected results, to clarify and/or seek additional information.
- Ask questions to identify and clarify evidence of an argument.

Engaging in Argument from Evidence

- Respectfully provide and receive critiques about one's explanations, procedures, models and questions by citing relevant evidence and posing and responding to questions that elicit pertinent elaboration and detail.
- Construct, use, and/or present 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.

Obtaining, Evaluating, and Communicating Information

- Communicate scientific and/or technical information (e.g. about a proposed object, tool, process, system) in writing and/or through oral presentations.

Crosscutting Concepts:

Systems and System Models

- Systems may interact with other systems; they may have sub-systems and be a part of larger complex systems.

Lesson: Come on Down (MS)

MS-PS2 Motion and Stability: Forces and Interactions

Performance Expectations:
MS-PS2-2. Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object. [Clarification Statement: Emphasis is on balanced (Newton's First Law) and unbalanced forces in a system, qualitative comparisons of forces, mass and changes in motion (Newton's Second Law), frame of reference, and specification of units.] [Assessment Boundary: Assessment is limited to forces and changes in motion in one-dimension in an inertial reference frame and to change in one variable at a time. Assessment does not include the use of trigonometry.]

Science and Engineering Practices:
Planning and Carrying Out Investigations
- Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim.

Disciplinary Core Ideas:
PS2.A: Forces and Motion
- The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion.
- All positions of objects and the directions of forces and motions must be described in an arbitrarily chosen reference frame and arbitrarily chosen units of size. In order to share information with other people, these choices must also be shared.

Crosscutting Concepts:
Stability and Change
- Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales.

Common Core State Standards Connections
ELA/Literacy –
RST.6-8.3 Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.

Mathematics –
MP.2 Reason abstractly and quantitatively.

Additional Science and Engineering Practices:
Asking Questions and Defining Problems
- Ask questions that arise from careful observation of phenomena, models, or unexpected results, to clarify and/or seek additional information.
- Ask questions that require sufficient and appropriate empirical evidence to answer.

Planning and Carrying Out Investigations

- Conduct an investigation and/or evaluate and/or revise the experimental design to produce data to serve as the basis for evidence that meet the goals of the investigation.

Analyzing and Interpreting Data

- Analyze and interpret data to determine similarities and differences in findings.

Using Mathematics and Computational Thinking

- Use mathematical representations to describe and/or support scientific conclusions and design solutions.
- Apply mathematical concepts and/or processes (such as ratio, rate, percent, basic operations, and simple algebra) to scientific and engineering questions and problems.

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.
- Apply scientific ideas, principles, and/or evidence to construct, revise and/or use an explanation for real-world phenomena, examples, or events.

Obtaining, Evaluating, and Communicating Information

- Gather, read, synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and methods used, and describe how they are supported or not supported by evidence.
- Communicate scientific and/or technical information (e.g. about a proposed object, tool, process, system) in writing and/or through oral presentations.

Connections to Nature of Science

Scientific Knowledge is Based on Empirical Evidence

- Science knowledge is based upon logical and conceptual connections between evidence and explanations.

Additional Crosscutting Concepts:

Scale, Proportion and Quantity

- Proportional relationships (e.g., speed as the ratio of distance traveled to time taken) among different types of quantities provide information about the magnitude of properties and processes.
- Scientific relationships can be represented through the use of algebraic expressions and equations.

Okeanos Explorer Education Materials Collection, Volume 1: Why Do We Explore?
Next Generation Science Standards Performance Expectations

Lesson: Calling All Explorers (HS)

No Performance Expectations

Science and Engineering Practices:

Obtaining, Evaluating, and Communicating Information

- 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.

Crosscutting Concepts:

None

Okeanos Explorer **Education Materials Collection, Volume 1: Why Do We Explore?**
Next Generation Science Standards Performance Expectations

Lesson: The Methane Circus (MS)

MS-LS4 Biological Evolution: Unity and Diversity

Performance Expectations:
MS-LS4-1. Analyze and interpret data for patterns in the fossil record that document the existence, diversity, extinction, and change of life forms throughout the history of life on Earth under the assumption that natural laws operate today as in the past. [Clarification Statement: Emphasis is on finding patterns of changes in the level of complexity of anatomical structures in organisms and the chronological order of fossil appearance in the rock layers.] [Assessment Boundary: Assessment does not include the names of individual species or geological eras in the fossil record.]

Science and Engineering Practices:
Analyzing and Interpreting Data
- Analyze and interpret data to determine similarities and differences in findings.

Connections to Nature of Science
Scientific Knowledge is Based on Empirical Evidence
- Science knowledge is based upon logical and conceptual connections between evidence and explanations.

Disciplinary Core Ideas:
LS4.A: Evidence of Common Ancestry and Diversity
- The collection of fossils and their placement in chronological order (e.g., through the location of the sedimentary layers in which they are found or through radioactive dating) is known as the fossil record. It documents the existence, diversity, extinction, and change of many life forms throughout the history of life on Earth.

Crosscutting Concepts:
Patterns
- Graphs, charts, and images can be used to identify patterns in data.

Connections to Nature of Science
Scientific Knowledge Assumes an Order and Consistency in Natural Systems
- Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation.

Common Core State Standards Connections
ELA/Literacy –
RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions
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).

Additional Science and Engineering Practices:
Obtaining, Evaluating, and Communicating Information
- Critically read scientific texts adapted for classroom use to determine the central ideas and/or obtain

scientific and/or technical information to describe patterns in and/or evidence about the natural and designed world(s).

- Communicate scientific and/or technical information (e.g. about a proposed object, tool, process, system) in writing and/or through oral presentations.

Additional Crosscutting Concepts:

Systems and System Models

- Models are limited in that they only represent certain aspects of the system under study.

Okeanos Explorer Education Materials Collection, Volume 1: Why Do We Explore?
Next Generation Science Standards Performance Expectations

Lesson: Where Have All the Glaciers Gone? (MS)

MS-ESS3 Earth and Human Activity

Performance Expectations:
MS-ESS3-5. Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century. [Clarification Statement: Examples of factors include human activities (such as fossil fuel combustion, cement production, and agricultural activity) and natural processes (such as changes in incoming solar radiation or volcanic activity). Examples of evidence can include tables, graphs, and maps of global and regional temperatures, atmospheric levels of gases such as carbon dioxide and methane, and the rates of human activities. Emphasis is on the major role that human activities play in causing the rise in global temperatures.]

Science and Engineering Practices:
Asking Questions and Defining Problems
- Ask questions to identify and clarify evidence of an argument.

Disciplinary Core Ideas:
ESS3.D: Global Climate Change
- Human activities, such as the release of greenhouse gases from burning fossil fuels, are major factors in the current rise in Earth's mean surface temperature (global warming). Reducing the level of climate change and reducing human vulnerability to whatever climate changes do occur depend on the understanding of climate science, engineering capabilities, and other kinds of knowledge, such as understanding of human behavior and on applying that knowledge wisely in decisions and activities.

Crosscutting Concepts:
Stability and Change
- Stability might be disturbed either by sudden events or gradual changes that accumulate over time.

Common Core State Standards Connections
ELA/Literacy –
RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts.

Additional Science and Engineering Practices:
Asking Questions and Defining Problems
- Ask questions to determine relationships between independent and dependent variables and relationships in models.
- Ask questions to clarify and/or refine a model, an explanation, or an engineering problem.

Developing and Using Models
- Develop a model to describe unobservable mechanisms.

Analyzing and Interpreting Data
- Construct, analyze, and/or interpret graphical displays of data and/or large data sets to identify linear and nonlinear relationships.
- Distinguish between causal and correlational relationships in data.

Obtaining, Evaluating, and Communicating Information

- Critically read scientific texts adapted for classroom use to determine the central ideas and/or obtain scientific and/or technical information to describe patterns in and/or evidence about the natural and designed world(s).
- Communicate scientific and/or technical information (e.g. about a proposed object, tool, process, system) in writing and/or through oral presentations.

Additional Crosscutting Concepts:

Patterns

- Patterns can be used to identify cause and effect relationships.
- Graphs, charts, and images can be used to identify patterns in data.

Cause and Effect: Mechanism and Prediction

- Cause and effect relationships may be used to predict phenomena in natural or designed systems.

Stability and Change

- Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales, including the atomic scale.

Lesson: History's Thermometers (HS)

HS-ESS3 Earth and Human Activity

Performance Expectations:
HS-ESS3-5. Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems. [Clarification Statement: Examples of evidence, for both data and climate model outputs, are for climate changes (such as precipitation and temperature) and their associated impacts (such as on sea level, glacial ice volumes, or atmosphere and ocean composition).] [Assessment Boundary: Assessment is limited to one example of a climate change and its associated impacts.]

Science and Engineering Practices:
Analyzing and Interpreting Data
- Analyze data using computational models in order to make valid and reliable scientific claims.

Connections to Nature of Science
Scientific Investigations Use a Variety of Methods
- Science investigations use diverse methods and do not always use the same set of procedures to obtain data.
- New technologies advance scientific knowledge.

Scientific Knowledge is Based on Empirical Evidence
- Science knowledge is based on empirical evidence.
- Science arguments are strengthened by multiple lines of evidence supporting a single explanation.

Disciplinary Core Ideas:
ESS3.D: Global Climate Change
- 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.

Crosscutting Concepts:
Stability and Change
- Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible.

Common Core State Standards Connections:
Mathematics –
MP.2 Reason abstractly and quantitatively.
MP.4 Model with mathematics.
HSN-Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

Additional Science and Engineering Practices:
Analyzing and Interpreting 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.

Using Mathematics and Computational Thinking

- Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations.

Constructing Explanations and Designing Solutions

- 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.

Obtaining, Evaluating, and Communicating Information

- 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 (including orally, graphically, textually, and mathematically).

Additional Crosscutting Concepts:

Patterns

- Mathematical representations are needed to identify some patterns.

Stability and Change

- Much of science deals with constructing explanations of how things change and how they remain stable.

Lesson: Animals of the Fire Ice (MS)

MS-PS1 Matter and Its Interactions

Performance Expectations:
MS-PS1-1. Develop models to describe the atomic composition of simple molecules and extended structures. [Clarification Statement: Emphasis is on developing models of molecules that vary in complexity. Examples of simple molecules could include ammonia and methanol. Examples of extended structures could include sodium chloride or diamonds. Examples of molecular-level models could include drawings, 3D ball and stick structures, or computer representations showing different molecules with different types of atoms.] [Assessment Boundary: Assessment does not include valence electrons and bonding energy, discussing the ionic nature of subunits of complex structures, or a complete depiction of all individual atoms in a complex molecule or extended structure.]

Science and Engineering Practices:
Developing and Using Models
- Develop a model to predict and/or describe phenomena.

Disciplinary Core Ideas:
PS1.A: Structure and Properties of Matter
- Substances are made from different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms.
- Solids may be formed from molecules, or they may be extended structures with repeating subunits.

Crosscutting Concepts:
Scale, Proportion, and Quantity
- Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small.

Common Core State Standards Connections:
ELA/Literacy -
RST.6-8.7 Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).
Mathematics –
MP.2 Reason abstractly and quantitatively.

MS-LS2 Ecosystems: Interactions, Energy, and Dynamics

Performance Expectations:
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.]

Science and Engineering Practices:
Constructing Explanations and Designing Solutions
- Construct an explanation that includes qualitative or quantitative relationships between variables that predict phenomena.

Disciplinary Core Ideas:

LS2.A: Interdependent Relationships in Ecosystems

- Similarly, predatory interactions may reduce the number of organisms or eliminate whole 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.

Crosscutting Concepts:

Patterns

- Patterns can be used to identify cause and effect relationships.

Common Core State Standards Connections:

ELA/Literacy –

RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts.

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.

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-LS2-3. 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.]

Science and Engineering Practices:

Developing and Using Models

- Develop a model to describe phenomena.

Disciplinary Core Ideas:

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.

Crosscutting Concepts:

Energy and Matter

- The transfer of energy can be tracked as energy flows through a natural system.

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Connections to Nature of Science

Scientific Knowledge Assumes an Order and Consistency in Natural Systems

- Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation.

Common Core State Standards Connections:
ELA/Literacy –
SL.8.5 Include multimedia components and visual displays in presentations to clarify claims and findings and emphasize salient points.

Additional Science and Engineering Practices:

Asking Questions and Defining Problems

- Ask questions that arise from careful observation of phenomena, models, or unexpected results, to clarify and/or seek additional information.
- Ask questions to identify and/or clarify evidence and/or the premise(s) of an argument.

Developing and Using Models

- Develop a model to describe unobservable mechanisms.

Obtaining, Evaluating, and Communicating Information

- Critically read scientific texts adapted for classroom use to determine the central ideas and/or obtain scientific and/or technical information to describe patterns in and/or evidence about the natural and designed world(s).
- Communicate scientific and/or technical information (e.g. about a proposed object, tool, process, system) in writing and/or through oral presentations.

Additional Cross Cutting Concepts:

Cause and Effect: Mechanism and Prediction

- Cause and effect relationships may be used to predict phenomena in natural or designed systems.

Systems and System Models

- Systems may interact with other systems; they may have sub-systems and be a part of larger complex systems.
- Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy, matter, and information flows within systems.

Structure and Function

- Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the shapes, composition, and relationships among its parts; therefore, complex natural and designed structures/systems can be analyzed to determine how they function.

Lesson: Oceans of Energy (MS)

MS-PS2 Motion and Stability: Forces and Interactions

Performance Expectations:
MS-PS2-3. Ask questions about data to determine the factors that affect the strength of electric and magnetic forces. [Clarification Statement: Examples of devices that use electric and magnetic forces could include electromagnets, electric motors, or generators. Examples of data could include the effect of the number of turns of wire on the strength of an electromagnet, or the effect of increasing the number or strength of magnets on the speed of an electric motor.] [Assessment Boundary: Assessment about questions that require quantitative answers is limited to proportional reasoning and algebraic thinking.]

Science and Engineering Practices:
Asking Questions and Defining Problems
- Ask questions that can be investigated within the scope of the classroom, outdoor environment, and museums and other public facilities with available resources and, when appropriate, frame a hypothesis based on observations and scientific principles.

Disciplinary Core Ideas:
PS2.B: Types of Interactions
- Electric and magnetic (electromagnetic) forces can be attractive or repulsive, and their sizes depend on the magnitudes of the charges, currents, or magnetic strengths involved and on the distances between the interacting objects.

Crosscutting Concepts:
Cause and Effect: Mechanism and Prediction
- Cause and effect relationships may be used to predict phenomena in natural or designed systems.

Common Core State Standards Connections:
ELA/Literacy –
RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.
RST.6-8.3 Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.

MS-PS2-5. Conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact. [Clarification Statement: Examples of this phenomenon could include the interactions of magnets, electrically-charged strips of tape, and electrically-charged pith balls. Examples of investigations could include first-hand experiences or simulations.] [Assessment Boundary: Assessment is limited to electric and magnetic fields, and limited to qualitative evidence for the existence of fields.]

Science and Engineering Practices:
Planning and Carrying Out Investigations
- Conduct an investigation and evaluate the experimental design to produce data to serve as the basis for evidence that can meet the goals of the investigation.

Disciplinary Core Ideas:

PS2.B: Types of Interactions

- Forces that act at a distance (electric, magnetic, and gravitational) can be explained by fields that extend through space and can be mapped by their effect on a test object (a charged object, or a ball, respectively).

Crosscutting Concepts:

Cause and Effect: Mechanism and Predictions

- Cause and effect relationships may be used to predict phenomena in natural or designed systems.

Connections to Engineering, Technology, and Applications of Science

Influence of Science, Engineering, and Technology on Society and the Natural World

- The uses of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions.

Common Core State Standards Connections:

ELA/Literacy –

RST.6-8.3 Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.

MS-PS3 Energy

Performance Expectations:

MS-PS3-2. Develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system.
[Clarification Statement: Emphasis is on relative amounts of potential energy, not on calculations of potential energy. Examples of objects within systems interacting at varying distances could include: the Earth and either a roller coaster cart at varying positions on a hill or objects at varying heights on shelves, changing the direction/orientation of a magnet, and a balloon with static electrical charge being brought closer to a classmate's hair. Examples of models could include representations, diagrams, pictures, and written descriptions of systems.] [Assessment Boundary: Assessment is limited to two objects and electric, magnetic, and gravitational interactions.]

Science and Engineering Practices:

Developing and Using Models

- Develop a model to describe unobservable mechanisms.

Disciplinary Core Ideas:

PS3.C: Relationship Between Energy and Forces

- When two objects interact, each one exerts a force on the other that can cause energy to be transferred to or from the object.

Crosscutting Concepts:

Systems and System Models

- Models can be used to represent systems and their interactions – such as inputs, processes, and outputs – and energy and matter flows within systems.

MS-PS3-5. Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object. [Clarification Statement: Examples of empirical evidence used in arguments could include an inventory or other representation of the energy before and after the transfer in the form of temperature changes or motion of object.] [Assessment Boundary: Assessment does not include calculations of energy.]

Science and Engineering Practices:
none

Disciplinary Core Ideas:
PS3.B: Conservation of Energy and Energy Transfer
- When the motion energy of an object changes, there is inevitably some other change in energy at the same time.

Crosscutting Concepts:
Energy and Matter: Flows, Cycles, and Conservation
- Energy may take different forms (e.g. energy in fields, thermal energy, energy of motion).

Common Core State Standards Connections:
ELA/Literacy –
RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.
Mathematics –
MP.2 Reason abstractly and quantitatively.

Additional Science and Engineering Practices:
Asking Questions and Defining Problems
- Ask questions to determine relationships between independent and dependent variables and relationships in models.
- Ask questions to clarify and/or refine a model, an explanation, or an engineering problem o to clarify and/or refine a model, an explanation, or an engineering problem.

Developing and Using Models
- Develop or modify a model—based on evidence – to match what happens if a variable or component of a system is changed.
- Develop and/or revise a model to show the relationships among variables, including those that are not observable but predict.

Constructing Explanations and Designing Solutions
- Apply scientific ideas or principles to design, construct, and/or test a design of an object, tool, process or system.

Obtaining, Evaluating, and Communicating Information
- Critically read scientific texts adapted for classroom use to determine the central ideas and/or obtain scientific and/or technical information to describe patterns in and/or evidence about the natural and designed world(s).
- Communicate scientific and/or technical information (e.g. about a proposed object, tool, process, system) in writing and/or through oral presentations.

Additional Crosscutting Concepts:
Patterns
- Patterns of performance of designed systems can be analyzed and interpreted to reengineer and improve the system.

Cause and Effect: Mechanism and Prediction
- Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system.

Energy and Matter: Flows, Cycles, and Conservation

- 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.
- Energy cannot be created or destroyed—only moves between one place and another place, between objects and/or fields, or between systems.
- Energy drives the cycling of matter within and between systems.

Structure and Function

- Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem. · The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials.

Connections to Engineering, Technology on Society and the Natural World

Influence of Science, Engineering, and Technology on Society and the Natural World

- All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural environment.
- The uses of technologies and limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions.

Okeanos Explorer Education Materials Collection, Volume 1: Why Do We Explore?
Next Generation Science Standards Performance Expectations

Lesson: What's the Big Deal (HS)

No Performance Expectations

Science and Engineering Practices:

Asking Questions and Defining Problems

- Ask questions that arise from examining models or a theory, to clarify and/or seek additional information and relationships.
- Ask questions to clarify and refine a model, an explanation, or an engineering problem.

Developing and Using Models

- 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.

Obtaining, Evaluating, and Communicating Information

- 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.
- 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 (including orally, graphically, textually, and mathematically).

Crosscutting Concepts:

Patterns

- Mathematical representations are needed to identify some patterns.

Cause and Effect: Mechanism and Prediction

- Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system.

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.

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.

Structure and Function

- The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials.

Stability and Change

- Much of science deals with constructing explanations of how things change and how they remain stable.

Connections to Nature of Science
Science is a Human Endeavor

- Science is a result of human endeavors, imagination, and creativity.

Lesson: Microfriends (MS)

No Performance Expectations

Science and Engineering Practices:

Asking Questions and Defining Problems

- Ask questions that arise from careful observation of phenomena, models, or unexpected results, to clarify and/or seek additional information.

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.

Obtaining, Evaluating, and Communicating Information

- Communicate scientific and/or technical information (e.g. about a proposed object, tool, process, system) in writing and/or through oral presentations.

Crosscutting Concepts:

Scale, Proportion, and Quantity

- Phenomena that can be observed at one scale may not be observable at another scale.

Systems and System Models

- Systems may interact with other systems; they may have sub-systems and be a part of larger complex systems.

Structure and Function

- Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the shapes, composition, and relationships among its parts; therefore, complex natural and designed structures/systems can be analyzed to determine how they function.

***Okeanos Explorer* Education Materials Collection, Volume 1: Why Do We Explore?**
Next Generation Science Standards Performance Expectations

Lesson: What Killed the Seeds (MS)

MS-LS1 From Molecules to Organisms: Structures and Processes

Performance Expectations:
MS-LS1-5. Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms. [Clarification Statement: Examples of local environmental conditions could include availability of food, light, space, and water. Examples of genetic factors could include large breed cattle and species of grass affecting growth of organisms. Examples of evidence could include drought decreasing plant growth, fertilizer increasing plant growth, different varieties of plant seeds growing at different rates in different conditions, and fish growing larger in large ponds than they do in small ponds.] [Assessment Boundary: Assessment does not include genetic mechanisms, gene regulation, or biochemical processes.]

Science and Engineering Practices:
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.

Disciplinary Core Ideas:
LS1.B: Growth and Development of Organisms
- Genetic factors as well as local conditions affect the growth of the adult plant.

Crosscutting Concepts:
Cause and Effect: Mechanism and Prediction
- Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.

Common Core State Standards Connections:
ELA/Literacy –
RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts.
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.
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.
WHST.6-8.9 Draw evidence from informational texts to support analysis, reflection, and research
Mathematics –
6.SP.A.2 Understand that a set of data collected to answer a statistical question has a distribution which can be described by its center, spread, and overall shape.
6.SP.B.4 Summarize numerical data sets in relation to their context.

Additional Science and Engineering Practices:
Asking Questions and Defining Problems
- Ask questions that arise from careful observation of phenomena, models, or unexpected results, to clarify and/or seek additional information.
- Ask questions that require sufficient and appropriate empirical evidence to answer.

Analyzing and Interpreting Data

- Analyze and interpret data to provide evidence for phenomena.
- Apply concepts of statistics and probability (including mean, median, mode, and variability) to analyze and characterize data, using digital tools when feasible.

Using Mathematics and Computational Thinking

- Apply mathematical concepts and/or processes (such as ratio, rate, percent, basic operations, and simple algebra) to scientific and engineering questions and problems.

Constructing Explanations and Designing Solutions

- Apply scientific ideas, principles, and/or evidence to construct, revise and/or use an explanation for real-world phenomena, examples, or events.

Obtaining, Evaluating, and Communicating Information

- Communicate scientific and/or technical information (e.g. about a proposed object, tool, process, system) in writing and/or through oral presentations.

Additional Crosscutting Concepts:

None

Lesson: Watch the Screen (HS)

No Performance Expectations

Science and Engineering Practices:

Planning and Carrying Out Investigations

- Plan and conduct an investigation or test a design solution in a safe and ethical manner including considerations of environmental, social, and personal impacts.

Analyzing and Interpreting 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.

Constructing Explanations and Designing Solutions

- Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables.

Connections to Nature of Science

Scientific Investigations Use a Variety of Methods

- Scientific inquiry is characterized by a common set of values that include: logical thinking, precision, open-mindedness, objectivity, skepticism, replicability of results, and honest and ethical reporting of findings.

Crosscutting Concepts:

None

***Okeanos Explorer* Education Materials Collection, Volume 1: Why Do We Explore?**
Next Generation Science Standards Performance Expectations

Lesson: Build Your Own Ecosystem (MS)

MS-LS1 From Molecules to Organisms: Structures and Processes

Performance Expectations:
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.]

Science and Engineering Practices:
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.

Connections to Nature of Science
Scientific Knowledge is Based on Empirical Evidence
- Science knowledge is based upon logical connections between evidence and explanations.

Disciplinary Core Ideas:
LS1.C: Organization for Matter and Energy Flow in Organisms
- Plants, algae (including phytoplankton), and many microorganisms use the energy from light to make sugars (food) from carbon dioxide from the atmosphere and water through the process of photosynthesis, which also releases oxygen. These sugars can be used immediately or stored for growth or later use.

PS3.D: Energy in Chemical Processes and Everyday Life
- The chemical reaction by which plants produce complex food molecules (sugars) requires an energy input (i.e., from sunlight) to occur. In this reaction, carbon dioxide and water combine to form carbon-based organic molecules and release oxygen.

Crosscutting Concepts:
Energy and Matter: Flows, Cycles, and Conservation
- Within a natural system, the transfer of energy drives the motion and/or cycling of matter.

MS-LS2 Ecosystems: Interactions, Energy, and Dynamics

Performance Expectations:
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.]

Science and Engineering Practices:
Developing and Using Models
- Develop a model to describe phenomena.

Disciplinary Core Ideas:

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.

Crosscutting Concepts:

Energy and Matter: Flows, Cycles, and Conservation

- The transfer of energy can be tracked as energy flows through a natural system.

Connections to Nature of Science

Scientific Knowledge Assumes an Order and Consistency in Natural Systems

- Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation.

Additional Science and Engineering Practices:

Asking Questions and Defining Problems

- Ask questions that arise from careful observation of phenomena, models, or unexpected results, to clarify and/or seek additional information.
- Ask questions that require sufficient and appropriate empirical evidence to answer.
- Ask questions that can be investigated within the scope of the classroom, outdoor environment, and museums and other public facilities with available resources and, when appropriate, frame a hypothesis based on observations and scientific principles.
- Ask questions that challenge the premise(s) of an argument or the interpretation of a data set.

Developing and Using Models

- Develop and/or use a model to predict and/or describe phenomena.

Additional Crosscutting Concepts:

Cause and Effect: Mechanism and Prediction

- Relationships can be classified as causal or correlational, and correlation does not necessarily imply causation.

Systems and System Models

- Systems may interact with other systems; they may have sub-systems and be a part of larger complex systems.
- Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy, matter, and information flows within systems.
- Models are limited in that they only represent certain aspects of the system under study.

Energy and Matter: Flows, Cycles and Conservation

- The transfer of energy can be tracked as energy flows through a designed or natural system.

Stability and Change

- Stability might be disturbed either by sudden events or gradual changes that accumulate over time.
- Systems in dynamic equilibrium are stable due to a balance of feedback mechanisms.

***Okeanos Explorer* Education Materials Collection, Volume 1: Why Do We Explore?**
Next Generation Science Standards Performance Expectations

Lesson: Stressed Out (MS)

MS-LS1 From Molecules to Organisms: Structures and Processes

Performance Expectations:
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.]

Science and Engineering Practices:
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.

Connections to Nature of Science
Scientific Knowledge is Based on Empirical Evidence
- Science knowledge is based upon logical connections between evidence and explanations.

Disciplinary Core Ideas:
LS1.C: Organization for Matter and Energy Flow in Organisms
- Plants, algae (including phytoplankton), and many microorganisms use the energy from light to make sugars (food) from carbon dioxide from the atmosphere and water through the process of photosynthesis, which also releases oxygen. These sugars can be used immediately or stored for growth or later use.

PS3.D: Energy in Chemical Processes and Everyday Life
- The chemical reaction by which plants produce complex food molecules (sugars) requires an energy input (i.e., from sunlight) to occur. In this reaction, carbon dioxide and water combine to form carbon-based organic molecules and release oxygen.

Crosscutting Concepts:
Energy and Matter: Flows, Cycles, and Conservation
- Within a natural system, the transfer of energy drives the motion and/or cycling of matter.

Common Core State Standards Connections:
ELA/Literacy –
RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts.
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.
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.
WHST.6-8.9 Draw evidence from informational texts to support analysis, reflection, and research.
Mathematics –
6.EE.C.9 Use variables to represent two quantities in a real-world problem that change in relationship to one another; write an equation to express one quantity, thought of as the dependent variable, in terms of the other quantity, thought of as the independent variable. Analyze the relationship between the dependent and independent variables using graphs and tables, and relate these to the equation.

MS-LS2 Ecosystems: Interactions, Energy, and Dynamics

Performance Expectations:

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.]

Science and Engineering Practices:

Analyzing and Interpreting Data

- Analyze and interpret data to provide evidence for phenomena.

Disciplinary Core Ideas:

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.

Crosscutting Concepts:

Cause and Effect: Mechanism and Prediction

- Cause and effect relationships may be used to predict phenomena in natural or designed systems.

Common Core State Standards Connections:

ELA/Literacy –

RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts.

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-LS2-2. 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.]

Science and Engineering Practices:

Constructing Explanations and Designing Solutions

- Construct an explanation that includes qualitative or quantitative relationships between variables that predict phenomena.

Disciplinary Core Ideas:

LS2.A: Interdependent Relationships in Ecosystems

- Similarly, predatory interactions may reduce the number of organisms or eliminate whole 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.

Crosscutting Concepts:

Patterns

- Patterns can be used to identify cause and effect relationships.

Common Core State Standards Connections:

ELA/Literacy –

RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts.

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.

WHST.6-8.9 Draw evidence from literary or informational texts to support analysis, reflection, and research.

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.

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.

Mathematics –

6.SP.B.5 Summarize numerical data sets in relation to their context.

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.]

Science and Engineering Practices:

Developing and Using Models

- Develop a model to describe phenomena.

Disciplinary Core Ideas:

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.

Crosscutting Concepts:

Energy and Matter: Flows, Cycles, and Conservation

- The transfer of energy can be tracked as energy flows through a natural system.

Connections to Nature of Science

Scientific Knowledge Assumes an Order and Consistency in Natural Systems

- Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation.

Common Core State Standards Connections:
ELA/Literacy –
SL.8.5 Include multimedia components and visual displays in presentations to clarify claims and findings and emphasize salient points.
Mathematics –
6.EE.C.9 Use variables to represent two quantities in a real-world problem that change in relationship to one another; write an equation to express one quantity, thought of as the dependent variable, in terms of the other quantity, thought of as the independent variable. Analyze the relationship between the dependent and independent variables using graphs and tables, and relate these to the equation.

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.]

Science and Engineering Practices:
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.

Disciplinary Core Ideas:
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.

Crosscutting Concepts:
Stability and Change
- Small changes in one part of a system might cause large changes in another part.

Common Core State Standards Connections:
ELA/Literacy –
RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts.
WHST.6-8.1 Write arguments to support claims with clear reasons and relevant evidence.
WHST.6-8.9 Draw evidence from literary or informational texts to support analysis, reflection, and research.

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.]

Science and Engineering Practices:
Engaging in Argument from Evidence
- Evaluate competing design solutions based on jointly developed and agreed-upon design criteria.

Disciplinary Core Ideas:
LS2.C: Ecosystem Dynamics, Functioning, and Resilience
- 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.

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.)

Crosscutting Concepts:

Stability and Change

▪ Small changes in one part of a system might cause large changes in another part.

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Connections to Engineering, Technology, and Applications of Science

Influence of Science, Engineering, and Technology on Society and the Natural World

▪ The use of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus technology use varies from region to region and over time.

Connections to Nature of Science

Science Addresses Questions About the Natural and Material World

▪ Science knowledge can describe consequences of actions but does not make the decisions that society takes.

Common Core State Standards Connections:

ELA/Literacy –

RST.6-8.8 Distinguish among facts, reasoned judgment based on research findings, and speculation in a text.

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.

Mathematics –

MP.4 Model with mathematics.

6.RP.A.3 Use ratio and rate reasoning to solve real-world and mathematical problems.

Additional Science and Engineering Practices:

Asking Questions and Defining Problems

▪ Ask questions that arise from careful observation of phenomena, models, or unexpected results, to clarify and/or seek additional information.

▪ Ask questions to identify and/or clarify evidence and/or the premise(s) of an argument.

▪ Ask questions to determine relationships between independent and dependent variables and relationships in models..

▪ Ask questions to clarify and/or refine a model, an explanation, or an engineering problem.

▪ Ask questions that require sufficient and appropriate empirical evidence to answer.

Developing and Using Models

▪ Evaluate limitations of a model for a proposed object or tool.

▪ Develop or modify a model—based on evidence – to match what happens if a variable or component of a system is changed.

▪ Use and/or develop a model of simple systems with uncertain and less predictable factors.

▪ Develop and/or revise a model to show the relationships among variables, including those that are not observable but predict observable phenomena.

▪ Develop a model to describe unobservable mechanisms.

▪ Develop and/or use a model to generate data to test ideas about phenomena in natural or designed systems, including those representing inputs and outputs, and those at unobservable scales.

Planning and Carrying Out Investigations

- Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim.
- Conduct an investigation and/or evaluate and/or revise the experimental design to produce data to serve as the basis for evidence that meet the goals of the investigation.
- Evaluate the accuracy of various methods for collecting data.
- Collect data to produce data to serve as the basis for evidence to answer scientific questions or test design solutions under a range of conditions.

Analyzing and Interpreting Data

- Apply concepts of statistics and probability (including mean, median, mode, and variability) to analyze and characterize data, using digital tools when feasible.
- Analyze and interpret data to determine similarities and differences in findings.

Using Mathematical Models and Computational Thinking

- Use mathematical representations to describe and/or support scientific conclusions and design solutions.
- Apply mathematical concepts and/or processes (such as ratio, rate, percent, basic operations, and simple algebra) to scientific and engineering questions and problems.

Constructing Explanations and Designing Solutions

- Construct an explanation using models or representations.
- Apply scientific ideas, principles, and/or evidence to construct, revise and/or use an explanation for real-world phenomena, examples, or events.
- Apply scientific reasoning to show why the data or evidence is adequate for the explanation or conclusion.

Obtaining Evaluating and Communicating Information

- Critically read scientific texts adapted for classroom use to determine the central ideas and/or obtain scientific and/or technical information to describe patterns in and/or evidence about the natural and designed world(s).
- Integrate qualitative and/or quantitative scientific and/or technical information in written text with that contained in media and visual displays to clarify claims and findings.
- Gather, read, synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and methods used, and describe how they are supported or not supported by evidence
- Communicate scientific and/or technical information (e.g. about a proposed object, tool, process, system) in writing and/or through oral presentations.

Additional Crosscutting Concepts:

Patterns

- Patterns in rates of change and other numerical relationships can provide information about natural and human designed systems.
- Graphs, charts, and images can be used to identify patterns in data.

Cause and Effect: Mechanism and Prediction

- Relationships can be classified as causal or correlational, and correlation does not necessarily imply causation.

Systems and System Models

- Models can be used to represent systems and their interactions—such as inputs, processes and

outputs—and energy, matter, and information flows within systems.
- Models are limited in that they only represent certain aspects of the system under study.

Stability and Change
- Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales, including the atomic scale.
- Stability might be disturbed either by sudden events or gradual changes that accumulate over time.
- Systems in dynamic equilibrium are stable due to a balance of feedback mechanisms.

Connections to Engineering, Technology, and Applications of Science
Influence of Science, Engineering, and Technology on Society and the Natural World
- All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural environment.

Okeanos Explorer **Education Materials Collection, Volume 2: Why Do We Explore?**
Next Generation Science Standards Performance Expectations

Lesson: Off Base (HS)

HS-PS1 Matter and Interaction

Performance Expectations:
HS-PS1-6. Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.* [Clarification Statement: Emphasis is on the application of Le Chatlier's Principle and on refining designs of chemical reaction systems, including descriptions of the connection between changes made at the macroscopic level and what happens at the molecular level. Examples of designs could include different ways to increase product formation including adding reactants or removing products.] [Assessment Boundary: Assessment is limited to specifying the change in only one variable at a time. Assessment does not include calculating equilibrium constants and concentrations.]

Science and Engineering Practices:
None

Disciplinary Core Ideas:
PS1.B: Chemical Reactions
- In many situations, a dynamic and condition-dependent balance between a reaction and the reverse reaction determines the numbers of all types of molecules present.

Crosscutting Concepts:
Stability and Change
- Much of science deals with constructing explanations of how things change and how they remain stable.

Common Core State Standards Connections:
ELA/Literacy-
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.

HS-ESS3 Earth and Human Activity

Performance Expectations:
HS-ESS3-6. Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity. [Clarification Statement: Examples of Earth systems to be considered are the hydrosphere, atmosphere, cryosphere, geosphere, and/or biosphere. An example of the far-reaching impacts from a human activity is how an increase in atmospheric carbon dioxide results in an increase in photosynthetic biomass on land and an increase in ocean acidification, with resulting impacts on sea organism health and marine populations.] [Assessment Boundary: Assessment does not include running computational representations but is limited to using the published results of scientific computational models.]

Science and Engineering Practices:
Using Mathematics and Computational Thinking
- Use a computational representation of phenomena or design solutions to describe and/or support claims and/or explanations.

Disciplinary Core Ideas:

ESS2.D: Weather and Climate

- 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.

ESS3.D. Global Climate Change

- 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.

Crosscutting Concepts:

Systems and System Models

- When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models.

Common Core State Standards Connections:

Mathematics -

MP.2 Reason abstractly and quantitatively.

HSN-Q.A.2 Define appropriate quantities for the purpose of descriptive modeling

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

Additional Science and Engineering Practices:

Asking Questions and Defining Problems

- Ask questions that arise from examining models or a theory, to clarify and/or seek additional information and relationships
- Ask questions to determine relationships, including quantitative relationships, between independent and dependent variables.
- 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.

Developing and Using Models

- 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.

Planning and Carrying Out Investigations

- 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.
- Plan and conduct an investigation or test a design solution in a safe and ethical manner including considerations of environmental, social, and personal impacts.
- Make directional hypotheses that specify what happens to a dependent variable when an independent variable is manipulated.

Analyzing and Interpreting 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.

Using Mathematics and Computational Thinking

- Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations.

Constructing Explanations and Designing Solutions

- Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables.
- 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.

Obtaining Evaluating and Communicating Information

- 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.

Additional Crosscutting Concepts:

Cause and Effect: Mechanism and Prediction

- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.
- Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system. ▪
- Changes in systems may have various causes that may not have equal effects.

Systems and System Models

- When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using 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.

Stability and Change

- Much of science deals with constructing explanations of how things change and how they remain stable.
- Feedback (negative or positive) can stabilize or destabilize a system.