Lesson Title: Which critters can you find at the Living Breakwaters?

Unit: Living Breakwaters (LB) Curriculum: Restoration and Resilience in Raritan Bay
Chapter: Which critters do you hope to find at the Living Breakwaters?

LESSON OVERVIEW

Grade: 6-8   Class Periods: 1-2   Setting: field and classroom   Subject Area(s): science

Lesson Summary
At a facility along NY Harbor where they can sample for critters in at least two different ways, students collect data from those samples. They use these data as a preliminary test of the hypotheses they developed in the previous lesson, ‘Which creatures do you hope to find at the Living Breakwaters?’

Objective(s)
- Students collect data from species samples on board a boat at the Living Breakwaters.
- Students compare these data to the predictions they developed in the previous lesson, ‘Which critters do you hope to find at the Living Breakwaters?’

MATERIALS & RESOURCES

Supplies
- Clipboards - one for each student
- Rite in the Rain (or other waterproof paper) - at least three sheets for each student
- Extra supplies for students to use, such as hand sanitizer, sunscreen, snacks, and water bottles
- A dry-bag or plenty of zippable plastic bags - enough to protect everyone’s electronic equipment from getting wet
- Work gloves or nitrile gloves - at least one pair for each student
- Sheet protectors - one per student, so they can bring the predictions they developed in the previous lesson, ‘Which critters do you hope to find at the Living Breakwaters?’

BEFORE YOU GET STARTED

Preparation
- Be sure to reach out well in advance to the organization that will help you sample critter from NY Harbor at least two different ways (for example seining and fish traps). To find an organization like that, start by contacting the Waterfront Alliance and the NY-NJ Harbor Estuary Program to ask for suggestions.
Students need to bring their completed work from the previous lesson. The previous lesson is called 'Which critters do you hope to find at the Living Breakwaters'. During that lesson, the students wrote down their predictions in the handout called ‘How can you find your critters at the Living Breakwaters?’ They need those predictions to motivate their data collection on-board.

You can complete the Explain, Elaborate, and Evaluate parts of the lesson on a subsequent day, back in the classroom.

**INSTRUCTION PLAN**

**Engage**
1. Guided by onboard personnel, students observe the different kinds of monitoring equipment that is available on the boat.
2. Students re-read their completed work in the handout called 'How can you find your critters at the Living Breakwaters?'
3. Now that they are looking at the equipment, students describe, in a small-group discussion:
   - Any surprises? Do the materials look different from what you were picturing in your mind?
   - What kinds of critters did you predict would be collected using the methods available on this boat? Were you all expecting some different things?
   - Now that you’ve heard from your classmates and are observing this equipment in real life, do you want to modify any of your predictions?
4. Students record their revised predictions.

**Explore**
1. Guided by onboard personnel, students collect critter samples in at least two different ways.
2. Students collect data from those samples.
3. Guided by onboard personnel, students also conduct water quality tests to correspond with the predictions they made in the previous lesson, for:
   - Salinity
   - Temperature
   - Amount of dissolved oxygen
   - Amount of dissolved plant nutrients, such as nitrates and phosphates
   - pH (how acidic / basic the water is)
   - Turbidity (how cloudy the water is -- the more cloudy the water is, the less light can get through it)
4. Students bring all their data back to school, where the lesson can be completed on a subsequent day.

**Explain**
In small group discussions, students consider:
● What were you expecting to see from each type of sampling method? Why were you expecting that?
● What data did you collect? Did you get the same data as your classmates?
● How did you record and display your data? How is that different from what your classmates did?

Elaborate
In a full-class discussion, students analyze:
● What critters had you been expecting to see at the Living Breakwaters, using each of the sampling methods?
● Which water quality factors did you predict would make a difference when it comes to finding the critters you were focusing on?
  ○ Did you think salinity would matter for your critters? What was the salinity that you measured from the boat? Was it unexpected? Do you think the salinity at that time affected which critters we found?
  ○ Did you think temperature would matter for your critters?.... And so on
● Did you find the critters you expected to find? Why do you think it turned out that way?

Evaluate
Students write their answers to the question: if you had unlimited time and resources to use this boat and its equipment for research anywhere you like in Raritan Bay, what would you like to know more about? Design a data collection plan, including:
● When, exactly, would you collect data? Be specific about time of day, time of year, and the tide. Explain your reasoning.
● Where, exactly would you collect data? Be specific about which locations in Raritan Bay you would visit. Explain your reasoning.
● What kinds of data would you collect? Which kinds of sampling methods are important for you to be able to find out what you want to know about the critters? What kinds of data would you collect about the water itself?
● How would this data tell you something interesting or important about the ecosystem(s) of Raritan Bay?
STANDARDS

NYC Scope and Sequence Grade 5

Crosscutting Concepts
● A system can be described in terms of its components and their interactions. (5-LS2-1)

Science and Engineering Practices
● Develop a model to describe phenomena. (5-PS1-1), (5-LS2-1)
● Use models to describe phenomena. (5-PS3-1)
● critiquing the scientific explanations or solutions proposed by peers by citing relevant evidence about the natural and designed world(s). Support an argument with evidence, data, or a model.

Grade 5 Unit 2: Matter and Energy in Ecosystems -- How do matter and energy flow through ecosystems?
Disciplinary Core Ideas organized by Performance Expectations
● 5-PS3-1. Use models to describe that energy in animals’ food (used for body repair, growth, motion, and to maintain body warmth) was once energy from the Sun.
  ○ Emphasis should be on plants converting light energy by photosynthesis into usable energy. Examples of models could include diagrams and flow charts.
● 5-LS1-1. Support an argument that plants get the materials they need for growth chiefly from air and water.
  ○ Emphasis is on the idea that plant matter comes mostly from air and water, not from the soil.
● 5-LS2-1. Develop a model to describe the movement of matter among plants (producers), animals (consumers), decomposers, and the environment.
Emphasis is on the flow of energy and cycling of matter in systems such as organisms, ecosystems, and/or Earth.

Assessment does not include molecular explanations.

LS2.A: Interdependent Relationships in Ecosystems

- The food of almost any kind of animal can be traced back to plants. Organisms are related in food webs in which some animals eat plants for food and other animals eat the animals that eat plants. Some organisms, such as fungi and bacteria, break down dead organisms (both plants or plants parts and animals) and therefore operate as “decomposers.” Decomposition eventually restores (recycles) some materials back to the soil. Organisms can survive only in environments in which their particular needs are met. A healthy ecosystem is one in which multiple species of different types are each able to meet their needs in a relatively stable web of life. Newly introduced species can damage the balance of an ecosystem. (5-LS2-1)

NYC Scope and Sequence Science 6-8

Science and Engineering Practices

- extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis
- Construct an explanation that includes qualitative or quantitative relationships between variables that predict phenomena
  - supported by multiple sources of evidence consistent with scientific ideas, principles, and theories.
- Develop and use a model to describe, test, and predict more abstract phenomena
- argument that supports or refutes claims for either explanations or solutions about the natural and designed world(s).

Crosscutting Concepts

- Patterns can be used to identify cause and effect relationships. (MS-LS2-2)
- Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-LS2-1)
- The transfer of energy can be tracked as energy flows through a natural system. (MS-LS2-3)
- Small changes in one part of a system might cause large changes in another part. (MS-LS2-4), (MS-LS2-5)
- Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability. (MS-LS1-4), (MS-LS1-5)
- Structures… can be visualized… and used to describe how their function depends on the shapes, composition, and relationships among their parts (MS-LS3-1)

Grade 6, Unit 3: Ecosystems -- Why does the Earth never run out of matter or energy?

Disciplinary Core Ideas organized by 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.
  - 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.
Growth of organisms and population increases are limited by access to resources. (MS-LS2-1)
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. (MS-LS2-1)
Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors. (MS-LS2-1)

- **MS-LS2-2.** Construct an explanation that predicts patterns of interactions among organisms in a variety of ecosystems.
  - Emphasis is on predicting patterns of interactions such as competition, predation, mutualism, and parasitism in different ecosystems in terms of the relationships among and between organisms.
  - 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. (MS-LS2-2)

- **MS-LS2-3.** Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.
  - Emphasis is on describing the conservation of matter and flow of energy associated with ecosystem, and on defining the boundaries of the ecosystem.
  - Assessment does not include the use of chemical reactions to describe the processes.
  - 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. (MS-LS2-3)

- **MS-LS2-4.** Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.
  - Emphasis is on recognizing patterns in data and making warranted inferences about shifts in populations due to changes in the ecosystem.
  - 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. (MS-LS2-4)

- **MS-LS2-5.** Evaluate competing design solutions for maintaining biodiversity and protecting ecosystem stability.
  - Examples of ecosystem protections could include water purification, waste management, nutrient recycling, prevention of soil erosion, and eradication of invasive species. Examples of design solution constraints could include scientific, economic, and social considerations.
○ Biodiversity describes the variety of species found in Earth’s ecosystems. The completeness or integrity of an ecosystem’s biodiversity is often used as a measure of its health. (MS-LS2-5)
○ Changes in biodiversity can influence humans’ resources, such as food, energy, and medicines, as well as ecosystem services that humans rely on—for example, water purification and recycling. (secondary to MS-LS2-5)
○ Humans impact biodiversity both positively and negatively. (secondary to MS-LS2-5)

Connections to Nature 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. (MS-LS2-5)

Science Addresses Questions About the Natural and Material World
● Scientific knowledge can describe the consequences of actions but does not necessarily prescribe the decisions that society takes. (MS-LS2-5)

Grade 8, Unit 3: Growth, Development, and Reproduction of Organisms
Disciplinary Core Ideas organized by Performance Expectations
● MS-LS1-4. Use argument based on empirical evidence and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants, respectively.
○ Clarification Statement: Examples of behaviors that affect the probability of animal reproduction could include nest building to protect young from cold, herding of animals to protect young from predators, and vocalization of animals and colorful plumage to attract mates for breeding. Examples of animal behaviors that affect the probability of plant reproduction could include transferring pollen or seeds, and creating conditions for seed germination and growth. Examples of plant structures could include bright flowers attracting butterflies that transfer pollen, flower nectar and odors that attract insects that transfer pollen, and hard shells on nuts that squirrels bury.
○ Animals engage in characteristic behaviors that increase the odds of reproduction. (MS-LS1-4)
○ Plants reproduce in a variety of ways, sometimes depending on animal behavior and specialized features for reproduction. (MS-LS1-4)

● MS-LS1-5. Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.
○ Examples of local environmental conditions could include availability of food, light, space, and water. Examples of genetic factors could include the genes responsible for size differences in different breeds of dogs. 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 does not include genetic mechanisms, gene regulation, biochemical processes, or natural selection.
Genetic factors as well as local conditions affect the growth of the adult plant. (MS-LS1-5)

Grade 8, Unit 4: Evolution, Natural Selection, and Adaptations

Disciplinary Core Ideas organized by Performance Expectations
- MS-LS4-3. Analyze displays of pictorial data to compare patterns of similarities in the embryological development across multiple species to identify relationships not evident in the fully formed anatomy.
  - Emphasis is on inferring general patterns of relatedness among embryos of different organisms by comparing the macroscopic appearance of diagrams or pictures.
  - Assessment of comparisons is limited to gross appearance of anatomical structures in embryological development.
  - Comparison of the embryological development of different species also reveals similarities that show relationships not evident in the fully-formed anatomy. (MS-LS4-3)

NYS NGSS -- what will be part of Living Environment

Science and Engineering Practices
- Develop a model based on evidence to illustrate the relationships between systems or components of a system. (HS-LS2-5)
- Use mathematical representations of phenomena or design solutions to support claims. (HS-LS2-4)
- Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources

Crosscutting Concepts
- Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales. (HS-LS2-5)
- Energy drives the cycling of matter within and between systems. (HS-LS2-3)

Disciplinary Core Idea
- LS2.B: Cycles of Matter and Energy Transfer in Ecosystems
  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. 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-LS2-4)

Connection to the Nature of Science
- Most scientific knowledge is quite durable, but is, in principle, subject to change based on new evidence and/or reinterpretation of existing evidence. (HS-LS2-3)
NGSS High School standards

Disciplinary Core Ideas

- **LS1.A Structure and function**
  Systems of specialized cells within organisms help perform essential functions of life. Any one system in an organism is made up of numerous parts. Feedback mechanisms maintain an organism’s internal conditions within certain limits and mediate behaviors.

- **LS1.B Growth and development of organisms**
  Growth and division of cells in organisms occurs by mitosis and differentiation for specific cell types.

- **LS2.A Interdependent relationships within ecosystems**
  The fundamental tension between resource availability and organism populations affects the abundance of species in any given ecosystem.

- **LS2.B Cycles of matter and energy transfer in ecosystems**
  Photosynthesis and cellular respiration provide most of the energy for life processes. Only a fraction of matter consumed at the lower level of a food web is transferred up, resulting in fewer organisms at higher levels. At each link in an ecosystem elements are combined in different ways and matter and energy are conserved. Photosynthesis and cellular respiration are key components of the global carbon cycle.

- **LS2.D Social interactions and group behavior**
  Group behavior has evolved because membership can increase the chances of survival for individuals and their genetic relatives.

- **LS3.A Inheritance of traits**
  DNA carries instructions for forming species’ characteristics. Each cell in an organism has the same genetic content, but genes expressed by cells can differ.

- **LS4.A Evidence of common ancestry and diversity**
  The ongoing branching that produces multiple lines of descent can be inferred by comparing DNA sequences, amino acid sequences, and anatomical and embryological evidence of different organisms.

- **LS4.B Natural selection**
  Natural selection occurs only if there is variation in the genes and traits between organisms in a population. Traits that positively affect survival can become more common in a population.

- **LS4.C Adaptation**
  Evolution results primarily from genetic variation of individuals in a species, competition for resources, and proliferation of organisms better able to survive and reproduce.

Crosscutting Concepts

- **Patterns**
  In grades 9-12, students observe patterns in systems at different scales and cite patterns as
empirical evidence for causality in supporting their explanations of phenomena. They recognize classifications or explanations used at one scale may not be useful or need revision using a different scale; thus requiring improved investigations and experiments. They use mathematical representations to identify certain patterns and analyze patterns of performance in order to reengineer and improve a designed system.

- **Cause and effect**
  In grades 9-12, students understand that empirical evidence is required to differentiate between cause and correlation and to make claims about specific causes and effects. They suggest cause and effect relationships to explain and predict behaviors in complex natural and designed systems. They also propose causal relationships by examining what is known about smaller scale mechanisms within the system. They recognize changes in systems may have various causes that may not have equal effects.

- **Scale, proportion, and quantity**
  In grades 9-12, students understand the significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. They recognize patterns observable at one scale may not be observable or exist at other scales, and some systems can only be studied indirectly as they are too small, too large, too fast, or too slow to observe directly. Students use orders of magnitude to understand how a model at one scale relates to a model at another scale. They use algebraic thinking to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth).

- **Systems and system models**
  In grades 9-12, students can investigate or analyze a system by defining its boundaries and initial conditions, as well as its inputs and outputs. They can use models (e.g., physical, mathematical, computer models) to simulate the flow of energy, matter, and interactions within and between systems at different scales. They can also use models and simulations to predict the behavior of a system, and recognize that these predictions have limited precision and reliability due to the assumptions and approximations inherent in the models. They can also design systems to do specific tasks.

- **Energy and matter: flows, cycles, and conservation**
  In grades 9-12, students learn that the total amount of energy and matter in closed systems is conserved. They can describe changes of energy and matter in a system in terms of energy and matter flows into, out of, and within that system. They also learn that energy cannot be created or destroyed. It 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**
  In grades 9-12, students investigate systems by examining the properties of different materials, the structures of different components, and their interconnections to reveal the system’s function and/or solve a problem. They infer the functions and properties of natural and designed objects and systems from their overall structure, the way their components are shaped and used, and the molecular substructures of their various materials.
Stability and change
In grades 9-12, students understand much of science deals with constructing explanations of how things change and how they remain stable. They quantify and model changes in systems over very short or very long periods of time. They see some changes are irreversible, and negative feedback can stabilize a system, while positive feedback can destabilize it. They recognize systems can be designed for greater or lesser stability.

Science and Engineering Practices

- Asking questions (for science) and defining problems (for engineering)
  ...in 9–12 progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations.
    - 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 determine relationships, including quantitative relationships, between independent and dependent variables.
      - to clarify and refine a model, an explanation, or an engineering problem.
    - Evaluate a question to determine if it is testable and relevant.
    - 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.
    - Ask and/or evaluate questions that challenge the premise(s) of an argument, the interpretation of a data set, or the suitability of a design.
    - Define a design problem that involves the development of a process or system with interacting components and criteria and constraints that may include social, technical, and/or environmental considerations.

- Developing and using models
  ...in 9-12 progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds.
    - 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.
    - Design a test of a model to ascertain its reliability.
    - 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 multiple types of models to provide mechanistic accounts and/or predict phenomena, and move flexibly between model types based on merits and limitations.
    - Develop a complex model that allows for manipulation and testing of a proposed process or 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.
Planning and carrying out investigations
...in 9-12 progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models.
  ○ 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 individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.
  ○ Plan and conduct an investigation or test a design solution in a safe and ethical manner including considerations of environmental, social, and personal impacts.
  ○ Select appropriate tools to collect, record, analyze, and evaluate data.
  ○ Make directional hypotheses that specify what happens to a dependent variable when an independent variable is manipulated.
  ○ Manipulate variables and collect data about a complex model of a proposed process or system to identify failure points or improve performance relative to criteria for success or other variables.

Analyzing and interpreting data
...in 9-12 progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data.
  ○ Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution.
  ○ Apply concepts of statistics and probability (including determining function fits to data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible.
  ○ Consider limitations of data analysis (e.g., measurement error, sample selection) when analyzing and interpreting data.
  ○ Compare and contrast various types of data sets (e.g., self-generated, archival) to examine consistency of measurements and observations.
  ○ Evaluate the impact of new data on a working explanation and/or model of a proposed process or system.
  ○ Analyze data to identify design features or characteristics of the components of a proposed process or system to optimize it relative to criteria for success.

Using mathematics and computational thinking
...in 9-12 progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.
  ○ Create and/or revise a computational model or simulation of a phenomenon, designed device, process, or system.
○ 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.
○ Use simple limit cases to test mathematical expressions, computer programs, algorithms, or simulations of a process or system to see if a model “makes sense” by comparing the outcomes with what is known about the real world.
○ 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.)

● Constructing explanations (for science) and designing solutions (for engineering) ...in 9-12 progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.
○ Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables.
○ 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 ideas, principles, and/or evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects.
○ 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.
○ Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.

● Engaging in argument from evidence ...in 9-12 progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science.
○ 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.
○ Construct, use, and/or present an oral and written argument or counter-arguments based on data and evidence.
○ Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge and student-generated evidence.
○ Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and/or logical arguments regarding relevant factors (e.g. economic, societal, environmental, ethical considerations).

● Obtaining, evaluating, and communicating information
  ...in 9-12 progresses to evaluating the validity and reliability of the claims, methods, and designs.
  ○ 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.
  ○ Evaluate the validity and reliability of and/or synthesize multiple claims, methods, and/or designs that appear in scientific and technical texts or media reports, verifying the data when possible.
  ○ 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, mathematically).