Science, Technology, and Engineering Standards

Science and engineering provide people with knowledge and tools to understand and address many of the challenges of a rapidly changing world, thus enabling them to be **creative and practical problem solvers** (Maine Guiding Principle C). Science is a way of knowing about the world that enables people to both engage in the construction of new knowledge and to use information to achieve desired ends (NIH). Engineering enables people to systematically solve problems using scientific knowledge, to design and test solutions and evaluate them using agreed-upon and measurable criteria.

Science and Engineering Literacy

In the last few decades, much has been written about the critical role of science literacy in an equitable and just society. For example, the Board on Science Education within the National Academies of Science argue that

> "Science literacy is desirable not only for individuals, but also for the health and well-being of communities and society. More than just basic knowledge of science facts, contemporary definitions of science literacy have expanded to include understandings of scientific processes and practices, familiarity with how science and scientists work, a capacity to weigh and evaluate the products of science, and an ability to engage in civic decisions about the value of science."

Here we recognize that, in addition to understanding and evaluating science knowledge and critiquing the development of that knowledge, learners must also develop literacy related to science and engineering practices and design. In other words, they should know about and be able to critique the processes by which engineers develop and test products in response to consumer, industrial, and/or civic needs. The Maine Science and Engineering Standards provide a framework for supporting K-12 students' development as **self-directed lifelong learners** (Maine Guiding Principle B) who are able to apply knowledge from the domains of science and engineering to set goals and make decisions.

Understanding Controversy in Science

Individuals have ready access to abundant information in our modern global society. Consequently, they will encounter myriad arguments related to various scientific topics. Moreover, arguments will change over time, as new evidence becomes available and as people draw on scientific evidence to formulate arguments in shifting social contexts. It is therefore imperative that individuals understand that controversy within the scientific community is normal and has been historically productive. "True scientific controversy involves competing scientific ideas that are evaluated according to the standards of science — i.e., fitting the evidence, generating accurate expectations, offering satisfying explanations, inspiring research, etc...few theories fit our observations of the world perfectly. There is usually some anomalous observation that doesn't seem to fit with our current understanding. Scientists assume that by working at such anomalies, they'll either disentangle them to see how they fit with the current theory or contribute to a new theory" ("Even Theories Change." Understanding Science. University of California Museum of Paleontology. 23 July 2018 <http://www.understandingscience.org/article/alvarez_01>). One well documented example of productive controversy is the development of modern theories that explain and predict phenomena in the physical world. Newton originally posited a theory of mechanics that adequately explained phenomena as varied as projectile motion and planetary orbit. Centuries later, Einstein developed the theory of special relativity to account for additional phenomena related to electricity and magnetism. The need to account for and predict the effects of gravity spurred scientists to offer the theory of general relativity. Thus, “theory change is a community process of feedback, experiment, observation, and communication. It usually involves interpreting existing data in new ways and incorporating those views with new results” ("Even Theories Change." Understanding Science. University of California Museum of Paleontology. 23 July 2018 <http://www.understandingscience.org/article/alvarez_01>).

Becoming Critical and Engaged Consumers of Science and Engineering
As learners encounter diverse perspectives related to scientific issues, it is crucial that they become **integrative and informed thinkers** (Maine Guiding Principle E) able to discern reliable and valid information. Such information is generated through accepted scientific and engineering practices (e.g., analyzing and interpreting data, engaging in argument from evidence, etc.). Armed with knowledge and these skills, learners will be able to function as **responsible and involved citizens** (Maine Guiding Principle D) who utilize **clear and effective communication** strategies (Maine Guiding Principle A) to participate productively in decision making that impacts the broader community.

References:

National Research Council. 2012. *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*. Washington, DC: The National Academies Press.

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NGSS Lead States. (2013). *Next Generation Science Standards*: For states, by states. Washington, DC: The National Academies Press.

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Committee on Science Literacy and Public Perception of Science; Board on Science Education; Division of Behavioral and Social Sciences and Education; National Academies of Sciences, Engineering, and Medicine; Snow CE, Dibner KA, editors. Washington (DC): National Academies Press (US); 2016 Oct 14.

OUTLINE OF SCIENCE, TECHNOLOGY AND ENGINEERING STRANDS AND STANDARDS

Physical Sciences

- PS1 Matter and Its Interactions
- PS2 Motion and Stability: Forces and Interactions
- PS3 Energy
- PS4 Waves and Their Applications in Technologies

Life Sciences

- LS1 From Molecules to Organisms: Structures and Processes
- LS2 Ecosystems: Interactions, Energy, and Dynamics
- LS3 Heredity: Inheritance and Variation of Traits
- LS4 Biological Evolution: Unity and Diversity

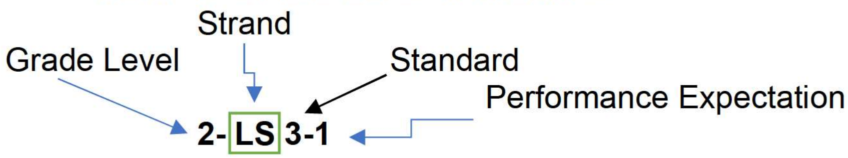
Earth and Space Sciences

- ESS1 Earth's Place in the Universe
- ESS2 Earth's Systems
- ESS3 Earth and Human Activity

Engineering, Technology, and Applications of Science

- ETS1 Engineering Design

HOW TO READ THE STANDARDS



COLOR SCHEME

Science & Engineering Practices (blue)
Disciplinary Core Ideas (orange)
Crosscutting Concepts (green)

	Further explanation: Emphasis is on how the experimental evidence supports the claim and how a theory is generally modified in light of new evidence. Examples of a phenomenon could include resonance, interference, diffraction, and photoelectric effect. Engaging in Argument from Evidence, Wave Properties, Systems and System Models
	<u>HS-PS4-4</u> Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter. Further explanation: Emphasis is on the idea that photons associated with different frequencies of light have different energies, and the damage to living tissue from electromagnetic radiation depends on the energy of the radiation. Examples of published materials could include trade books, magazines, web resources, videos, and other passages that may reflect bias. Arguments and evidence could be made for dangers of cell phone usage or living near high voltage power lines. Obtaining, Evaluating, and Communicating Information, Electromagnetic Radiation, Cause and Effect
	<u>HS-PS4-5</u> Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy. Further explanation: Examples could include solar cells capturing light and converting it to electricity; medical imaging; and communications technology. Obtaining, Evaluating, and Communicating Information, Wave Properties, Electromagnetic Radiation, Information Technologies and Instrumentation, Cause and Effect

Strand	Life Sciences (LS)		
Standard	LS1: From Molecules to Organisms: Structures and Processes		
	Childhood		
	Kindergarten	Grade 1	Grade 2
Performance Expectations	**<u>K-LS1-1</u> Use observations to describe patterns of what plants and animals (including humans) need to survive.** Further explanation: Examples of patterns could include that animals need	**<u>1-LS1-1</u> Use materials to design a solution to a human problem by mimicking how plants and/or animals use their external parts to help them survive, grow, and meet their needs.** Further explanation: Examples of human problems that can be solved by mimicking plant or animal solutions could include	

	to take in food but plants do not, the different kinds of food needed by different types of animals, the requirement of plants to have light, and that all living things need water. Examples could include the pattern a bear makes when preparing to hibernate for winter, the seasonal patterns of trees losing and/or keeping their leaves. Analyzing and Interpreting Data, Organization for Matter and Energy Flow in Organisms, Patterns	designing clothing or equipment to protect bicyclists by mimicking turtle shells, acorn shells, and animal scales; stabilizing structures by mimicking animal tails and roots on plants; keeping out intruders by mimicking thorns on branches and animal quills; waterproofing boots, jackets, gloves thereby mimicking animal feathers and, detecting intruders by mimicking eyes and ears. Constructing Explanations and Designing Solutions, Structure and Function, Information Processing, Structure and Function **1-LS1-2 Read texts and use media to determine patterns in behavior of parents and offspring that help offspring survive.** Further explanation: Examples of patterns of behaviors could include the signals that offspring make (such as crying, cheeping, and other vocalizations) and the responses of the parents (such as feeding, comforting, and protecting the offspring). Potential Maine connections include Maine animal sounds to signal their offspring (e.g. loons, moose, deer, coyotes, etc.) and how animals, especially birds, bring back food for their young. Obtaining, Evaluating, and Communicating Information, Growth and Development of Organisms, Patterns	

Strand	Life Sciences (LS)		
Standard	LS1: From Molecules to Organisms: Structures and Processes		
	Childhood		
	Grade 3	Grade 4	Grade 5
Performance Expectations	**3-LS1-1 Develop models to describe that organisms have unique and diverse life cycles but all have in common birth, growth, reproduction, and death.** Further Explanation: Changes organisms go through during their life form a pattern. Potential Maine connections include frogs in vernal pools, Atlantic salmon life cycle and gestation vs. metamorphosis. Developing and Using Models, Growth and Development of Organisms, Patterns	**4-LS1-1 Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction.** Further Explanation: Examples of structures could include thorns, stems, roots, colored petals, heart, stomach, lung, brain, and skin found in Maine plants and animals. Engaging in Argument from Evidence, Structure and Function, Systems and System Models **4-LS1-2 Use a model to describe that animals receive different types of information**	**5-LS1-1 Support an argument that plants get the materials they need for growth chiefly from air and water.** Further Explanation: Emphasis is on the idea that plant matter comes mostly from air and water, not from the soil. Investigate Maine plants. Engaging in Argument from Evidence, Organization for Matter and Energy Flow in Organisms, Energy and Matter

		through their senses, process the information in their brain, and respond to the information in different ways. Further Explanation: Emphasis is on systems of information transfer. Engaging in Argument from Evidence, Information Processing, Systems and System Models	

Strand	Life Sciences (LS)
Standard	LS1: From Molecules to Organisms: Structures and Processes
	Early Adolescence
	Grades 6-8
Performance Expectations	**MS-LS1-1 Conduct an investigation to provide evidence that living things are made of cells; either one cell or many different numbers and types of cells.** Further explanation: Emphasis is on developing evidence that living things are made of cells, distinguishing between living and non-living things, and understanding that living things may be made of one cell or many and varied cells. Planning and carrying out investigations; structure and function; scale, proportion, and quantity
	MS-LS1-2 Develop and use a model to describe the function of a cell as a whole and ways the parts of cells contribute to the function. Further explanation: Emphasis is on the cell functioning as a whole system and the primary role of identified parts of the cell, specifically the nucleus, chloroplasts, mitochondria, cell membrane, and cell wall. Developing and using models; structure and function; structure and function
	MS-LS1-3 Use argument supported by evidence for how the body is a system of interacting sub-systems composed of groups of cells.

	Further explanation: Emphasis is on conceptual understanding that cells form tissues and tissues form organs specialized for particular body functions. Examples could include the interaction of sub-systems within a system and the normal functioning of those systems. Engaging in argument from evidence; structure and function; system and system models
	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. Further explanation: 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. Potential Maine connections could include herding of white-tail deer and caribou, vocalizations of moose and cardinals, and keystone species such as those on the coast (e.g. harbor seals and sea stars).
	MS-LS1-5 Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms. Further explanation: 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 the 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 in small ponds. Examples could include winter and cold temperatures, hibernation (e.g. black bear), and the migration of hummingbirds and Canada geese. Constructing explanations and designing solutions; growth and development of organisms; cause and effect
	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. Further explanation: Emphasis is on tracing movement of matter and flow of energy. Constructing explanations and designing solutions; organization for matter and energy flow in organisms; energy in chemical processes and everyday life; energy and matter
	MS-LS1-7 Develop a model to describe how food is rearranged through chemical reactions forming new molecules that support growth and/or release energy as this matter moves through an organism.

	Further explanation: Emphasis is on describing that molecules are broken apart and put back together and that in this process energy is released. Developing and using models; organization for matter and energy flow in organisms; energy in chemical processes and everyday life; energy and matter
	<u>MS-LS1-8</u> Gather and synthesize information that sensory receptors respond to stimuli by sending messages to the brain for immediate behavior or storage as memories. Obtaining, evaluating, and communicating information; information processing; cause and effect

Strand	Life Sciences (LS)
Standard	LS1: From Molecules to Organisms: Structures and Processes
	Adolescence
	Grades 9-Diploma
Performance Expectations	**<u>HS-LS1-1</u> Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins which carry out the essential functions of life through systems of specialized cells.** Further explanation: Emphasis is on protein synthesis from DNA to codon to amino acid sequence. Constructing Explanations and Designing Solutions, Structure and Function, Structure and Function
	<u>HS-LS1-2</u> Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms. Further explanation: Emphasis is on functions at the organism system level such as nutrient uptake, water delivery, and organism movement in response to neural stimuli. An example of an interacting system could be an artery depending on the proper function of elastic tissue and smooth muscle to regulate and deliver the proper amount of blood within the circulatory system. Another example could be the water and nutrient intake in soft shell clams. Developing and Using Models, Structure and Function, Systems and System Models
	<u>HS-LS1-3</u> Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.

	Further explanation: Examples of investigations could include heart rate response to exercise, stomate response to moisture and temperature, and root development in response to water levels. Another example is commonly observed in the daphnia heart rate response to changes in temperature, caffeine, alcohol, or nicotine. Planning and Carrying out Investigations, Structure and Function, Stability and Change
	<u>HS-LS1-4</u> Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms. Developing and Using Models, Growth and Development of Organisms, Systems and System Models
	<u>HS-LS1-5</u> Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy. Further explanation: Emphasis is on illustrating inputs and outputs of matter and the transfer and transformation of energy in photosynthesis by plants and other photosynthesizing organisms. Examples of models could include diagrams, chemical equations, and conceptual models. Models may focus on Maine based economy of photosynthetic organisms such as seaweeds, potatoes and pine trees. Developing and Using Models, Organization for Matter and Energy flow in Organisms, Energy and Matter
	<u>HS-LS1-6</u> Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules. Further explanation: Emphasis is on using evidence from models and simulations to support explanations. Constructing Explanations and Designing Solutions, Organization for Matter and energy Flow in Organisms, Energy and Matter
	<u>HS-LS1-7</u> Use a model to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed, resulting in a net transfer of energy. Further explanation: Emphasis is on the conceptual understanding of the inputs and outputs of the process of cellular respiration. An example could be a moose eating a lily pad, the lily pad producing energy for the moose and the breathing of oxygen by the moose to enable the process of cellular respiration. Developing and Using Models, Organization for Matter and Energy Flow in Organisms, Energy and Matter

Strand	Life Sciences (LS)		
Standard	LS2: Ecosystems: Interactions, Energy, and Dynamics		
	Childhood		
	Kindergarten	Grade 1	Grade 2
Performance Expectations			**2-LS2-1 Plan and conduct an investigation to determine if plants need sunlight and water to grow.** Planning and Carrying out Investigations, Interdependent Relationships in Ecosystems, Cause and Effect **2-LS2-2 Develop a simple model that mimics the function of an animal in dispersing seeds or pollinating plants.** Further explanation: Examples of animals or insects that pollinate plants or disperse seeds could include bees, hummingbirds or bats. An example of a model could be using Velcro to show how seeds of burdocks are spread. Developing and Using Models, Interdependent Relationships in Ecosystems, Developing Possible Solutions, Structure and Function

Strand	Life Sciences (LS)		
Standard	LS2: Ecosystems: Interactions, Energy, and Dynamics		
	Childhood		
	Grade 3	Grade 4	Grade 5

Performance Expectations	**<u>3-LS2-1</u> Construct an argument that some animals form groups that help members survive.** Further explanation: Maine animals that form groups such as coyotes, deer herds, turkeys, bees, moose, salmon and alewives migration. Engaging in Argument from Evidence, Social Interactions and Group Behaviors, Cause and Effect		**<u>5-LS2-1</u> Develop a model to describe the movement of matter among plants, animals, decomposers, and the environment.** Further Explanation: Emphasis is on the idea that matter that is not food (air, water, decomposed materials in soil) is changed by plants into matter that is food. Examples of systems could include organisms, ecosystems, and the Earth. Utilize Maine or Atlantic plants and animals to develop a model of a food chain or web. Developing and Using Models, Interdependent Relationships in Ecosystems, Cycles of Matter and Energy Transfer, Systems and System Models

Strand	Life Sciences (LS)
Standard	LS2: Ecosystems: Interactions, Energy, and Dynamics
	Early Adolescence
	Grades 6-8
Performance Expectations	**<u>MS-LS2-1</u> Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.** Further explanation: Emphasis is on cause and effect relationships between resources and the growth of individual organisms and the numbers of organisms in ecosystems during periods of abundant and scarce resources. Analyzing and interpreting data; interdependent relationships in ecosystems; cause and effect
	<u>MS-LS2-2</u> Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.

	Further explanation: 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. Potential Maine connections include predation: coyotes and house cats with smaller prey or white tail deer and wolves; mutualism in the union of algae and fungus to form lichen; parasitism in deer ticks on dogs; and commensalism when barnacles attach to minke whales or a grey squirrel makes a nest in a red oak tree. Constructing explanations and designing solutions; interdependent relationships in ecosystems; patterns
	MS-LS2-3 Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem. Further explanation: 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. Explore the reason behind burning blueberry fields biennially and the cycling of matter. Developing and using models; cycle of matter and energy transfer in ecosystems; energy and matter
	MS-LS2-4 Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations. Further explanation: 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. Examples include the introduction of invasive species like the green crab or knotweed and their impact on native species. Explore the impacts of farming, urban sprawl and pollution. Engaging in argument from evidence; ecosystem dynamics, functioning, and resilience; stability and change
	MS-LS2-5 Evaluate competing design solutions for maintaining biodiversity and ecosystem services. Further explanation: 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. Consider the balance of conservation with the logging of forests or with the lobster and blueberry industries. Engaging in argument from evidence; ecosystem dynamics, functioning, and resilience; biodiversity and humans; developing possible solutions; stability and change

Strand	Life Sciences (LS)
Standard	LS2: Ecosystems: Interactions, Energy, and Dynamics
	Adolescence
	Grades 9-Diploma
Performance Expectations	**HS-LS2-1 Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales.** Further Explanation: Emphasis is on quantitative analysis and comparison of the relationships among interdependent factors including boundaries, resources, climate, and competition. Examples of mathematical comparisons could include graphs, charts, histograms, and population changes gathered from simulations or historical data sets. Examples could include a look at historical data of the population of a species that has moved north into Maine, such as opossum, and how it has changed as the climate in Maine has changed. Observe data of the populations of harbor seals and the effect that a hunting ban has had on their population and the resulting increase in the number of large predatory sharks in the Gulf of Maine. Using Mathematics and Computational Thinking, Interdependent Relationships in Ecosystems, Scale, Proportion, and Quantity
	HS-LS2-2 Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales. Further explanation: Examples of mathematical representations include finding the average, determining trends, and using graphical comparisons of multiple sets of data. Examples could include a graphical analysis of historical data on the population of trout and/or landlocked salmon before and after the introduction of bass into Moosehead Lake. Or data on a variety of populations (biodiversity) affected by dredging for sea scallops. Using Mathematics and Computational Thinking, Interdependent Relationships in Ecosystems, Scale, Proportion, and Quantity
	HS-LS2-3 Construct and revise an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions. Further explanation: Emphasis is on conceptual understanding of the role of aerobic and anaerobic respiration in different environments. An example could include a classroom lab activity around a Winogradsky Column with groups changing a variable such as temperature or light. Additional examples could look at the fermentation processes when blue-green algae is grown in aerobic and anaerobic environments. Constructing Explanations and Designing Solutions, Cycles of Matter and Energy Transfer in Ecosystems, Energy and Matter

	<u>HS-LS2-4</u> Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem. Further Explanation: Emphasis is on using a mathematical model of stored energy in biomass to describe the transfer of energy from one trophic level to another and that matter and energy are conserved as matter cycles and energy flows through ecosystems. Emphasis is on atoms and molecules such as carbon, oxygen, hydrogen and nitrogen being conserved as they move through an ecosystem. An example could include an illustration of a food pyramid students may find in Maine (e.g. seaweed → snail → fish → shark, or grass → insects → turkeys → foxes). Using Mathematics and Computational Thinking, Cycles of Matter and Energy Transfer in Ecosystems, Energy and Matter
	<u>HS-LS2-5</u> Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere. Further explanation: Examples of models could include simulations and mathematical models. Models may include multi-media illustration of the carbon cycle to include a Maine ecosystem they are familiar with such as pond, seaside, farm, forest, etc. Developing and Using Models, Cycles of Matter and Energy Transfer, Energy in Chemical Processes, Systems and System Models
	<u>HS-LS2-6</u> Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem. Further explanation: Examples of changes in ecosystem conditions could include modest biological or physical changes, such as moderate hunting or a seasonal flood; and extreme changes, such as volcanic eruption or sea level rise. Examples could include how the number of moose hunting licenses impacts other populations or how fishing limits or shortened seasons decreases the catch of many fish species and the effects on ground fish or smaller fish. Engaging in Argument from Evidence, Ecosystem Dynamics, Functioning, and Resilience, Stability and Change
	<u>HS-LS2-7</u> Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity. Further explanation: Examples of human activities can include urbanization, building dams, and dissemination of invasive species. Potential Maine connections include the effects of: salting the roads in winter, introducing green crabs into coastal waters, introducing invasive species into Maine lakes, or examining historical data on water pollution in the Androscoggin during the height of mill activity, closing of mills and legislation on water quality.

	Constructing Explanations and Designing Solutions, Ecosystem Dynamics, Functioning, and Resilience, Biodiversity and Humans, Developing Possible Solutions, Stability and Change
	HS-LS2-8 Evaluate the evidence for the role of group behavior on individual and species' chances to survive and reproduce. Further explanation: Emphasis is on: (1) distinguishing between group and individual behavior, (2) identifying evidence supporting the outcomes of group behavior, and (3) developing logical and reasonable arguments based on evidence. Examples of group behaviors could include flocking, schooling, herding, and cooperative behaviors such as hunting, migrating, and swarming. Examples could include turkeys flocking to evade hunters or Canada geese migrating to and through Maine for breeding purposes. Engaging in Argument from Evidence, Social Interactions and Group Behavior, Cause and Effect

Strand	Life Sciences (LS)		
Standard	LS3 Heredity: Inheritance and Variation of Traits		
	Childhood		
	Kindergarten	Grade 1	Grade 2
Performance Expectations		**1-LS3-1 Make observations to construct an evidence-based account that young plants and animals are like, but not exactly like, their parents.** Further explanation: Examples of patterns could include features that plants or animals share. Examples of observations could include that leaves from the same kind of plant are the same shape but can differ in size and that a particular breed of dog looks like its parents but is not exactly the same.	

		Constructing Explanations and Designing Solutions, Inheritance of Traits, Variation of Traits, Patterns	

Strand	Life Sciences (LS)		
Standard	LS3 Heredity: Inheritance and Variation of Traits		
	Childhood		
	Grade 3	Grade 4	Grade 5
Performance Expectations	**3-LS3-1 Analyze and interpret data to provide evidence that plants and animals have traits inherited from parents and that variation of these traits exists in a group of similar organisms.** Further Explanation: Patterns are the similarities and differences in traits shared between offspring and their parents, or among siblings. Emphasis is on organisms other than humans, such as lupins, apples or garden plants. Analyzing and Interpreting Data, Inheritance of Traits, Variation of Traits, Patterns **3-LS3-2 Use evidence to support the explanation that traits can be influenced by the environment.** Further Explanation: Examples of the environment affecting a trait could include normally tall plants grown with insufficient water are stunted; and, a pet dog that is given too much food and little exercise may become overweight. In addition, hydrangea grown under higher acidic conditions will cause the petals to turn blue.		

	Constructing Explanations an Designing Solutions, Inheritance of Traits, Variation of Traits, Cause and Effect		

Strand	Life Sciences (LS)
Standard	LS3 Heredity: Inheritance and Variation of Traits
	Early Adolescence
	Grades 6-8
Performance Expectations	**MS-LS3-1 Develop and use a model to describe why structural changes to genes (mutations) located on chromosomes may affect proteins and may result in harmful, beneficial, or neutral effects to the structure and function of an organism.** Further explanation: Emphasis is on conceptual understanding that changes in genetic material may result in making different proteins. Developing and using models; inheritance of traits; variation of traits; structure and function
	MS-LS3-2 Develop and use a model to describe why asexual reproduction results in offspring with identical genetic information and sexual reproduction results in offspring with genetic variation. Further explanation: Emphasis is on using models such as Punnett squares, diagrams, and simulations to describe the cause and effect relationship of gene transmission from parent(s) to offspring and the resulting genetic variation. Connections can be made to Maine agricultural crops, i.e. strawberries, blueberries, and potatoes. Developing and using models; growth and development of organisms; inheritance of traits; variation of traits; cause and effect

Strand	Life Sciences (LS)
Standard	LS3 Heredity: Inheritance and Variation of Traits
	Adolescence
	Grades 9-Diploma
Performance Expectations	**HS-LS3-1 Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring**

	Further explanation: Emphasis is on the asking of clarifying questions about the general principles of genetics. An example is how cystic fibrosis (one of the most common autosomal recessive inherited diseases in Maine) is passed from parents to child. Asking Questions and Defining Problems, Structure and Function, Inheritance of Traits, Cause and Effect
	HS-LS3-2 Make and defend a claim based on evidence that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors. Further explanation: Emphasis is on using data to support arguments for the way variation occurs. Provide data on specific mutations caused by environmental factors. Engaging in Argument from Evidence, Variation of Traits, Cause and Effect
	HS-LS3-3 Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population. Further explanation: Emphasis is on the use of mathematics to describe the probability of traits as it relates to genetic and environmental factors in the expression of traits. An example would be the population of red fox in Maine and the incidences of the red allele vs. the sable allele. Analyzing and Interpreting Data, Variation of Traits, Scale, Proportion, and Quantity

Strand	Life Sciences (LS)		
Standard	LS4 Biological Evolution: Unity and Diversity		
	Childhood		
	Kindergarten	Grade 1	Grade 2
Performance Expectations			**2-LS4-1 Make observations of plants and animals to compare the diversity of life in different habitats.** Further Explanation: Emphasis is on the diversity of living things in each of a variety of different habitats. Potential Maine connections include Maine habitats (e.g. ocean, lake/pond, mountains, forests, cities, etc.)

			Planning and Carrying out Investigations, Biodiversity in Humans

Strand	Life Sciences (LS)		
Standard	LS4 Biological Evolution: Unity and Diversity		
	Childhood		
	Grade 3	Grade 4	Grade 5
Performance Expectations	**3-LS4-1 Analyze and interpret data from fossils to provide evidence of the organisms and environments in which they lived long ago.** Further Explanation: Examples of data could include type, size, and distributions of fossil organisms. Examples of fossils and environments could include marine fossils found on dry land, tropical plant fossils found in Arctic areas, and fossils of extinct organisms. Analyzing and Interpreting Data, Evidence of Common Ancestry and Diversity, Scale, Proportion, and Quantity **3-LS4-2 Use evidence to construct an explanation for how the variations in characteristics among individuals of the same species may provide advantages in surviving, finding mates, and reproducing.** Further Explanation: Examples of cause and effect relationships could be plants that have larger thorns than other plants may be less likely to be eaten by predators and animals that have better camouflage coloration than other animals may be more likely to survive and therefore more likely to leave offspring such as yellow spotted salamanders and newts.		

	Constructing Explanations an Designing Solutions, Natural Selection, Cause and Effect **<u>3-LS4-3</u> Construct an argument with evidence that in a particular habitat some organisms can survive well, some survive less well, and some cannot survive at all.** Further Explanation: Examples of evidence could include needs and characteristics of the organisms (such as loons) and habitats involved. The organisms and their habitats make up a system in which the parts depend on each other. Potential Maine connections include the introduction of Pike and Bass into areas that are non-native to the species and their impact on native trout and other native species. Engaging in Argument from Evidence, Inheritance of Traits, Variation of Traits, Scale, Proportion, and Quantity, Cause and Effect **<u>3-LS4-4</u> Make a claim about the merit of a solution to a problem caused when the environment changes and the types of plants and animals that live there may change.** Further Explanation: Examples of environmental changes could include changes in land characteristics, water distribution, temperature, food, and other organisms. Lobster migrate as a result of water temperature, Cod follow prey fish (Mackerel), Atlantic Salmon start life in streams and migrate to saltwater. Engaging in Argument from Evidence, Biodiversity and Humans, Ecosystem Dynamics, Functioning, and Resilience, Systems and System Models		

Strand	Life Sciences (LS)
Standard	LS4 Biological Evolution: Unity and Diversity
	Early Adolescence
	Grades 6-8
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.** Further explanation: 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 rock layers. Analyzing and interpreting data; evidence of common ancestry and diversity; patterns
	MS-LS4-2 Apply scientific ideas to construct an explanation for the anatomical similarities and differences among modern organisms and between modern and fossil organisms to infer evolutionary relationships. Further explanation: Emphasis is on explanations of the evolutionary relationships among organisms in terms of similarities or differences of the gross appearance of anatomical structures. Constructing explanations and designing solutions; evidence of common ancestry and diversity; patterns
	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. Further explanation: Emphasis is on inferring general patterns of relatedness among embryos of different organisms by comparing the macroscopic appearance of diagrams or pictures. Analyzing and interpreting data; evidence of common ancestry and diversity; patterns
	MS-LS4-4 Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment. Further explanation: Emphasis is on using simple probability statements and proportional reasoning to construct explanations. Constructing explanations and designing solutions; natural selection; cause and effect
	MS-LS4-5 Gather and synthesize information about the technologies that have changed the way humans influence the inheritance of desired traits in organisms.

	Further explanation: Emphasis is on synthesizing information from reliable sources about the influence of humans on genetic outcomes in artificial selection (such as genetic modification, animal husbandry, and gene therapy) and on the impacts these technologies have on society as well as the technologies leading to these scientific discoveries. Obtaining, evaluating, and communicating information; natural selection; cause and effect
	MS-LS4-6 Use mathematical representations to support explanations of how natural selection may lead to increases and decreases of specific traits in populations over time. Further explanation: Emphasis is on using mathematical models, probability statements, and proportional reasoning to support explanations of trends in changes to populations over time. Using mathematics and computational thinking; adaptation; cause and effect

Strand	Life Sciences (LS)
Standard	LS4 Biological Evolution: Unity and Diversity
	Adolescence
	Grades 9-Diploma
Performance Expectations	**HS-LS4-1 Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence.** Further explanation: Emphasis is on a conceptual understanding of the role each line of evidence has relating to common ancestry and biological evolution. Examples of evidence could include similarities in DNA sequences, anatomical structures, and order of appearance of structures in embryological development. Obtaining, Evaluating, and Communicating Information, Evidence of Common Ancestry and Diversity, Patterns
	HS-LS4-2 Construct an explanation based on evidence that the process of evolution primarily results from four factors: (1) the potential for a species to increase in number, (2) the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for limited

	resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment. Further explanation: Emphasis is on using evidence to explain the influence each of the four factors has on number of organisms, behaviors, morphology, or physiology in terms of ability to compete for limited resources and subsequent survival of individuals and adaptation of species. Examples of evidence could include mathematical models such as simple distribution graphs and proportional reasoning. Constructing Explanations and Designing Solutions, Adaptation, Cause and Effect
	<u>HS-LS4-3</u> Apply concepts of statistics and probability to support explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait. Further explanation: Emphasis is on analyzing shifts in numerical distribution of traits and using these shifts as evidence to support explanations. Observe historical data for the distribution of humpback whales in the Gulf of Maine looking specifically at skin pigmentation. Analyzing and Interpreting Data, Natural Selection, Adaptation, Patterns
	<u>HS-LS4-4</u> Construct an explanation based on evidence for how natural selection leads to adaptation of populations. Further explanation: Emphasis is on using data to provide evidence for how specific biotic and abiotic differences in ecosystems (such as ranges of seasonal temperature, long-term climate change, acidity, light, geographic barriers, or evolution of other organisms) contribute to a change in gene frequency over time, leading to adaptation of populations. Constructing Explanations and Designing Solutions, Adaptation, Cause and Effect
	<u>HS-LS4-5</u> Evaluate the evidence supporting claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species. Further explanation: Emphasis is on determining cause and effect relationships for how changes to the environment such as deforestation, fishing, application of fertilizers, drought, flood, and the rate of change of the environment affect distribution or disappearance of traits in species. Engaging in Argument from Evidence, Adaptation, Cause and Effect
	<u>HS-LS4-6</u> Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.

	Further explanation: Emphasis is on designing solutions for a proposed problem related to threatened or endangered species, or to genetic variation of organisms for multiple species. Using Mathematics and Computational Thinking, Biodiversity and Humans, Developing Possible Solutions, Cause and Effect