NEXT GENERATION SCIENCE STANDARDS

2019-20 NGSS Biology Curriculum Map - Mililani High School

QUARTER	CORE IDEA*
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*The evidence statements, corresponding clarification statements and assessment boundaries for Core Ideas HS-LS1-LS4, ETS1, and HS-ESS2 are found on pages 8-14.

DISCIPLINARY CORE IDEA: LS2: Ecosystems: Interactions, Energy, and Dynamics
How and why do organisms interact with their environment and what are the effects of these interactions?

COMPONENT IDEAS	DISCIPLINARY CORE IDEA PROGRESSION (HIGH SCHOOL)
LS2.A: Interdependent Relationships in Ecosystems	• Ecosystems have carrying capacities, which are limits to the numbers of organisms and populations they can support. These limits result from such factors as the availability of living and nonliving resources and from such challenges such as predation, competition, and disease. Organisms would have the capacity to produce populations of great size were it not for the fact that environments and resources are finite. This fundamental tension affects the abundance (number of individuals) of species in any given ecosystem. (**HS-LS2-1**), (**HS-LS2-2**)
LS2.B: Cycles of Matter and Energy Transfer in Ecosystems	• Photosynthesis and cellular respiration (including anaerobic processes) provide most of the energy for life processes. (**HS-LS2-3**)
	• Plants or algae form the lowest level of the food web. At each link upward in a food web, only a small fraction of the matter consumed at the lower level is transferred upward, to produce growth and release energy in cellular respiration at the higher level. Given this inefficiency, there are generally fewer organisms at higher levels of a food web. Some matter reacts to release energy for life functions, some matter is stored in newly made structures, and much is discarded. The chemical elements that make up the molecules of organisms pass through food webs and into and out of the atmosphere and soil, and they are combined and recombined in different ways. At each link in an ecosystem, matter and energy are conserved. (**HS-LS2-4**)
	• Photosynthesis and cellular respiration are important components of the carbon cycle, in which carbon is exchanged among the biosphere, atmosphere, oceans, and geosphere through chemical, physical, geological, and biological processes. (**HS-LS2-5**)
LS2.C: Ecosystem Dynamics, Functioning, and Resilience	• A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions. If a modest biological or physical disturbance to an ecosystem occurs, it may return to its more or less original status (i.e., the ecosystem is resilient), as opposed to becoming a very different ecosystem. Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of ecosystems in terms of resources and habitat availability. (**HS-LS2-2**), (**HS-LS2-6**)
	• Moreover, anthropogenic changes (induced by human activity) in the environment—including habitat destruction, pollution, introduction of invasive species, overexploitation, and climate change—can disrupt an ecosystem and threaten the survival of some species. (**HS-LS2-7**)
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. (**HS-LS2-8**)

DISCIPLINARY CORE IDEA: LS1: From Molecules to Organisms: Structures and Processes *How do organisms live, grow, respond to their environment, and reproduce?*	
COMPONENT IDEAS	**DISCIPLINARY CORE IDEA PROGRESSION (HIGH SCHOOL)**
LS1.A: Structure and Function	• Systems of specialized cells within organisms help them perform the essential functions of life. (**HS-LS1-1**)
	• All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins, which carry out most of the work of cells. (**HS-LS1-1**) (**secondary to HS-LS3-1**)
	• Multicellular organisms have a hierarchical structural organization, in which any one system is made up of numerous parts and is itself a component of the next level. (**HS-LS1-2**)
	• Feedback mechanisms maintain a living system's internal conditions within certain limits and mediate behaviors, allowing it to remain alive and functional even as external conditions change within some range. Feedback mechanisms can encourage (through positive feedback) or discourage (negative feedback) what is going on inside the living system. (**HS-LS1-3**)
LS1.B: Growth and Development of Organisms	• In multicellular organisms individual cells grow and then divide via a process called mitosis, thereby allowing the organism to grow. The organism begins as a single cell (fertilized egg) that divides successively to produce many cells, with each parent cell passing identical genetic material (two variants of each chromosome pair) to both daughter cells. Cellular division and differentiation produce and maintain a complex organism, composed of systems of tissues and organs that work together to meet the needs of the whole organism. (**HS-LS1-4**)
LS1.C: Organization for Matter and Energy Flow in Organisms	• The process of photosynthesis converts light energy to stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen. (**HS-LS1-5**)
	• The sugar molecules thus formed contain carbon, hydrogen, and oxygen: their hydrocarbon backbones are used to make amino acids and other carbon-based molecules that can be assembled into larger molecules (such as proteins or DNA), used for example to form new cells. (**HS-LS1-6**)
	• As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products. (**HS-LS1-6**), (**HS-LS1-7**)
	• As a result of these chemical reactions, energy is transferred from one system of interacting molecules to another and release energy to the surrounding environment and to maintain body temperature. Cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and new compounds are formed that can transport energy to muscles. (**HS-LS1-7**)
LS1.D: Information Processing	Not applicable

DISCIPLINARY CORE IDEA: LS3: Heredity: Inheritance and Variation of Traits *How are characteristics of one generation passed to the next? How can individuals of the same species and even siblings have different characteristics?*	
COMPONENT IDEAS	**DISCIPLINARY CORE IDEA PROGRESSION (HIGH SCHOOL)**
LS3.A: Inheritance of Traits	• Each chromosome consists of a single very long DNA molecule, and each gene on the chromosome is a particular segment of that DNA. The instructions for forming species' characteristics are carried in DNA. All cells in an organism have the same genetic content, but the genes used (expressed) by the cell may be regulated in different ways. Not all DNA codes for a protein; some segments of DNA are involved in regulatory or structural functions, and some have no as-yet known function. (**HS-LS3-1**)
LS3.B: Variation of Traits	• In sexual reproduction, chromosomes can sometimes swap sections during the process of meiosis (cell division), thereby creating new genetic combinations and thus more genetic variation. Although DNA replication is tightly regulated and remarkably accurate, errors do occur and result in mutations, which are also a source of genetic variation. Environmental factors can also cause mutations in genes, and viable mutations are inherited. (**HS-LS3-2**)
	• Environmental factors also affect expression of traits, and hence affect the probability of occurrences of traits in a population. Thus the variation and distribution of traits observed depends on both genetic and environmental factors. (**HS-LS3-2**), (**HS-LS3-3**)

DISCIPLINARY CORE IDEA: LS4: Biological Evolution: Unity and Diversity

How can there be so many similarities among organisms yet so many different kinds of plants, animals, and microorganisms? How does biodiversity affect humans?

COMPONENT IDEAS	**DISCIPLINARY CORE IDEA PROGRESSION (HIGH SCHOOL)**
LS4.A: Evidence of Common Ancestry and Diversity	• Genetic information provides evidence of evolution. DNA sequences vary among species, but there are many overlaps; in fact, the ongoing branching that produces multiple lines of descent can be inferred by comparing the DNA sequences of different organisms. Such information is also derivable from the similarities and differences in amino acid sequences and from anatomical and embryological evidence. (**HS-LS4-1**)
LS4.B: Natural Selection	• Natural selection occurs only if there is both (1) variation in the genetic information between organisms in a population and (2) variation in the expression of that genetic information—that is, trait variation—that leads to differences in performance among individuals. (**HS-LS4-2**), (**HS-LS4-3**)
	• The traits that positively affect survival are more likely to be reproduced, and thus are more common in the population. (**HS-LS4-3**)
LS4.C: Adaptation	• Evolution is a consequence of the interaction of four factors: (1) the potential for a species to increase in number, (2) the genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for an environment's limited supply of the resources that individuals need in order to survive and reproduce, and (4) the ensuing proliferation of those organisms that are better able to survive and reproduce in that environment. (**HS-LS4-2**)
	• Natural selection leads to adaptation, that is, to a population dominated by organisms that are anatomically, behaviorally, and physiologically well suited to survive and reproduce in a specific environment. That is, the differential survival and reproduction of organisms in a population that have an advantageous heritable trait leads to an increase in the proportion of individuals in future generations that have the trait and to a decrease in the proportion of individuals that do not. (**HS-LS4-3**), (**HS-LS4-4**)
	• Adaptation also means that the distribution of traits in a population can change when conditions change. (**HS-LS4-3**)
	• Changes in the physical environment, whether naturally occurring or human induced, have thus contributed to the expansion of some species, the emergence of new distinct species as populations diverge under different conditions, and the decline–and sometimes the extinction–of some species. (**HS-LS4-5**), (**HS-LS4-6**)
	• Species become extinct because they can no longer survive and reproduce in their altered environment. If members cannot adjust to change that is too fast or drastic, the opportunity for the species' evolution is lost. (**HS-LS4-5**)
LS4.D: Biodiversity and Humans	• Biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction). (**secondary to HS-LS2-7**)
	• Humans depend on the living world for the resources and other benefits provided by biodiversity. But human activity is also having adverse impacts on biodiversity through overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change. Thus sustaining biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth. Sustaining biodiversity also aids humanity by preserving landscapes of recreational or inspirational value. (**secondary to HS-LS2-7**) (**HS-LS4-6**)

DISCIPLINARY CORE IDEA: HS-ESS2 Earth's Systems (HS-ESS2-7 only)	
COMPONENT IDEAS	**DISCIPLINARY CORE IDEA PROGRESSION (HIGH SCHOOL)**
ESS2.D: Weather and Climate	• Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen. (**HS-ESS2-6**), (**HS-ESS2-7**)
ESS2.E Biogeology	• The many dynamic and delicate feedbacks between the biosphere and other Earth systems cause a continual co-evolution of Earth's surface and the life that exists on it. (**HS-ESS2-7**)

DISCIPLINARY CORE IDEA: ETS1: Engineering Design	
COMPONENT IDEAS	**DISCIPLINARY CORE IDEA PROGRESSION (HIGH SCHOOL)**
ETS1.A: Defining and Delimiting Engineering Problems	• Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. (**HS-ETS1-1**), (**secondary to HS-PS2-3**), (**secondary to HS-PS3-3**)
	• Humanity faces major global challenges today, such as the need for supplies of clean water and food or for energy sources that minimize pollution, which can be addressed through engineering. These global challenges also may have manifestations in local communities. (**HS-ETS1-1**)
ETS1.B: Developing Possible Solutions	• When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. (**HS-ETS1-3**), (**secondary to HS-LS4-6**), (**secondary to HS-ESS3-2**), (**secondary HS-ESS3-4**)
	• Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs. (**HS-ETS1-4**)
ETS1.C: Optimizing the Design Solution	• Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed. (**HS-ETS1-2**), (**secondary to HS-PS1-6**), (**secondary to HS-PS2-3**)

EVIDENCE STATEMENTS OF PERFORMANCE EXPECTATIONS	
HS-LS1-1	**Students who demonstrate understanding can:** 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. **Clarification Statement:** None **Assessment Boundary:** Assessment does not include identification of specific cell or tissue types, whole body systems, specific protein structures and functions, or the biochemistry of protein synthesis.
HS-LS1-2	**Students who demonstrate understanding can:** Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms. **Clarification Statement:** 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. **Assessment Boundary:** Assessment does not include interactions and functions at the molecular or chemical reaction level.
HS-LS1-3	**Students who demonstrate understanding can:** Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis. **Clarification Statement:** Examples of investigations could include heart rate response to exercise, stomate response to moisture and temperature, and root development in response to water levels. **Assessment Boundary:** Assessment does not include the cellular processes involved in the feedback mechanism.
HS-LS1-4	**Students who demonstrate understanding can:** Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms. **Clarification Statement:** None **Assessment Boundary:** Assessment does not include specific gene control mechanisms or rote memorization of the steps of mitosis.
HS-LS1-5	**Students who demonstrate understanding can:** Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy. **Clarification Statement:**

	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. **Assessment Boundary:** Assessment does not include specific biochemical steps.
HS-LS1-6	**Students who demonstrate understanding can:** 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. **Clarification Statement:** Emphasis is on using evidence from models and simulations to support explanations. **Assessment Boundary:** Assessment does not include the details of the specific chemical reactions or identification of macromolecules.
HS-LS1-7	**Students who demonstrate understanding can:** 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. **Clarification Statement:** Emphasis is on the conceptual understanding of the inputs and outputs of the process of cellular respiration. **Assessment Boundary:** Assessment should not include identification of the steps or specific processes involved in cellular respiration.
HS-LS2-1	**Students who demonstrate understanding can:** Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales. **Clarification Statement:** 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. **Assessment Boundary:** Assessment does not include deriving mathematical equations to make comparisons.
HS-LS2-2	**Students who demonstrate understanding can:** Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales. **Clarification Statement:** Examples of mathematical representations include finding the average, determining trends, and using graphical comparisons of multiple sets of data. **Assessment Boundary:** Assessment is limited to provided data.
HS-LS2-3	**Students who demonstrate understanding can:** Construct and revise an explanation based on evidence for the cycling of matter and

	flow of energy in aerobic and anaerobic conditions. **Clarification Statement:** Emphasis is on conceptual understanding of the role of aerobic and anaerobic respiration in different environments. **Assessment Boundary:** Assessment does not include the specific chemical processes of either aerobic or anaerobic respiration.
HS-LS2-4	**Students who demonstrate understanding can:** Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem. **Clarification Statement:** 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. **Assessment Boundary:** Assessment is limited to proportional reasoning to describe the cycling of matter and flow of energy.
HS-LS2-5	**Students who demonstrate understanding can:** Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere. **Clarification Statement:** Examples of models could include simulations and mathematical models. **Assessment Boundary:** Assessment does not include the specific chemical steps of photosynthesis and respiration.
HS-LS2-6	**Students who demonstrate understanding can:** 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. **Clarification Statement:** 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. **Assessment Boundary:** None
HS-LS2-7	**Students who demonstrate understanding can:** Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity. **Clarification Statement:** Examples of human activities can include urbanization, building dams, and dissemination of invasive species. **Assessment Boundary:** None

HS-LS2-8	**Students who demonstrate understanding can:** Evaluate the evidence for the role of group behavior on individual and species' chances to survive and reproduce. **Clarification Statement:** 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. **Assessment Boundary:** None
HS-LS3-1	**Students who demonstrate understanding can:** Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring. **Clarification Statement:** None **Assessment Boundary:** Assessment does not include the phases of meiosis or the biochemical mechanism of specific steps in the process.
HS-LS3-2	**Students who demonstrate understanding can:** 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. **Clarification Statement:** Emphasis is on using data to support arguments for the way variation occurs. **Assessment Boundary:** Assessment does not include the phases of meiosis or the biochemical mechanism of specific steps in the process.
HS-LS3-3	**Students who demonstrate understanding can:** Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population. **Clarification Statement:** 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. **Assessment Boundary:** Assessment does not include Hardy-Weinberg calculations.
HS-LS4-1	**Students who demonstrate understanding can:** Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence. **Clarification Statement:** 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. **Assessment Boundary:** None

HS-LS4-2	**Students who demonstrate understanding can:** 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. **Clarification Statement:** Emphasis is on using evidence to explain the influence each of the four factors has on the 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. **Assessment Boundary:** Assessment does not include other mechanisms of evolution, such as genetic drift, gene flow through migration, and co-evolution.
HS-LS4-3	**Students who demonstrate understanding can:** 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. **Clarification Statement:** Emphasis is on analyzing shifts in numerical distribution of traits and using these shifts as evidence to support explanations. **Assessment Boundary:** Assessment is limited to basic statistical and graphical analysis. Assessment does not include allele frequency calculations.
HS-LS4-4	**Students who demonstrate understanding can:** Construct an explanation based on evidence for how natural selection leads to adaptation of populations. **Clarification Statement:** 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. **Assessment Boundary:** None
HS-LS4-5	**Students who demonstrate understanding can:** 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. **Clarification Statement:** 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. **Assessment Boundary:** None
HS-LS4-6	**Students who demonstrate understanding can:** Create or revise a simulation to test a solution to mitigate adverse impacts of human

	activity on biodiversity. **Clarification Statement:** Emphasis is on designing solutions for a proposed problem related to threatened or endangered species, or to genetic variation of organisms for multiple species. **Assessment Boundary:** None
HS-ESS2-7	**Students who demonstrate understanding can:** Construct an argument based on evidence about the simultaneous coevolution of Earth's systems and life on Earth. **Clarification Statement:** Emphasis is on the dynamic causes, effects, and feedbacks between the biosphere and Earth's other systems, whereby geoscience factors control the evolution of life, which in turn continuously alters Earth's surface. Examples include how photosynthetic life altered the atmosphere through the production of oxygen, which in turn increased weathering rates and allowed for the evolution of animal life; how microbial life on land increased the formation of soil, which in turn allowed for the evolution of land plants; or how the evolution of corals created reefs that altered patterns of erosion and deposition along coastlines and provided habitats for the evolution of new life forms. **Assessment Boundary:** Assessment does not include a comprehensive understanding of the mechanisms of how the biosphere interacts with all of Earth's other systems.
HS-ETS1-1	**Students who demonstrate understanding can:** Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants. **Clarification Statement:** None **Assessment Boundary:** None
HS-ETS1-2	**Students who demonstrate understanding can:** Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering. **Clarification Statement:** None **Assessment Boundary:** None
HS-ETS1-3	**Students who demonstrate understanding can:** Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts. **Clarification Statement:** None **Assessment Boundary:** None
HS-ETS1-4	**Students who demonstrate understanding can:** Use a computer simulation to model the impact of proposed solutions to a complex

	real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem. **Clarification Statement:** None **Assessment Boundary:** None