Achievement Level Descriptors (ALDs)

Grade High School

Maine Science Assessment

New Meridian Corporation

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Maine Department of Education

Contents

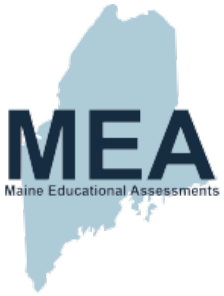
What are ALDs?

- The Achievement Level Descriptors (ALDs) document is intended to be used as a guideline to describe the four levels of achievement, levels of student mastery of the Standards & Instruction - Science & Engineering, identified by the Maine DOE. This document is to support the effective teaching and assessment of Maine K–12 science and engineering instructional programs.

- The ALDs are written to align with the Next Generation Science Standards (NGSS) Topics. The NGSS topics are standards that are grouped to show the natural connections between the Disciplinary Core Ideas. To support the intent of the standards for science instruction and assessment in Maine, all Science and Engineering Practices (SEPs) and Cross-Cutting Concepts (CCC) can be used interchangeably with any of the Disciplinary Core Ideas (DCI), not just the ones found in the performance expectations. It is the intent that the SEP and CCC are selected to enhance the application of the DCIs to make sense of a phenomenon presented in a scenario.

General Achievement Levels for Maine

Level 1 Well Below State Expectations	Level 2 Below State Expectations	Level 3 At State Expectations	Level 4 Above State Expectations
The student's work demonstrates a minimal understanding of essential concepts in science. The student's responses demonstrate minimal ability to solve problems. Explanations are illogical, incomplete, or missing connections among central ideas. There are multiple inaccuracies.	The student's work demonstrates an incomplete understanding of essential concepts in science and inconsistent connections among central ideas. The student's responses demonstrate some ability to analyze and solve problems, but the quality of responses is inconsistent. Explanation of concepts may be incomplete or unclear.	The student's work demonstrates an adequate understanding of essential concepts in science, including the ability to make connections among central ideas. The student's responses demonstrate the ability to analyze and solve routine problems and explain central concepts with sufficient clarity and accuracy to demonstrate general understanding.	The student's work demonstrates a thorough understanding of essential concepts in science, including the ability to make multiple connections among central ideas. The student's responses demonstrate the ability to synthesize information, analyze and solve difficult problems, and explain complex concepts using evidence and proper terminology to support and communicate logical conclusions.



How to read this document and the process used by New Meridian

The NGSS topic is listed in the top left corner (and is a clickable link to the NGSS topic page). The ALD for each of the 4 levels of achievement (Well Below State Expectations; Below State Expectations; At State Expectations; Above State Expectations) runs along the top. The ALD statements are combinations of grade level DCIs (shown in orange and regular font), SEPs (shown in blue and underlined), and CCCs (shown in green and italicized). These are exemplar targets that have been constructed by New Meridian Science staff, with feedback from the ME DOE. Again, the intention is to demonstrate that any DCI can be combined with any SEP and any CCC for a particular topic and grade level. There are NOT ALDs for each individual Performance Expectation (PE).

The left column contains the exact text of the grade level DCIs included within a topic, pulled from the NGSS. For each grade, for most topics, each DCI for each topic is met at least once in at least one of the four achievement levels. The grade-level DCI, SEP, and CCC that were used are listed below each ALD. The SEPs are from the NGSS SEP matrix found here (starting on p. 17), and the CCCs are from the NGSS CCC matrix found here (p. 15–17).

The reference DCIs are located below the tables and are the DCIs from either the "Above State Expectations" ALD (Grade 5 is MS, and MS is HS), or the "Well Below State Expectations" ALD (Grade 5 is Grades 2–4, MS is Grade 5, and HS is MS). These DCIs are referenced in regard to topic progression.

Example ALD table showing the progression of DCIs:
The DCI alone is not what determines the achievement level, rather it is the combination of the 3 dimensions. So, for each exemplar DCI, all other achievement levels could be possible, if combined with different SEPs or CCCs. These documents just give the 4 exemplars, rather than the progression of a single dimension across all 4 achievement levels.

Topic 5.Structure and Properties of Matter	**Well Below State Expectations**	**Below State Expectations**	**At State Expectations**	**Above State Expectations**
Topic DCIs **PS1.A: Structure and Properties of Matter** • Matter of any type can be subdivided into particles that are too small to see, but even then the matter still exists and can be detected by other means. A model showing that gases are made from matter particles that are too small to see and are moving freely around in space can explain many observations, including the inflation and shape of a balloon and the effects of air on larger particles or objects. • Measurements of a variety of properties can be used to identify materials. (Boundary: At this grade level, mass and weight are not distinguished, and no attempt is made to define the unseen particles or explain the atomic-scale mechanism of evaporation and condensation.) • The amount (weight) of matter is conserved when it changes form, even in transitions in which it seems to vanish. **PS1.B: Chemical Reactions** • When two or more different substances are mixed, a new substance with different properties may be formed. • No matter what reaction or change in properties occurs, the total weight of the substances does not change. (Boundary: Mass and weight are not distinguished at this grade level.)	Represent data to reveal *patterns which indicate* that materials can be identified based on their properties, and those properties are suitable for different purposes.			
		Use evidence (measurements) to support an explanation that matter is conserved when substances are mixed, even if a new substance is formed, *given that the total weight of the starting substance(s) is equal to the weight of the new substance(s).*		
			Plan an investigation to show that gases are made of particles that *are too small to be seen* but can be detected in other ways.	
				Support an argument that a new substance *has formed when* different substances are mixed.
	Grade Level DCI, SEP, and *CCC*			
	PS1.A SEP4 (Evaluate) *CCC1 (Patterns)*	PS1.A SEP3 (Investigate) *CCC3 (Scale, Proportion, and Quantity)*	PS1.A PS1.B SEP6 (Reason Scientifically) *CCC3 (Scale, Proportion, and Quantity)*	PS1.B SEP7 (Evaluate) *CCC2 (Cause and Effect)*

High School

Physical Science Topics

Topic HS.Structure and Properties of Matter	**Well Below** **State Expectations**	**Below** **State Expectations**	**At State** **Expectations**	**Above** **State Expectations**
Topic DCIs **PS1.A Structure and Properties of Matter** • Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons. • The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states. • The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms. **PS1.C: Nuclear Processes** • Nuclear processes, including fusion, fission, and radioactive decays of unstable nuclei, involve release or absorption of energy. The total number of neutrons plus protons does not change in any nuclear process. **PS2.B: Types of Interactions** • Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects.	Analyze data to make valid scientific claims that atoms *consist of subatomic particles that determine the properties and characteristics* of elements.	Plan an investigation to produce data to serve as evidence supporting the claim that each element has characteristic properties which can be predicted *based on the placement on the periodic table.*	Develop or revise a model to predict the reactivity (e.g., attraction and repulsion between electrically charged particles, leading to the type of bond formed) between different atoms *based on their placement in the periodic table.*	Develop a model to illustrate the differences between the nuclear processes of fusion, fission, and radioactive decay, including *the changes in energy* involved in each process.
	Grade Level DCI, SEP, and *CCC*			
	PS1.A SEP4 (Evaluate) *CCC6 (Structure and Function)*	PS1.A SEP3 (Investigate) *CCC1 (Patterns)*	PS1.A PS2.B SEP2 (Reason Scientifically) *CCC1 (Patterns)*	PS1.C SEP2 (Reason Scientifically) *CCC5 (Energy and Matter)*

Reference DCI:
Well Below State Expectations: Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it. (MS, PS1.A)

Topic HS.Forces and Interactions	**Well Below State Expectations**	**Below State Expectations**	**At State Expectations**	**Above State Expectations**
Topic DCIs **PS2.A: Forces and Motion** • Newton's second law accurately predicts changes in the motion of macroscopic objects. • Momentum is defined for a particular frame of reference; it is the mass times the velocity of the object. • If a system interacts with objects outside itself, the total momentum of the system can change; however, any such change is balanced by changes in the momentum of objects outside the system. **PS2.B: Types of Interactions** • Newton's law of universal gravitation and Coulomb's law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects. • Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields.	Use Newton's 2nd law to make a hypothesis about *what happens* to the motion of an object *when there is a change* in force or mass.	Use a model to support explanations that a magnetic field *can be generated by* an electric circuit.	Construct an argument based on data that the total momentum *of a system* is conserved in a collision between 2 objects.	Use mathematical representations to support the claim that the gravitational force between 2 objects is *dependent upon the masses of the objects and their distance apart.*
	Grade Level DCI, SEP, and *CCC*			
	PS2.A SEP3 (Investigate) *CCC2 (Cause and Effect)*	PS2.B SEP2 (Reason Scientifically) *CCC2 (Cause and Effect)*	PS2.A SEP7 (Evaluate) *CCC4 (Systems and System Models)*	PS2.B SEP5 (Evaluate) *CCC1 (Patterns)*

Reference DCI:
Well Below State Expectations: The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion. (MS, PS2.A)

Topic HS.Chemical Reactions	**Well Below State Expectations**	**Below State Expectations**	**At State Expectations**	**Above State Expectations**
Topic DCIs **PS1.A: Structure and Properties of Matter** • The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states. • A stable molecule has less energy than the same set of atoms separated; one must provide at least this energy in order to take the molecule apart. **PS1.B: Chemical Reactions** • Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy. • In many situations, a dynamic and condition-dependent balance between a reaction and the reverse reaction determines the numbers of all types of molecules present. • The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions.	Use a model to predict the properties and interactions of atoms based on the *repeating patterns* found on the periodic table.	Use mathematical representations to support a claim that *the number of different kinds of atoms in a chemical reaction is balanced* between the products and the reactants.	Develop or revise a model to predict the *products* of a chemical reaction based on properties of the *reactants*.	Apply scientific reasoning to link evidence to support an explanation that in a chemical reaction, all *energy is conserved.*
	Grade Level DCI, SEP, and *CCC*			
	PS1.A SEP2 (Reason Scientifically) *CCC1 (Patterns)*	PS1.B SEP5 (Evaluate) *CCC5 (Energy and Matter)*	PS1.A PS1.B SEP2 (Reason Scientifically) *CCC5 (Energy and Matter)*	PS1.A PS1.B SEP6 (Reason Scientifically) *CCC5 (Energy and Matter)*

Reference DCI:
Well Below State Expectations: Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants. (MS, PS1.B)

Topic HS.Energy	**Well Below State Expectations**	**Below State Expectations**	**At State Expectations**	**Above State Expectations**
Topic DCIs **PS3.A: Definitions of Energy** • Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms. • At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. • These relationships are better understood at the microscopic scale, at which all of the different manifestations of energy can be modeled as a combination of energy associated with the motion of particles and energy associated with the configuration (relative position of the particles). In some cases the relative position energy can be thought of as stored in fields (which mediate interactions between particles). This last concept includes radiation, a phenomenon in which energy stored in fields moves across space. **PS3.B: Conservation of Energy and Energy Transfer** • Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system. • Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. • Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g., relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior. • The availability of energy limits what can occur in any system. • Uncontrolled systems always evolve toward more stable states—that is, toward more uniform energy distribution (e.g., water flows downhill, objects hotter than their surrounding environment cool down).	Plan an investigation to produce data that can serve as evidence to support the claim that the type of material used in a closed system affects the *transfer of thermal energy.*	Provide evidence that thermal equilibrium has been reached in *a system.*	Use computational representations of the potential energy of a ball at the top of a hill and of the kinetic energy of the ball in motion to support an explanation that *energy in a system is conserved.*	Construct an explanation as to why the potential energy in an electrical field between 2 charged objects decreases *as the objects move farther apart.*
	Grade Level DCI, SEP, and *CCC*			
	PS3.A SEP3 (Investigate) *CCC5 (Energy and Matter)*	PS3.B SEP6 (Reason Scientifically) *CCC4 (Systems and System Models)*	PS3.B SEP5 (Evaluate) *CCC5 (Energy and Matter)*	PS3.C SEP6 (Reason Scientifically) *CCC2 (Cause and Effect)*

PS3.C: Relationship Between Energy and Forces • When two objects interacting through a field change relative position, the energy stored in the field is changed. **PS3.D: Energy in Chemical Processes** • Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment.				

Reference DCIs:
Well Below State Expectations: The amount of energy transfer needed to change the temperature of a matter sample by a given amount depends on the nature of the matter, the size of the sample, and the environment. (MS, PS3.B)

Energy is spontaneously transferred out of hotter regions or objects and into colder ones. (MS, PS3.B)

Topic HS.Waves and Electromagnetic Radiation	**Well Below** **State Expectations**	**Below** **State Expectations**	**At State** **Expectations**	**Above** **State Expectations**
Topic DCIs **PS4.A: Wave Properties** • The wavelength and frequency of a wave are related to one another by the speed of travel of the wave, which depends on the type of wave and the medium through which it is passing. • Information can be digitized (e.g., a picture stored as the values of an array of pixels); in this form, it can be stored reliably in computer memory and sent over long distances as a series of wave pulses. • [From the 3–5 grade band endpoints] Waves can add or cancel one another as they cross, depending on their relative phase (i.e., relative position of peaks and troughs of the waves), but they emerge unaffected by each other. (Boundary: The discussion at this grade level is qualitative only; it can be based on the fact that two different sounds can pass a location in different directions without getting mixed up.) **PS4.B: Electromagnetic Radiation** • Electromagnetic radiation (e.g., radio, microwaves, light) can be modeled as a wave of changing electric and magnetic fields or as particles called photons. The wave model is useful for explaining many features of electromagnetic radiation, and the particle model explains other features. • When light or longer wavelength electromagnetic radiation is absorbed in matter, it is generally converted into thermal energy (heat). Shorter wavelength electromagnetic radiation (ultraviolet, X-rays, gamma rays) can ionize atoms and cause damage to living cells. • Photoelectric materials emit electrons when they absorb light of a high-enough frequency. **PS4.C: Information Technologies and Instrumentation** • Multiple technologies based on the understanding of waves and their interactions with matter are part of everyday experiences in the modern world (e.g., medical imaging, communications, scanners) and in scientific research. They are essential tools for producing, transmitting, and capturing signals and for storing and interpreting the information contained in them.	Ask and/or evaluate questions to *choose between colors* for a model sports team uniform *that would make the wearer feel cooler* outside on a sunny day.	Construct an explanation as to why *a lightning strike is seen before the thunder is heard.*	Apply scientific reasoning to link evidence to the claim that *increasing the amplitude*, not the frequency, of a radio wave *will increase the volume of the music.*	Make and defend a claim based on evidence for why an *X-ray functions better to diagnose a broken bone* than an ultrasound.
	Grade Level DCI, SEP, and *CCC*			
	PS4.B SEP1 (Investigate) *CCC2 (Cause and Effect)*	PS4.A SEP6 (Reason Scientifically) *CCC3 (Scale, Proportion, and quality)*	PS4.A SEP6 (Reason Scientifically) *CCC2 (Cause and Effect)*	PS4.C SEP6 (Evaluate) *CCC6 (Structure and Function)*

Reference DCI:
Well Below State Expectations: When light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on the object's material and the frequency (color) of the light. (MS, PS4.B)

High School

Life Science Topics

Topic HS.Matter and Energy in Organisms and Ecosystems	**Well Below State Expectations**	**Below State Expectations**	**At State Expectations**	**Above State Expectations**
Topic DCIs **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. • 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. • As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products. • As a result of these chemical reactions, energy is transferred from one system of interacting molecules to another. Cellular respiration is a chemical process in which the bonds of food molecules and oxygen molecules are broken and new compounds are formed that can transport energy to muscles. Cellular respiration also releases the energy needed to maintain body temperature despite ongoing energy transfer to the surrounding environment. **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. • 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. • 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.	Ask questions to seek additional information about how plants use energy from light to *convert carbon dioxide and water into oxygen and sugars,* which can be consumed by other organisms for energy.	Develop or revise a model based on evidence that illustrates that the *products of photosynthesis become the reactants of cellular respiration* and are the molecules that are rearranged to support *growth or released as energy* within organisms in a food web.	Analyze data to make valid and reliable scientific claims that through the process of cellular respiration, some of the energy from food molecules is lost to the environment, while the rest *is transferred to cellular energy,* which can be used to maintain homeostasis.	Apply scientific reasoning to provide evidence to support the explanation that as a part of cellular respiration, sugar *molecules are rearranged* to make amino acids and other carbon-based macromolecules, which can be used to form new cells.
	Grade Level DCI, SEP, and *CCC*			
	LS1.C SEP1 (Investigate) *CCC5 (Energy and Matter)*	LS1.C LS2.B SEP2 (Reason Scientifically) *primary CCC4 (Systems and System models)* *secondary CCC5 (Energy and Matter)*	LS1.C LS2.B SEP4 (Evaluate) *CCC5 (Energy and Matter)*	LS1.C SEP6 (Reason Scientifically) *CCC5 (Energy and Matter)*

Reference DCIs:

Well Below State Expectations: Plants, algae (including phytoplankton), and many microorganisms use the energy from light to make sugars (food) from carbon dioxide from the atmosphere and water through the process of photosynthesis, which also releases oxygen. These sugars can be used immediately or stored for growth or later use. (MS, LS1.C)

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.B)

Topic HS.Interdependent Relationships in Ecosystems	**Well Below** **State Expectations**	**Below** **State Expectations**	**At State** **Expectations**	**Above** **State Expectations**
Topic DCIs **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. **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. • 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. **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. **LS4.C: Adaptation** • 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.	Ask questions to determine *relationships between* group behavior and a species' chances for survival.	Use a model to predict the *effects of a particular change* in environmental conditions on species expansion or extinction.	Use *mathematical representations* to support claims *that the carrying capacity of a population is based on factors such as competition and disease.*	Develop models based on evidence to predict the differences in the effects of a *modest disturbance vs. a major disturbance* on an ecosystem.
	Grade Level DCI, SEP, and *CCC*			
	LS2.D SEP1 (Investigate) *CCC2 (Cause and Effect)*	LS4.C SEP2 (Developing and Using Models) *CCC2 (Cause and Effect)*	LS2.A SEP5 (Evaluate) *CCC1 (Patterns)*	LS2.C SEP2 (Reason Scientifically) *CCC7 (Stability and Change)*

Reference DCIs: N/A

Topic HS.Natural Selection and Evolution	**Well Below State Expectations**	**Below State Expectations**	**At State Expectations**	**Above State Expectations**
Topic DCIs **LS4.A: Evidence of Common Ancestry and Diversity** • Genetic information, like the fossil record, 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. **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. • The traits that positively affect survival are more likely to be reproduced, and thus are more common in the population. **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. • 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.	Make a hypothesis about how a *change in environmental conditions* could contribute to the extinction of a species.	Analyze data to identify the *cause-and-effect relationship* between genetic variation of a trait in a species, a competitive advantage of a variation, and the evolution of that trait in a species.	Apply scientific evidence from *patterns* shown by at least two sources (fossils, anatomy, embryology, or biochemistry) to propose an explanation of a species' ancestry.	Apply concepts of statistics and probability *to determine patterns* of change in the distribution of phenotypes in a population to predict how selective pressure may change the distribution over time.
	Grade Level DCI, SEP, and *CCC*			
	LS4.C SEP1 (Investigate) *CCC7 (Stability and Change)*	LS4.C SEP1 (Investigate) *CCC7 (Stability and Change)*	LS4.A SEP6 (Reason Scientifically) *CCC1 (Patterns)*	LS4.B LS4.C SEP5 (Evaluate) *CCC1 (Patterns)*

• Adaptation also means that the distribution of traits in a population can change when conditions change. • 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. • 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.				

Reference DCI:

Well Below State Expectations:

Adaptation by natural selection acting over generations is one important process by which species change over time in response to changes in environmental conditions. Traits that support successful survival and reproduction in the new environment become more common; those that do not become less common. Thus, the distribution of traits in a population changes. (MS, LS4.C)

Topic HS.Inheritance and Variation of Traits	**Well Below State Expectations**	**Below State Expectations**	**At State Expectations**	**Above State Expectations**
Topic DCIs **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) **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)	Ask questions to seek additional information as to why certain *traits are only found in specific* types of *environments*.	Apply scientific principles to explain the relationship between *the structures of* chromosomes, DNA molecules, and genes.	Use a model to explain that genetic variability among organisms within the same population is *due to* errors in DNA replication or mutations in genes that can be *caused by* environmental factors.	Analyze data using *the patterns shown in* a pedigree to identify the genotypes of individuals represented in the pedigree.
	Grade Level DCI, SEP, and *CCC*			
	LS3.B SEP1 (Investigate) *CCC6 (Structure and Function)*	LS3.A SEP6 (Reason Scientifically) *CCC6 (Structure and Function)*	LS1.B LS3.B SEP2 (Reason Scientifically) *CCC2 (Cause and Effect)*	LS3.A SEP4 (Evaluate) *CCC1 (Patterns)*

Reference DCI:

Well Below State Expectations: In addition to variations that arise from sexual reproduction, genetic information can be altered because of mutations. Though rare, mutations may result in changes to the structure and function of proteins. Some changes are beneficial, others harmful, and some neutral to the organism. (MS, LS3.B)

Topic HS.Structure and Function	**Well Below State Expectations**	**Below State Expectations**	**At State Expectations**	**Above State Expectations**
Topic DCIs **LS1.A: Structure and Function** • Systems of specialized cells within organisms help them perform the essential functions of life. • 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. • 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. • 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.	Ask questions to clarify how cells can become specialized to *carry out different functions* in multicellular organisms.	Use a model to describe how the *parts of multiple body systems* interact with each other to allow an organism to perform a given function.	Develop a model showing how the steps of the feedback mechanisms involved in a biological process, such as developing a fever, help to *maintain homeostasis.*	Analyze data (DNA sequences) in order to make valid and reliable claims that the *function of DNA is the same for all cells, but variations in the structure* of DNA allow for the production of proteins unique to different organisms.
	Grade Level DCI, SEP, and *CCC*			
	LS1.A SEP1 (Investigate) *CCC6 (Structure and Function)*	LS1.A SEP2 (Reason Scientifically) *CCC4 (Systems and System Models)*	LS1.A SEP2 (Reason Scientifically) *CCC4 (Stability and Change)*	LS1.A SEP4 (Evaluate) *CCC6 (Structure and Function)*

Reference DCI:
Well Below State Expectations: In multicellular organisms, the body is a system of multiple interacting subsystems. These subsystems are groups of cells that work together to form tissues and organs that are specialized for particular body functions. (MS, LS1.A)

High School

Earth and Space Science Topics

Topic HS.Weather and Climate	**Well Below State Expectations**	**Below State Expectations**	**At State Expectations**	**Above State Expectations**
Topic DCIs **ESS2.A: Earth Materials and Systems** • The geological record shows that changes to global and regional climate can be caused by interactions among changes in the sun's energy output or Earth's orbit, tectonic events, ocean circulation, volcanic activity, glaciers, vegetation, and human activities. These changes can occur on a variety of time scales from sudden (e.g., volcanic ash clouds) to intermediate (ice ages) to very long-term tectonic cycles. (HS-ESS2-4) **ESS2.D: Weather and Climate** • The foundation for Earth's global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's re-radiation into space. (HS-ESS2-4) • Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate. (HS-ESS2-6), (HS-ESS2-4) **ESS3.D: Global Climate Change** • Though the magnitudes of human impacts are greater than they have ever been, so too are human abilities to model, predict, and manage current and future impacts. (HS-ESS3-5)	Analyze data to make valid claims that weather and climate *are influenced* by interactions involving sunlight, the oceans, landforms, and the atmosphere, as well as human activities.	Use data to construct an argument that global climate *change is a result of* human activities.	Ask questions that evaluate the interpretation of a data set regarding global climate change *as a result of an increase in greenhouse gases* in the atmosphere, which has led to increasing global temperatures that impact local weather.	Predict the impacts on a local environment *caused by* an aspect (e.g., temperature, precipitation, ocean pH, glacial ice, sea level, ocean current, or atmospheric circulation) of climate change.
	Grade Level DCI, SEP, and *CCC*			
	ESS2.A ESS2.D SEP4 (Evaluate) *CCC2 (Cause and Effect)*	ESS2.A ESS2.D ESS3.D SEP7 (Evaluate) *CCC2 (Cause and Effect)*	ESS2.D ESS3.D SEP1 (Investigate) *CCC2 (Cause and Effect)*	ESS2.D ESS3.D SEP2 (Reason Scientifically) *CCC2 (Cause and Effect)*

Reference DCIs:

Well Below State Expectations: The complex patterns of the changes and the movement of water in the atmosphere, determined by winds, landforms, and ocean temperatures and currents, are major determinants of local weather patterns. (MS,ESS2.C)

Weather and climate are influenced by interactions involving sunlight, the ocean, the atmosphere, ice, landforms, and living things. These interactions vary with latitude, altitude, and local and regional geography, all of which can affect oceanic and atmospheric flow patterns. Because these patterns are so complex, weather can only be predicted probabilistically. (MS, ESS2.D)

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

Topic HS.Earth's Systems	**Well Below** **State Expectations**	**Below** **State Expectations**	**At State** **Expectations**	**Above** **State Expectations**
Topic DCIs **ESS2.A: Earth Materials and Systems** • Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. • Evidence from deep probes and seismic waves, reconstructions of historical changes in Earth's surface and its magnetic field, and an understanding of physical and chemical processes lead to a model of Earth with a hot but solid inner core, a liquid outer core, a solid mantle and crust. Motions of the mantle and its plates occur primarily through thermal convection, which involves the cycling of matter due to the outward flow of energy from Earth's interior and gravitational movement of denser materials toward the interior. **ESS2.B: Plate Tectonics and Large-Scale System Interactions** • The radioactive decay of unstable isotopes continually generates new energy within Earth's crust and mantle, providing the primary source of the heat that drives mantle convection. Plate tectonics can be viewed as the surface expression of mantle convection. **ESS2.C: The Roles of Water in Earth's Surface Processes** • The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics. These properties include water's exceptional capacity to absorb, store, and release large amounts of energy, transmit sunlight, expand upon freezing, dissolve and transport materials, and lower the viscosities and melting points of rocks. **ESS2.D: Weather and Climate** • The foundation for Earth's global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's re-radiation into space. • Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen. • Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate.	Ask questions to determine *relationships between* the location of hydrothermal vents and other geologic features in the ocean, such as mid-ocean ridges.	Develop a model based on evidence to illustrate how a *change* such as deforestation can result in a feedback loop that affects another Earth system.	Apply scientific reasoning to link evidence to claims that the *emergence of photosynthetic organisms* led to a change in the concentration of oxygen in the atmosphere, which in part allowed for the *evolution* of animals.	Analyze data to make valid claims about *the effects of* properties of water such as density, polarity, and heat capacity on patterns of temperature and wind, as well as the *effects of* water in shaping Earth's surfaces.
	Grade Level DCI, SEP, and *CCC*			
	ESS2.A ESS2.B SEP1 (Investigate) *CCC1 (Patterns)*	ESS2.A ESS2.D ESS2.E SEP6 (Reason Scientifically) *CCC7 (Stability and Change)*	ESS2.A SEP2 (Reason Scientifically) *CCC7 (Stability and Change)*	ESS2.C SEP4 (Evaluate) *CCC2 (Cause and Effect)*

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.				

Reference DCIs: N/A

Topic HS.Space Systems	**Well Below** **State Expectations**	**Below** **State Expectations**	**At State** **Expectations**	**Above** **State Expectations**
Topic DCIs **ESS1.A: The Universe and Its Stars** • The star called the sun is changing and will burn out over a lifespan of approximately 10 billion years. • The study of stars' light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth. • The Big Bang theory is supported by observations of distant galaxies receding from our own, of the measured composition of stars and non-stellar gases, and of the maps of spectra of the primordial radiation (cosmic microwave background) that still fills the universe. • Other than the hydrogen and helium formed at the time of the Big Bang, nuclear fusion within stars produces all atomic nuclei lighter than and including iron, and the process releases electromagnetic energy. Heavier elements are produced when certain massive stars achieve a supernova stage and explode. **ESS1.B: Earth and the Solar System** • Kepler's laws describe common features of the motions of orbiting objects, including their elliptical paths around the sun. Orbits may change due to the gravitational effects from, or collisions with, other objects in the solar system.	Make a qualitative claim from given *position and time data* to support whether the universe is expanding at a constant rate in all directions.	Apply scientific ideas to provide an explanation for why *Earth orbits the sun* and not the moon.	Use a model to predict how the *proportions* of hydrogen and helium present in the sun change as the sun ages.	Analyze *absorption spectra* to determine the composition of an exoplanet's atmosphere.
	Grade Level DCI, SEP, and *CCC*			
	ESS1.A SEP6 (Reason Scientifically) *CCC3 (Scale, Proportion, and Quantity)*	ESS1.A SEP2 (Reason Scientifically) *CCC (Scale, proportion, and quantity)*	ESS1.B SEP6 (Reason Scientifically) *CCC4 (Systems and System Models)*	ESS1.A SEP4 (Evaluate) *CCC1 (Patterns)*

Reference DCI:
Well Below State Expectations: The solar system appears to have formed from a disk of dust and gas, drawn together by gravity. (MS, ESS1.B)

Topic HS.History of Earth	**Well Below State Expectations**	**Below State Expectations**	**At State Expectations**	**Above State Expectations**
Topic DCIs **ESS1.C: The History of Planet Earth** • Continental rocks, which can be older than 4 billion years, are generally much older than the rocks of the ocean floor, which are less than 200 million years old. • Although active geologic processes, such as plate tectonics and erosion, have destroyed or altered most of the very early rock record on Earth, other objects in the solar system, such as lunar rocks, asteroids, and meteorites, have changed little over billions of years. Studying these objects can provide information about Earth's formation and early history. **ESS2.A: Earth Materials and Systems** • Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. **ESS2.B: Plate Tectonics and Large-Scale System Interactions** • Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth's surface and provides a framework for understanding its geologic history. • Plate movements are responsible for most continental and ocean-floor features and for the distribution of most rocks and minerals within Earth's crust.	Use a model to determine the *relative age* of when geologic features, such as islands, formed based on their position from a mid-ocean ridge.	Ask questions to clarify an explanation about *the pattern of* impact craters and the age of most rocks on Earth compared to other solar system planets and moons.	Apply scientific principles to explain *the pattern of* why continental rocks are much older than oceanic rocks.	Apply scientific reasoning to link evidence to claims about proposed theories of *events that led to* the origination of Earth's moon to assess the extent to which the reasoning and data support the conclusion.
	Grade Level DCI, SEP, and *CCC*			
	ESS2.B SEP2 (Reason Scientifically) *CCC3 (Scale, Proportion, and Quantity)*	ESS1.C SEP1 (Investigate) *CCC1 (Patterns)*	ESS1.C ESS2.A SEP6 (Reason Scientifically) *CCC1 (Patterns)*	ESS1.C SEP6 (Reason Scientifically) *CCC2 (Cause and Effect)*

Reference DCI:
Well Below State Expectations: Maps of ancient land and water patterns, based on investigations of rocks and fossils, make clear how Earth's plates have moved great distances, collided, and spread apart. (MS, ESS2.B)

Topic HS.Human Sustainability	**Well Below State Expectations**	**Below State Expectations**	**At State Expectations**	**Above State Expectations**
Topic DCIs **ESS3.A: Natural Resources** • Resource availability has guided the development of human society. • All forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors. **ESS3.B: Natural Hazards** • Natural hazards and other geologic events have shaped the course of human history; [they] have significantly altered the sizes of human populations and have driven human migrations. **ESS3.C: Human Impacts on Earth Systems** • The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources. • Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude ecosystem degradation. **ESS3.D: Global Climate Change** • Through computer simulations and other studies, important discoveries are still being made about how the ocean, the atmosphere, and the biosphere interact and are modified in response to human activities.	Make a quantitative and/or qualitative claim regarding the relationship between physical properties of the ocean and biodiversity of the ocean as compared to the *patterns of human activity* in recent history.	Compare and evaluate possible solutions for natural hazard events such as landslides based on *how they impact the environment* and humans.	Revise a model *to show how recycling can minimize the negative effects* of a human activity such as mining.	Provide evidence to support the claim that the consumption of energy resources *can change* based on the needs of the population using them.
	Grade Level DCI, SEP, and *CCC*			
	ESS3.D SEP6 (Reason Scientifically) *CCC1 (Patterns)*	ESS3.B SEP7 (Evaluate) *CCC2 (Cause and Effect)*	ESS3.C SEP2 (Reason Scientifically) *CCC2 (Cause and Effect)*	ESS3.A ESS3.C SEP6 (Reason Scientifically) *CCC7 (Stability and Change)*

Reference DCI:
Well Below State Expectations: Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things. (MS, ESS3.C)