VERMONT
AGENCY OF EDUCATION

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Science – Sample Proficiency-Based Graduation Requirements and Performance Indicators

Vermont Content Area Graduation Proficiencies and Performance Indicators:

- Are required by Section 2120.8 of the Education Quality Standards
- Reflect existing learning standards required by the VT State Board of Education, under the VT Framework of Standards
- Are designed to be used in conjunction with the VT Transferable Skill Graduation Proficiencies, which outline students' desired skills and habits across content areas
- Include three sets of performance indicators differentiated by grade cluster – Elementary, Middle, and High School
- Serve as benchmarks of learning progression for elementary and middle school

This document is designed to:

- Assist Vermont Supervisory Union/School Districts (SU/SDs) and schools in developing learning expectations for their students
- Promote consistency across schools and SU/SDs for all students
- Increase personalization and flexibility for instruction and learning
- Help build curriculum and steer assessment development
- Support formative assessment practices, including the use of Performance Assessments
- Simultaneously provide data and insight into achievement when aligned with the transferable skills
- Support student achievement of the expected content standards

Science Equity: Access to high-quality, standards-based science and STEM learning begins with equitable opportunities and adequate time to engage with all three dimensions of the Next Generation Science Standards. Continued emphasis on culturally sustaining science learning for all students will support equity and access within science and STEM education. By maintaining an equity lens to teaching and learning, we recognize the historic exclusion and marginalization of minority student groups and their communities, learn to support racial justice, and work to eliminate ongoing prejudice in the field of science.

The considerations below, though not a complete list, offer sample topics and scientists that may be brought into classroom curriculum to help address equitable learning in the classroom. It is important to note that both the list of potentially controversial socio-scientific issues (SSIs) and the list of historically marginalized scientists are at a surface level, and to truly attend to science equity, a change must occur in classroom culture and pedagogy. The Spotlight on Science Equity [LINK] provides educators with considerations and resources for attending to equity and access within their classrooms.

Contact Information:

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GRADUATION PROFICIENCIES	PERFORMANCE INDICATORS — ELEMENTARY SCHOOL	PERFORMANCE INDICATORS — MIDDLE SCHOOL	PERFORMANCE INDICATORS — HIGH SCHOOL
1. PHYSICAL SCIENCES: **STRUCTURE/PROPERTIES OF MATTER, FORCES, AND INTERACTIONS** Understand and analyze matter, reactions and physical systems as demonstrated through the integration of scientific and engineering practices and crosscutting concepts (PS 1 and PS 2) **Spotlight on Equity** Phenomena Topics: • Food additives • Water Quality Degradation • Pesticides and the Epidemics of Disease Scientist Considerations: • Chien-Shiung Wu • Alejandro Corichi • Émile du Châtelet	a. Develop a model to describe that matter is made of particles too small to be seen. (5-PS1-1) b. Measure and graph quantities to provide evidence that regardless of the type of change that occurs when heating, cooling, or mixing substances, the total weight of matter is conserved. (5-PS1-2) c. Plan and conduct investigations, make observations and measurements to identify materials based on their (observable) properties. (5-PS1-3) AND (2-PS1-1) d. Conduct an investigation to determine whether the mixing of two or more substances results in new substances. (5-PS1-4) e. Construct an evidence-based account of how an object made of a small set of pieces can be disassembled and made into a new object. (2-PS1-3)	a. Develop models to describe the atomic composition of simple molecules and extended structures. (MS-PS1-1) b. Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred. (MS-PS1- 2) c. Gather and make sense of information to describe that synthetic materials come from natural resources and impact society. (MS-PS1-3) d. Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed. (MS-PS1-4) e. Develop and use a model to describe how the total number of atoms does not change in a chemical reaction and thus mass is conserved. (MS-PS1-5)	a. Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms. (HS-PS1-1) b. Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron state of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties. (HS-PS1-2) c. Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles. (HS-PS1-3) d. Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy. (HS-PS1-4)

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1. PHYSICAL SCIENCES: STRUCTURE/PROPERTIES OF MATTER, FORCES, AND INTERACTIONS (cont.)	f. Construct an argument with evidence that some changes caused by heating or cooling can be reversed and some cannot. (2-PS1-4) g. Plan and conduct an investigation to describe and classify different kinds of materials by their observable properties. (2-PS2-1) h. Support an argument that the gravitational force exerted by Earth on objects is directed down. (5-PS-2-1) i. Use evidence to construct an explanation relating the speed of an object to the energy of that object.(4-PS3-1) j. Ask questions and predict outcomes about the changes in energy that occur when objects collide. (4-PS3-3) k. Make observations and/or measurements of an object's motion to provide evidence that a pattern can be used to predict future motion. (3-PS2-2)	f. Plan an investigation to provide evidence that the change in an object's motion depends on the mass of the object. (MS-PS2-2) g. Ask questions about data to determine the factors that affect the strength of electric and magnetic forces. (MS-PS2-3) h. Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects. (MS-PS2-4) i. Conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact. (MS-PS2-5)	e. Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs. (HS-PS1-5) f. Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction. (HS-PS1-7) g. Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay. (HS- PS1-8) h. Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration. (HS-PS2-1)

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1. PHYSICAL SCIENCES: STRUCTURE/PROPERTIES OF MATTER, FORCES, AND INTERACTIONS (cont.)	l. Plan and conduct an investigation to provide evidence of the effects of different strengths of different directions of pushes and pulls (K-PS2-1); AND conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object. (3-PS2-1) m. Ask questions to determine cause and effect relationships of electric or magnetic interactions between two objects not in contact with each other. (3-PS2-3)		i. Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system. (HS-PS2-2) j. Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects. (HS-PS2-4) k. Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current. (HS-PS2-5)

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2. PHYSICAL SCIENCES: ENERGY, WAVES, AND ELECTROMAGNETIC RADIATION Understand and analyze energy and the characteristics and dynamics of waves as demonstrated through the integration of scientific and engineering practices and crosscutting concepts (PS 3 and PS 4) **Spotlight on Equity** Phenomena Topics: • Green Energy Debate • Access to Digital Technology • Solar Easements and Solar Rights Scientist Considerations: • Nidhal Guessoum • Ilesanmi Adesida • Lise Meitner	a. Use models to describe that the energy in animals' food (used for body repair, growth, motion, and to maintain body warmth) was once energy from the Sun. (5-PS3-1) b. Use evidence to construct an explanation relating the speed of an object to the energy of that object. (4-PS3-1) c. Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents. (4-PS3-2) d. Ask questions and predict outcomes about the changes in energy that occur when objects collide. (4-PS3-3) e. Make observations to determine the effect of sunlight on Earth's surface. (K-PS3-1) f. Develop a model of waves to describe patterns in terms of amplitude and wavelength and that waves can cause objects to move. (4-PS4-1)	a. Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object. (MS-PS3-1) b. Develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system. (MS-PS3-2) c. Plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample. (MS-PS3-4) d. Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object. (MS-PS3-5)	a. Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known. (HS-PS3-1) b. Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as either motions of particles or energy stored in fields. (HS-PS3-2) c. Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics). (HS-PS3-4)

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2. PHYSICAL SCIENCES: ENERGY, WAVES, AND ELECTROMAGNETIC RADIATION (cont.)	g. Develop a model to describe that light reflecting from objects and entering the eye allows objects to be seen. (4-PS4-2) h. Plan and conduct investigations to provide evidence that vibrating materials can make sound and that sound can make materials vibrate. (1-PS4-1) i. Make observations to construct an evidence-based account that objects in darkness can be seen only when illuminated. (1-PS-4-2) j. Plan and conduct investigations to determine the effect of placing objects made with different materials in the path of a beam of light. (1-PS4-3)	f. Use mathematical representations to describe a simple model for waves that includes how the amplitude of a wave is related to the energy in a wave. (MS-PS4-1) g. Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials. (MS-PS4-2) h. Integrate qualitative scientific and technical information to support the claim that digitized signals are a more reliable way to encode and transmit information than analog signals. (MS-PS4-3)	d. Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction. (HS-PS3-5) e. Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media. (HS-PS4-1) f. Evaluate questions about the advantages of using a digital transmission and storage of information. (HS-PS4-2) g. Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other. (HS-PS4-3)

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2. PHYSICAL SCIENCES: ENERGY, WAVES, AND ELECTROMAGNETIC RADIATION (cont.)			h. Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter. (HS-PS4-4)

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3. LIFE SCIENCES: STRUCTURE, FUNCTION, AND INFORMATION PROCESSING Understand and analyze molecular, structural, and chemical biology as demonstrated through the integration of scientific and engineering practices and crosscutting concepts (LS 1) **Spotlight on Equity** Phenomena Topics: • Genetic Diseases and Mutations • Genetic Engineering • Genetically Modified Organisms Scientist Considerations: • Ignacio Chapela • Ben Barres • Elsie Widdowson	a. Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction. (4-LS1-1) b. Use a model to describe that animals receive different types of information through their senses, process the information in their brain, and respond to the information in different ways. (4-LS1-2) c. Develop models to describe that organisms have unique and diverse life cycles but all have in common birth, growth, reproduction, and death. (3-LS1-1) d. Plan and conduct an investigation to determine if plants need sunlight and water to grow. (2-LS2-1)	a. Conduct an investigation to provide evidence that living things are made of cells; either one cell or many different numbers and types of cells. (MS-LS1-1) b. Develop and use a model to describe the function of a cell as a whole, and the ways parts of cells contribute to the function. (MS-LS1-2) c. Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells. (MS-LS1-3) d. 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. (MS-LS1-4)	a. 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. (HS-LS1-1) b. Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms. (HS-LS1-2) c. Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis. (HS-LS1-3) d. Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms. (HS-LS1-4)

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3. LIFE SCIENCES: STRUCTURE, FUNCTION, AND INFORMATION PROCESSING (cont.)	e. Use observations to describe patterns of what plants and animals (including humans) need to survive. (K-LS1- 1) f. Read texts and use media to determine patterns in behavior of parents and offspring that help offspring survive. (1-LS1-2) g. Support an argument that plants get the materials they need for growth chiefly from air and water. (5-LS1-1)	e. Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms. (MS- LS1-5) f. 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. (MS-LS1-6) g. 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. (MS-LS1-7) h. Gather and synthesize information that sensory receptors respond to stimuli by sending messages to the brain for immediate behavior or storage as memories. (MS-LS1-8)	e. Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy. (HS-LS1-5) f. 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. (HS-LS1-6) g. 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. (HS-LS1-7)

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4. LIFE SCIENCES: MATTER AND ENERGY IN ORGANISMS AND ECOSYSTEMS Understand and analyze the characteristics, functions, and behavioral interactions within an ecosystem as demonstrated through the integration of scientific and engineering practices and crosscutting concepts (LS 2) **Spotlight on Equity** Phenomena Topics: • Human Overpopulation • Desertification and Deforestation • Invasive Species Scientist Considerations: • Anya Lim • Fina Opio • Maria Sibylla Merian	a. Develop a model to describe the movement of matter among plants, animals, decomposers, and the environment. (5-LS2-1) b. Construct an argument that some animals form groups that help members survive. (3-LS2-1) c. Plan and conduct an investigation to determine if plants need sunlight and water to grow. (2-LS2-1)	a. Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem. (MS-LS2-1) b. Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems. (MS-LS2-2) c. Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem. (MS-LS2-3) d. Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations. (MS-LS2-4)	a. Use mathematical representations to support explanations carrying capacity of ecosystems at different scales. (HS-LS2-1) b. Use mathematical representations to support and revise explanations about factors affecting biodiversity scales. (HS-LS2-2) c. Construct and revise an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions. (HS-LS2-3) d. Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem. (HS-LS2-4) e. Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, & geosphere. (HS-LS2-5)

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4. LIFE SCIENCES: MATTER AND ENERGY IN ORGANISMS AND ECOSYSTEMS (cont.)			f. 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. (HS-LS2-6) g. Evaluate the evidence for the role of group behavior on individual and species' chances to survive and reproduce. (HS-LS2-8)

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5. LIFE SCIENCES: GROWTH, DEVELOPMENT, AND REPRODUCTION OF ORGANISMS, NATURAL SELECTION, AND ADAPTATIONS Understand and analyze genetics, adaptation, and biodiversity as demonstrated through the integration of scientific and engineering practices and crosscutting concepts. (LS3 and LS4) **Spotlight on Equity** Phenomena Topics: • Antimicrobial Resistance • Bioengineering • Embryonic Stem Cell Research Scientist Considerations: • Manuel Patarroyo • Sara Josephine Baker • Sidat Yaffa	a. 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. (3-LS3-1) b. Make observations to construct an evidence-based account that young plants and animals are like, but not exactly like, their parents. (1-LS23-1) c. 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. (3-LS4-2) d. Analyze and interpret data from fossils to provide evidence of the organisms and the environments in which they lived long ago. (3-LS4-1) e. Use evidence to support the explanation that traits can be influenced by the environment. (3-LS3-2)	a. Develop and use a model to describe why structural changes to genes (mutations) located on chromosomes may affect proteins and may results in harmful, beneficial, or neutral effects to the structure and function of the organism. (MS-LS3-1) b. Develop and use a model to describe why a sexual reproduction results in offspring with identical genetic information and sexual reproduction results in offspring with genetic variation. (MS-LS3-2) c. Analyze and interpret data for patterns in the fossil record that documents that 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. (MS-LS4-1)	a. Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring. (HS-LS3-1) b. Make and defend a claim based on evidence that inheritable genetic variations may result from new genetic combinations through meiosis, viable errors occurring during replication, and/or mutations caused by environmental factors. (HS-LS3-2) c. Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population. (HS-LS3-3) d. Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence. (HS-LS4-1)

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5. LIFE SCIENCES: GROWTH, DEVELOPMENT, AND REPRODUCTION OF ORGANISMS, NATURAL SELECTION, AND ADAPTATIONS (cont.)	f. 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. (3-LS4-3) g. 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. (2-LS4-1)	d. 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. (MS-LS4-2) e. 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. (MS -LS4-3) f. 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. (MS-LS4-4)	e. 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. (HS-LS4-2) f. 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. (HS-LS4-3) g. Construct an explanation based on evidence for how natural selection leads to adaptation of populations. (HS-LS4-4)

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5. LIFE SCIENCES: GROWTH, DEVELOPMENT, AND REPRODUCTION OF ORGANISMS, NATURAL SELECTION, AND ADAPTATIONS (cont.)		g. Gather and synthesize information about the technologies that have changed the way humans influence the inheritance of desired traits in organisms. (MS -LS4-5) h. Use mathematical representations to support explanations of how natural selection may lead to increases and decreases of specific traits in populations over time. (MS -LS4-6)	h. Evaluate the evidence supporting claims that changes in environmental conditions may result in increases in the number of individuals of some species, the emergence of new species over time, the extinction of other species. (HSLS45)

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6. EARTH AND SPACESCIENCES: EARTH, SPACE, AND THE UNIVERSE Understand and analyze the origins, interactions and relationships between and among the Earth, our solar system, and the universe as demonstrated through the integration of scientific and engineeringpractices and cross- cutting concepts (ESS1) **Spotlight on Equity** Phenomena Topics: • Theory of the Big Bang • Militarization of Space • Impacts of Solar Flares Scientists Considerations: • Annie Jump Cannon • Yariv Bash • Michio Kaku	a. Support an argument that differences in the apparent brightness of the Sun compared to other stars is due totheir relative distances from the Earth. (5-ESS1-1) b. Use observations of the Sun, Moon, and stars to describe patterns that can be predicted. (1-ESS1-1) c. Represent data in graphical displays to reveal patterns of daily changes in length and direction of shadows, dayand night, and the seasonal appearance of some stars inthe night sky. (5-ESS1-2) d. Make observations at different times of year to relatethe amount of daylight to the time of year. (1-ESS1-2) e. Identify evidence from patterns in rock formations andfossils in rock layers for changes in a landscape over time to support an explanation for those changes. (4- ESS1-1)	a. Develop and use a model of the Earth-Sun-Moon system to describe the cyclic patterns of lunar phases, eclipses ofthe sun and moon, and seasons. (MS-ESS1-1) b. Develop and use a model to describe the role of gravity in the motions within galaxies and the solar system. (MS-ESS1-2) c. Analyze and interpret data to determine scale propertiesof objects in the solar system. (MS-ESS1-3) d. Construct a scientific explanation based on evidence fromrock strata for how the geologic time scale is used to organize Earth's 4.6-billion-year-old history. (MS-ESS1-4)	a. Develop a model based on evidence to illustrate the life spanof the Sun and the role of nuclear fusion in the Sun's core to release energy that eventually reaches Earth in the form of radiation. (HS-ESS1-1) b. Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the universe. (HS-ESS1-2) c. Communicate scientific ideas about the way stars, over theirlife cycle, produce elements. (HS-ESS1-3) d. Use mathematical or computational representations to predictthe motion of orbiting objects in the solar system. (HS-ESS1-4) e. Evaluate evidence of the past and current movements of continental and oceanic crust and the theory of plate tectonics to explain the ages of crustal rocks. (HS-ESS1-5)

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6. EARTH AND SPACESCIENCES: EARTH, SPACE, AND THE UNIVERSE (cont.)	f. Use information from several sources to provide evidence that Earth events can occur quickly or slowly.(2-ESS1-1)		f. Apply scientific reasoning and evidence from ancientEarth materials, meteorites, and other planetary surfaces to construct an account of Earth's formation and early history. (HS-ESS1-6)
7. EARTH AND SPACE SCIENCES: EARTH SYSTEMS Understand and analyzeEarth's systems and therelationship between human activity and the earth as demonstrated through the integration of scientific and engineering practices and cross-cutting concepts (ESS 2 and ESS 3) **Spotlight on Equity** Phenomena Topics: • Climate Change • Conflict Minerals and Resources • Extreme Weather and Erosion Scientists Considerations: • Sergio Barrientos • Inge Lehmann • Alredo Alvarado Hernández	a. Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact. (5-ESS2-1) b. Describe and graph the amounts and percentages of water and fresh water in various reservoirs to provide evidence about the distribution of water on Earth. (4- ESS2-1) c. Analyze and interpret data from maps to describe patterns of Earth's features. (4-ESS2-2) d. Develop a model to represent the shapes and kinds of land and bodies of water in an area. (2-ESS2-2)	a. Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process. (MS-ESS2-1) b. Analyze and interpret data on the distribution of fossils and rocks, continental shapes, and seafloor structures to provide evidence of the past plate motions. (MS-ESS2-3) c. Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales. (MS-ESS2-2) d. Develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity. (MS-ESS2-4)	a. Develop a model to illustrate how Earth's internal and surface processes operate at different spatial and temporal scales to form continental and ocean-floor features. (HS-ESS2-1) b. Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems (HS-ESS2-2) c. Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection. (HS-ESS2-3) d. Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate. (HS-ESS2-4)

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7. EARTH AND SPACE SCIENCES: EARTH SYSTEMS (cont.)	e. Obtain information to identify where water is found on Earth and that it can be solid or liquid. (2-ESS2-3) f. Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment. (5-ESS3-1) g. Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment. (4-ESS3-1) h. Represent data in tables and graphical displays to describe typical weather conditions expected during a particular season (3-ESS2-1); AND use and share observations of local weather conditions to describe patterns over time. [K-ESS2-1) i. Obtain and combine information to describe climates in different regions of the world. (3-ESS2-2)	e. Collect data to provide evidence for how the motions and complex interactions of air masses results in changes in weather conditions. (MS-ESS2-5) f. Develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates. (MS-ESS2-6) g. Construct a scientific explanation based on evidence for how the uneven distributions of Earth's mineral, energy and groundwater resources are the result of past and current geoscience processes. (MS-ESS3-1) h. Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects. (MS-ESS3-2)	e. Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes. (HS-ESS2-5) f. Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere. (HS-ESS2-6) g. Construct an argument based on evidence about the simultaneous coevolution of Earth's systems and life on Earth. (HS-ESS2-7) h. Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity. (HS-ESS3-1) i. Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity. (HS-ESS3-3)

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7. EARTH AND SPACE SCIENCES: EARTH SYSTEMS (cont.)	j. Construct an argument supported by evidence for how plants and animals (including humans) can change the environment to meet their needs. (K-ESS2-2) k. Use a model to represent the relationship between the needs of different plants and animals (including humans) and the places they live. (K-ESS3-1)	i. Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems. (MS-ESS3-4) j. Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century. (MS-ESS3-5)	j. Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems. (HS-ESS3-5) k. Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity. (HS-ESS3-6)

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8. TECHNOLOGY, AND APPLICATION OF SCIENCE Demonstrate engineering concepts across multiple disciplines and novel situations as demonstrated through the integration of scientific and engineering practices and cross- cutting concepts (ETS). While performance indicators that end with an * were originally assigned to an earlier standard (DCI) by NGSS, they are listed here because they demonstrate application of engineering. These performance indicators may also serve to inform whether students can demonstrate proficiency in the particular content standard in which they were originally assigned. **Spotlight on Equity** Phenomena Topics: • Artificial Intelligence's impact on society • Warfare Engineering • Climate Engineering Scientists Considerations: • Ada Lovelace • Ilesanmi Adesida • Fernanda Viégas	**Define and Delimit Engineering Problems** **Ask questions, make observations and gather information about a situation people want to change to define a simple problem that can be solved through development of a new object or tool, AND define a simple design problem reflecting a need or want that includes specified criteria for success and constraints on materials, time, or cost.** **(K-2-ETS1-1; 3-5-ETS1-1)** a. Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.* (4-PS- 3-4) b. Ask questions to obtain information about the purpose of weather forecasting to prepare for, respond to severe weather.* (K-ESS3-2) c. Analyze data obtained from testing different materials to determine which materials have the properties that are best suited for an intended purpose.* (2-PS1-2)	**Define and Delimit Engineering Problems** **Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions. (MS-ETS1-1)** a. Apply scientific principles to design, construct and test a device that either minimizes of maximizes thermal energy transfer.* (MS-PS3-3) **Develop Possible Solutions** **Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem (MSETS1-2); AND develop models to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved. (MS-ETS1-4)**	**Define and Delimit Engineering Problems** **Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants. (HS-ETS1-1)** a. Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.* (HS-PS3-3) **Develop Possible Solutions** **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 (HS-ETS1-3); AND 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. (HS ETS1-4)**

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8. TECHNOLOGY, AND APPLICATION OF SCIENCE (cont.)	d. Analyze data to determine if a design solution works as intended to change the speed or direction of an objectwith a push or a pull.* (K PS2-2) **Develop Possible Solutions** **Develop simple sketches, drawings or physical models to show how an object's shape helps it function to solve a problem; AND generate and compare multiple possible solutions to a problem based on how well each is likely tomeet the criteria and constraints of the problem.** **(K-2-ETS1-2; 3-5-ETS1-2)** e. Make a claim about the merit of a solution to a problemcaused when the environment changes and the types ofplant s and animals that live there may change. (3-LS4- 4) f. Develop a simple model that mimics the function of an animal dispersing seeds or pollinating plants.* (2-LS2-2)	b. Undertake a design project to construct, test and modify a device that either releases or absorbs thermal energy by chemical processes.* (MS-PS1-6) c. Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.* (MSPS3-3) d. Evaluate competing design solutions for maintaining biodiversity and ecosystem services.* (MS-LS2-5) **Optimize the Design Solution** **Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success (MS- ETS1-3); AND develop models to generate data for iterativetesting and modification of a proposed object, tool, or process such that an optimal design can be achieved. (MS ETS1-4)**	b. Design, evaluate, and refine a solution for reducing theimpacts of human activities on the environment and biodiversity.* (HS- LS2-7) c. Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.* (HS-LS4-6) d. Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost- benefit ratios.* (HS-ESS3-2) e. Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.* (HS-ESS3-4)

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8. TECHNOLOGY, AND APPLICATION OF SCIENCE (cont.)	g. Communicate solutions that will reduce the impact ofhumans on the land, water, air, and/or other living things in the local environment.* (K-ESS3-3) **Optimize the Design Solution** **Analyze data from tests of two objects designed to solvethe same problem to compare the strengths and weakness of how each perform; AND plan and carry outfair tests and analyze data from tests to determine if a design solution works as intended and compare the strengths and weaknesses of how each performs.** **(K-2-ETS1-3; 3-5-ETS1-3)** h. Generate and compare multiple solutions to reduce theimpacts of natural Earth processes on humans.* (4- ESS3-2) **i.** Compare multiple solutions designed to slow or prevent wind or water from changing the shape of the land. (2 ESS2-1)	e. Undertake a design project to construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes.* (MS-PS1-6) **Links among Engineering, Technology, Science and Society** f. Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects.* (MS-PS2-1) g. Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.* (MS-ESS3-3) Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects.* (MS-PS2-1)	**f.** 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. (HS-ETS1-4) **Optimize the Design Solution** **Design a solution to a complex real world problem by breaking itdown into smaller, more manageable problems that can be solved through engineering. (HS-ETS1-2)**

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8. TECHNOLOGY, AND APPLICATION OF SCIENCE (cont.)	**Links among Engineering, Technology, Science and Society** j. Define a simple design problem that can be solved by applying scientific ideas about magnets.* (3-PS2-4) k. Make a claim about the merit of a design solution that reduces the impacts of a weather-related hazard. (3-ESS3-1) l. 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.* (1-LS1-1) m. Use tools and materials to design and build a device that uses light or sound to solve the problem of communicating over a distance.* (1-PS4-4) n. Generate and compare multiple solutions that use patterns to transfer information.* (4-PS4-3)		g. Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.* (HS-PS1-6) h. Apply scientific and engineering ideas to design, evaluate, andrefine a device that minimizes the force on a macroscopic object during a collision.* (HS-PS2-3) **Links among Engineering, Technology, Science and Society** i. Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.* (HS-PS2-6) j. 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.* (HS-PS4-5)