# VERMONT ALTERNATE ASSESSMENT FOR SCIENCE – NEXT GENERATION SCIENCE STANDARDS (NGSS)

## ACHIEVEMENT LEVEL DESCRIPTORS



The VTAA Science Achievement Level Descriptors (ALDs) define the content knowledge, skills, and processes that students at a particular achievement level should be able to do. As they are not an exhaustive list of curricular tasks or pieces of content students are responsible for knowing, they can be used as an additional resource for developing curriculum. They were developed to provide descriptions of each proficiency level and are used to establish performance standards.

**Essence Statement:** The Essence Statement describes the core ideas within an Achievement Expectation (PE) distilled down to a level appropriate for the students participating in the Alternate Assessment. In some instances, this distillation of the PE into an Essence Statement was not possible, and those PEs will not be included in the assessment.

**Exceeds:** A student who is <u>exceeds</u> demonstrates a level of understanding that includes the ability to “bring together” the Disciplinary Core Ideas (DCI) and/or Science and Engineering Practices (SEP) and/or Cross-Cutting Concepts (CCC) associated with a PE.

**Meets:** A student who <u>meets</u> demonstrates an understanding of the DCI and/or SEP and/or CCC within a PE at the level described in the Essence Statement.

**Approaching:** A student who is <u>approaching</u> demonstrates some understanding of the content of the PE, but that understanding is incomplete and does not yet meet the expectations found in the Essence Statement. This student’s understanding is partial but emerging.

**Beginning:** A student who is <u>beginning</u> demonstrates a level of understanding that is at a very preliminary level. This student’s understanding is nonexistent or incomplete, and he or she has difficulty meeting the expectations of a student who approaches expectations.

Note: Achievement Expectations (PEs) where Essence Statements and Achievement Level Descriptor fields are in gray will not be assessed.

Abbreviations Used: **NGSS**: Next Generation Science Standards, **PE**: NGSS Achievement Expectation, **SEP**: NGSS Science and Engineering Practice, **CCC**: NGSS Cross Cutting Concept

# ELEMENTARY (Administered in Grade 5)

## VT Alternate Science – NGSS Elementary

| Next Generation Science Standards | | Essence Statements | Achievement-Level Descriptors | | | |
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| PE | SEP / DCI / CCC | | Beginning | Approaching | Meets | Exceeds |
| **Physical Science: PS 1 Matter and Interactions ❖ A. Structure and Properties of Matter ❖ B. Chemical Reactions ❖ C. Nuclear Processes** | | | | | | |
| **5-PS1-1**<br>Develop a model to describe that matter is made of particles too small to be seen. | **SEP: Developing and Using Models**<br>Use models to describe phenomena.<br><br>**DCI: Structure and Properties of Matter**<br>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.<br><br>**CCC: Scale, Proportion, and Quantity**<br>Natural objects exist from the very small to the immensely large. | Matter of any type can be broken down into particles that are too small to see, but still exists and can be detected by other means. | Identify examples of matter including solids, liquids, and gases. | Recognize that if a pure substance (e.g., a cube of sugar, pieces of salt) is broken up into small pieces, each piece is still a piece of that substance. | Demonstrate an understanding that when a substance is dissolved the pieces are still present but are too small to see (e.g., sugar particles dissolved in water are still present; thus, the water is sweet). | Identify models that prove matter is present even though it is too small to be seen (e.g., trapping gas in a balloon, tissue moving when you blow on it, evaporation of liquids). |
| **5-PS1-2**<br>Measure and graph quantities to provide evidence that, regardless of the type of change that occurs when melting, cooling, or mixing substances, the total weight of matter is conserved. | **SEP: Using Mathematics and Computational Thinking**<br>Measure and graph quantities such as weight to address scientific and engineering questions and problems.<br><br>**DCI: Structure and Properties of Matter**<br>The amount (weight) of matter is conserved when it changes form, even in transitions in which it seems to vanish.<br>**DCI: Chemical Reactions**<br>No matter what reaction or change in properties occurs, the total weight of the substances does not change.<br><br>**CCC: Scale, Proportion, and Quantity** Standard units are used to measure and describe physical quantities such as weight, time, temperature, and volume. | Mass (weight) stays the same when materials change (when melted, cooled, mixed, or react to form new materials).<br>Note: NGSS does not distinguish between mass and weight at this grade level. | Recognize that matter (solids or liquids) has mass (weight). | Recognize that matter (solids or liquids) has the same mass (weight) after a change (example--whole apple vs cut up pieces of apple) showing that matter is conserved. | Identify weight data that shows the total weight of matter before and after heating, cooling, or mixing materials stays the same. | Recognizing that weight is conserved, determine a missing piece of data, when a change occurs (given all the weights except one). |

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| **5-PS1-3**<br>Make observations and measurements to identify materials based on their properties. | **SEP: Planning and Carrying Out Investigations**<br>Make observations and measurements to produce data as the basis for an explanation of a phenomenon.<br>**DCI: Structure and Properties of Matter**<br>Measurements of a variety of properties can be used to identify materials.<br>**CCC: Scale, Proportion, and Quantity**<br>Standard units are used to measure and describe physical quantities such as weight, time, temperature, and volume. | Different substances have different properties (e.g., color, hardness, reflectivity, melting point, boiling point, response to magnetic forces, conductivity, solubility). | Identify a property of a material (e.g., color, hardness, flexibility, texture, luster). | Determine which materials possess a specified property (e.g., color, hardness). | Differentiate substances that have different physical/chemical properties. | Make observations and identify a material based on its properties (e.g., color, hardness, melting point, solubility). |
| **5-PS1-4**<br>Conduct an investigation to determine whether the mixing of two or more substances results in new substances. | **SEP: Planning and Carrying Out Investigations**<br>Conduct an investigation in which variables are controlled to produce data, which serve as the evidence.<br>**DCI: Chemical Reactions**<br>When two or more different substances are mixed, a new substance with different properties may be formed.<br>**CCC: Cause and Effect**<br>Cause and effect relationships are routinely identified and used to explain change. | Recognize changes that indicate that a chemical reaction has occurred. | Identify that mixtures consist of at least two substances. | Identify the properties of a new substance after two substances are mixed (e.g., dissolution, color change, change in volume or mass, bubbling). | Use observations to determine if the mixing of two or more substances results in a chemical change. (Signs include color change, production of a different smell, change of temperature, formation of a gas [bubbles], formation of a solid.) | Use observations to identify whether the material formed by mixing two substances has the same or different properties as either of the substances that were mixed. |

| Physical Science: PS 2 Motion and Stability: Forces and Interactions ❖ A. Forces and Motion ❖ B. Types of Interactions ❖ C. Stability and Instability in Physical Systems | | | | | | |
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| **3-PS2-1** Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object. | **SEP: Planning and Carrying Out Investigations** Plan and conduct an investigation in which variables are controlled to produce data, which serve as the evidence. **DCI: Forces and Motion** Each force acts on one particular object and has both strength and a direction. **DCI: Types of Interactions** Objects in contact exert forces on each other. **CCC: Cause and Effect** Cause and effect relationships are routinely identified. | Forces can cause an object to move, and changes in forces can change that motion (e.g., students pushing on a wooden crate). | Identify if an object will move if a given force is applied. | Recognize a force as a push or a pull. | Identify unbalanced forces as the cause of an object's movement. | Predict how an object's motion would change if the forces acting on it change. |
| **3-PS2-2** Make observations and/or measurements of an object's motion to provide evidence that a pattern can be used to predict future motion. | **SEP: Planning and Carrying Out Investigations** Make observations to produce data as evidence for an explanation of a phenomenon. **DCI: Forces and Motion** The patterns of an object's motion can be observed and measured; when the motion exhibits a regular pattern, future motion can be predicted. **CCC: Patterns** Patterns of change can be used to make predictions. | Patterns of motion can be used to predict future motion (e.g., a child on a see saw [up/ down] or swing [back/ forth]). | Identify when an object is moving. (See 3-PS2-1.) | Identify motion that is following a pattern. | Use data (presented pictorially) related to the motion of an object whose motion is following a pattern to predict future motion. | Use data (presented in tabular information) related to the motion of an object whose motion is following a pattern to predict future motion. |
| **3-PS2-3** Ask questions to determine cause and effect relationships of electrical or magnetic interactions between two objects not in contact with each other. | **SEP: Asking Questions and Defining Problems** Ask questions that can be investigated based on patterns such as cause and effect relationships. **DCI: Types of Interactions** Electric and magnetic forces between a pair of objects do not require that the objects be in contact. The sizes of the forces in each situation depend on the properties of the objects and their distances apart and, for forces between magnets, on their orientation relative to each other. **CCC: Cause and Effect** Cause and effect relationships can be identified, tested, and used to explain change. | Some forces, such as electrical and magnetic forces, do not require objects to be in contact to interact. | Identify which objects would be affected by magnetic forces (e.g., iron clip, paper wrapper, plastic cup, wooden pencil). | Recognize that magnets can pull some objects toward them AND can push some objects away (when magnets have similar poles "facing each other") without touching them. | Describe how magnets interact with metal objects when they are not in contact with each other. | Identify a question(s) (cause and effect) that could be asked and answered about the interaction of a magnet and a variety of items, given illustrations of metal objects mixed with non-metal objects (e.g., rice and paper clips). |

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| **3-PS2-4**<br>Define a simple design problem that can be solved by applying scientific ideas about magnets. | **SEP: Asking Questions and Defining Problems**<br>Define a simple problem that can be solved through the development of a new or improved object or tool.<br>**DCI: Types of Interactions**<br>Electric and magnetic forces between a pair of objects do not require that the objects be in contact. The sizes of the forces in each situation depend on the properties of the objects and their distances apart and, for forces between magnets, on their orientation relative to each other.<br>**CCC: Science, Engineering, and Technology Are Interdependent**<br>Scientific discoveries about the natural world can often lead to new and improved technologies. | DCI addressed in 3-PS2-3. | | | | |
| **5-PS2-1**<br>Support an argument that the gravitational force exerted by Earth on objects is directed down. | **SEP: Engaging in Argument from Evidence**<br>Support an argument with evidence, data, or a model.<br>**DCI: Types of Interactions**<br>The gravitational force of Earth acting on an object near Earth's surface pulls that object toward the planet's center.<br>**CCC: Cause and Effect**<br>Cause and effect relationships are routinely identified and used to explain change. | Gravity causes objects to fall toward Earth. | Identify that objects fall downward. | Identify that gravity is a force that affects all objects. | Use observations to determine that objects, regardless of their weight, fall toward the Earth due to Earth's gravitational force. | Determine if an observation supports the claim that objects fall downward toward the Earth. |
| **Physical Science: PS 3 Energy** ❖ **A. Definitions of Energy** ❖ **B. Conservation of Energy and Energy Transfer** ❖ **C. Relationship Between Energy and Forces** ❖ **D. Energy and Chemical Processes in Everyday Life** | | | | | | |
| **4PS3-1**<br>Use evidence to construct an explanation relating the speed of an object to the energy of that object. | **SEP: Constructing Explanations and Designing Solutions**<br>Use evidence (e.g., measurements, observations, patterns) to construct an explanation.<br>**DCI: Definition of Energy**<br>The faster a given object is moving, the more energy it possesses.<br>**CCC: Energy and Matter**<br>Energy can be transferred in various ways and between objects. | The faster a given object is moving, the more energy it has and the greater the impact will be if it strikes another object.<br>(A "given object" is important here. It is not about comparing the energy of different objects, although two | Identify that an object can move at different speeds (faster, slower). | Identify the conditions under which an object can move (e.g., the object requires energy to move [kinetic energy/push or pull]). | Recognize that if two identical objects are moving at different speeds, then the one moving faster has more energy. | Use data (information in tables, observations, or patterns) to identify the instance where energy is greatest or least if similar objects are moving at different speeds. |

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| | | identical objects at different speeds can be compared.) | | | | |
| **4-PS3-2**<br>Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electrical currents. | **SEP: Planning and Carrying Out Investigations**<br>Make observations to produce data to serve as the basis for evidence for an explanation of a phenomenon or test a design solution.<br>**DCI: Definitions of Energy**<br>Energy can be moved from place to place by moving objects or through sound, light, or electric currents.<br>**DCI: Conservation of Energy and Energy Transfer**<br>Energy can be transferred from place to place and also be transformed from one form to another.<br>**CCC: Energy and Matter**<br>Energy can be transferred in various ways and between objects. | Energy can be moved from place to place by moving objects or through sound, light, or electricity. | Recognize motion, sound, light, or electricity as forms of energy. | Identify the type of energy present in different circumstances (e.g., motion, sound, light, or electricity). | Identify examples of energy moving from place to place (e.g., electrical energy in a circuit, light or sound across a room, a moving object going from one place to another). | Given a scenario where energy moves and is changed into a different form, identify the transformation. For example, a restaurant uses lamps to keep the food warm. The lamp is plugged into an electrical socket. How does the energy from the socket transform to keep the food warm? |
| **4-PS3-3**<br>Ask questions and predict outcomes about the changes in energy that occur when objects collide. | **SEP: Asking Questions and Defining Problems**<br>Ask questions that can be investigated and predict reasonable outcomes based on patterns such as cause and effect relationships.<br>**DCI: Definitions of Energy**<br>See 4-PS3-2.<br>**DCI: Conservation of Energy and Energy Transfer**<br>See 4-PS3-2.<br>**DCI: Relationship Between Energy and Forces**<br>When objects collide, the contact forces transfer energy so as to change the objects' motions.<br>**CCC: Energy and Matter**<br>Energy can be transferred in various ways and between objects. | When a moving object collides with another object, energy is transferred and the motion changes. | Identify that a collision occurs when two objects hit each other. Identify that a collision of a moving object with a stationary object can cause the stationary object to move. | Recognize that objects move due to the energy that they possess. Identify that the energy in a moving object can be transferred to another object that it collides with. | Predict the motion of a stationary object as energy is transferred when another object collides with it. | Identify that the harder/ stronger the push, the farther and faster an object will move. Predict the direction an object will move after a collision. |

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| **4-PS3-4**<br>Apply scientific ideas to design, task, and refine a device that converts energy from one form to another. | **SEP: Constructing Explanations and Designing Solutions**<br>Apply scientific ideas to solve design problems.<br><br>**DCI: Conservation of Energy and Energy Transfer**<br>Energy can also be transferred from place to place by electric currents, which can then be used locally to produce motion, sound, heat, or light.<br>**DCI: Energy in Chemical Processes and Everyday Life**<br>The expression "produce energy" typically refers to the conversion of stored energy into a desired form for practical use.<br><br>**CCC: Energy and Matter**<br>Energy can be transferred in various ways and between objects. | Energy can be transferred from place to place and converted from one form to another for a variety of uses. | Identify a source of energy (e.g., battery, moving car). | Identify what form of energy is produced by a device (source) (e.g., sound, light, heat, motion, electricity). | Identify a missing component in a device that changes energy from one form to another (e.g., circuit, a battery lighting a light, a bell ringing). | Use components to "build" a device that changes energy from one form to another (e.g., a simple circuit to light a bulb). |
| **5-PS3-1**<br>Use models to describe that energy in animals' food (used for body repair, growth, and motion and to maintain body warmth) was once energy from the sun. | **SEP: Developing and Using Models**<br>Use models to describe phenomena.<br>**DCI: Energy: Energy in Chemical Processes and Everyday Life**<br>The energy released from food was once energy from the sun that was captured by plants in the chemical process that forms plant matter.<br>**DCI: Organization for Matter and Energy Flow in Organisms**<br>Food provides animals with the materials they need for body repair and growth and the energy they need to maintain body warmth and for motion.<br>**CCC: Energy and Matter**<br>Energy can be transferred in various ways and between objects. | Since all food can eventually be traced back to plants, energy that animals use for body repair, growth, motion, and warmth is energy that once came from the sun. | Identify that animals need food to survive. | Identify the source of an animal's energy as its food. (Complete a two-step food chain.) | Trace the source of the materials an animal needs for body maintenance, growth, and motion to the sun. | Given all the components of a food chain, put them in order starting with the sun and ending with an animal.<br><br>Recognize the effects of removing the sun from a given energy flow model.<br><br>(The models should be limited to 3 or 4 components including the sun and the animal.) |

| Physical Science: PS 4 Waves and Their Applications in Technologies ❖ A. Wave Properties ❖ B. Electromagnetic Radiation ❖ C. Information Technologies and Instrumentation | | | | | | |
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| **4-PS4-1**<br>Develop a model of waves to describe patterns in terms of amplitude and wavelength and that waves can cause objects to move. | **SEP: Developing and Using Models**<br>Develop a model using an analogy, example, or abstract representation to describe a scientific principle.<br><br>**DCI: Wave Properties**<br>Waves have regular patterns of motion. They can be made in water by disturbing the surface. When waves move across the water, the water goes up and down in place; there is no net motion in the direction of the wave except when the water meets a beach.<br>Waves of the same type can differ in amplitude and wavelength.<br><br>**CCC: Patterns**<br>Similarities and differences in patterns can be used to sort, classify, and analyze simple rates of change for natural phenomena. | Waves can differ in amplitude (height) and wavelength (spacing between waves), but they follow a regular pattern of motion. | Identify that waves are created when an object falls into water. | Identify that the size of an object that falls into water can make waves bigger or smaller. | Compare the pattern of two waves with different amplitude or wavelength. | Predict an object's motion based on the pattern of the wave. |
| **4-PS4-2**<br>Develop a model to describe that light reflecting from objects and entering the eyes allows objects to be seen. | **SEP: Developing and Using Models**<br>Develop a model to describe phenomena.<br><br>**DCI: Electromagnetic Radiation**<br>An object can be seen when light reflected from its surface enters the eyes.<br><br>**CCC: Cause and Effect**<br>Cause and effect relationships are routinely identified. | Light reflecting from objects and entering the eyes allows the object to be seen. | Identify the sources of light. | Identify that light is needed to see objects. | Identify a model that shows the reflection of light following a path between a light source, the object, and the eye. | Complete the components of a model (diagram) that shows the path of the reflection of light. |
| **4-PS4-3**<br>Generate and compare multiple solutions that use patterns to transfer information. | **SEP: Constructing Explanations and Designing Solutions**<br>Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design solution.<br><br>**DCI: Information Technologies and Instrumentation**<br>Digitized information can be transmitted over long distances without significant degradation. High-tech devices can receive and decode information—convert it from digitized form to voice—and vice versa.<br>**DCI: Optimizing the Design Solution**<br>Different solutions need to be tested in order to determine which of them best solves the problem.<br><br>**CCC: Patterns**<br>Similarities and differences in patterns can be used to sort and classify designed products. | This Achievement Expectation will not be assessed at the elementary level. | | | | |

| Life Science: LS 1 From Molecules to Organisms: Structures and Processes ❖ A. Structure and Function ❖ B. Growth and Development of Organisms ❖ C. Organization for Matter and Energy Flow in Organisms ❖ D. Information Processing | | | | | | |
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| **3-LS1-1**<br>Develop models to describe that organisms have unique and diverse life cycles, but all have in common birth, growth, reproduction, and death. | **SEP: Developing and Using Models**<br>Develop models to describe phenomena.<br><br>**DCI: Growth and Development of Organisms**<br>Reproduction is essential to the continued existence of organisms. Plants and animals have unique and diverse life cycles.<br><br>**CCC: Patterns**<br>Patterns of change can be used to make predictions. | All living things have a life cycle that includes birth, growth, reproduction, and death. | Identify that organisms are born and grow. | Identify the components of an organism's life cycle. | Given the stages of the life cycle of an organism, put them in order (e.g., develop a model). | Make a prediction about what would happen to a species if it didn't reproduce. |
| **4-LS1-1**<br>Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction. | **SEP: Engaging in Argument from Evidence**<br>Construct an argument with evidence, data, and/or a model.<br><br>**DCI: Structure and Function**<br>Plants and animals have both internal and external structures that serve various functions in growth, survival, behavior, and reproduction.<br><br>**CCC: Systems and System Models**<br>A system can be described in terms of its components and their interactions. | Structures of organisms have different functions to support survival. | Identify plant and animal structures. | Distinguish between internal and external structures. | Identify the functions (survival, growth, behavior, and/or reproduction) of various plant and animal structures. (Structures could include thorns, stems, roots, colored petals, heart, stomach, lung, brain, skeleton, and skin.) | Identify the plant or animal structure that best meets the plant's or animal's needs in a given scenario (e.g., ducks have webbed feet while pigeons have "claws"). |
| **4-LS1-2**<br>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. | **SEP: Developing and Using Models**<br>Use a model to test interactions concerning the functioning of a natural system.<br><br>**DCI: Information Processing**<br>Different senses are specialized for particular kinds of information, which may be then processed by the animal's brain. Animals are able to use their perceptions and memories to guide their actions.<br><br>**CCC: Systems and System Models**<br>A system can be described in terms of its components and their interactions. | Animals receive information through their senses, process the information, and respond. | Identify the senses animals use to receive stimuli. | Identify environmental stimuli to which animals respond. | Identify animal structures that enable them to detect, process, and react to information from their surroundings. | Identify how an animal responds to information from its surroundings. |

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| **5-LS1-1** Support an argument that plants get the materials they need for growth chiefly from air and water. | **SEP: Engaging in Argument from Evidence** Support an argument with evidence, data, or a model. **DCI: Organization for Matter and Energy Flow in Organisms** Plants acquire their material for growth chiefly from air and water. **CCC: Energy and Matter** Matter is transported into, out of, and within systems. | Water and air are essential for plant growth. | Identify a plant as a living organism. | Identify that plants have needs to survive. | Identify air and water as the chief sources of growth materials for plants. | Use data to explain that plants get the materials they need for growth from air and water (e.g., the effect of various amounts of water on plant growth). |
| **Life Science: LS 2 Ecosystems: Interactions, Energy, and Dynamics ❖ A. Interdependent Relationships in Ecosystems ❖ B. Cycles of Matter and Energy Transfer in Ecosystems ❖ C. Ecosystem Dynamics, Functioning, and Resilience ❖ D. Social Interactions and Group Behavior** | | | | | | |
| **3-LS2-1** Construct an argument that some animals form groups that help members survive. | **SEP: Engaging in Argument from Evidence** Develop models to describe phenomena. **DCI: Social Interactions and Group Behavior** Being part of a group helps animals obtain food, defend themselves, and cope with changes. **CCC: Cause and Effect** Cause and effect relationships are routinely identified and used to explain change. | Some animals form groups to help them survive. | Identify groups of predator and prey animals. | Identify an animal group's behavior (e.g., herding, hunting in packs, raising and protecting young). | Determine how the group behavior helps the animals survive. (Benefits might include obtaining food and protection.) | Use evidence to determine a predator or prey group's behaviors and how they help the animals. |
| **5-LS2-1** Develop a model to describe the movement of matter among plants, animals, decomposers, and the environment. | **SEP: Developing and Using Models** Develop a model to describe phenomena. **DCI: Interdependent Relationships in Ecosystems** The food of almost any kind of animal can be traced back to plants. Organisms are related in food webs in which some animals eat plants for food and other animals eat the animals that eat plants. Some organisms, such as fungi and bacteria, break down dead organisms. Organisms can survive only in environments in which their particular needs are met. A healthy ecosystem is one in which multiple species of different types are each able to meet their needs in a relatively stable web of life. Newly introduced species can damage the balance of an ecosystem. **DCI: Cycles of Matter and Energy Transfer in Ecosystems** Matter cycles between the air and soil and among plants, animals, and microbes as these organisms live and die. **CCC: Systems and Systems Models** A system can be described in terms of its components and their interactions. | Producers, consumers, and decomposers have roles in the movement of matter in a food web. | Identify plants and animals as producers or consumers. | Identify the components of a food web (producer, consumer, and decomposer). | Identify the role of producers, consumers, and decomposers. | Use a model to show how matter flows through an ecosystem. Given a food chain, identify the flow of energy between organisms. |

| Life Science: LS 3 Heredity, Inheritance and Variation of Traits ❖ A. Inheritance of Traits ❖ B. Variation of Traits | | | | | | |
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| **3-LS3-1**<br>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. | **SEP: Analyzing and Interpreting Data**<br>Analyze and interpret data to make sense of phenomena using logical reasoning.<br>**DCI: Inheritance of Traits**<br>Many characteristics of organisms are inherited from their parents.<br>**DCI: Variation of Traits** Different organisms vary in how they look and function because they have different inherited information.<br>**CCC: Patterns**<br>Similarities and differences in patterns can be used to sort and classify natural phenomena. | Many of the traits of organisms are similar to those of their parents (e.g., size, color). | Identify a trait of a plant or animal that could be inherited. | Identify one similarity between a parent and their offspring. | Identify similarities and differences between parents and their offspring. | When given data, predict traits that would be similar between parents and offspring (e.g., parent dogs and a litter of puppies). |
| **3-LS3-2**<br>Use evidence to support the explanation that traits can be influenced by the environment. | **SEP: Constructing Explanations and Designing Solutions**<br>Use evidence (e.g., observations, patterns) to support an explanation.<br>**DCI: Inheritance of Traits**<br>Some characteristics result from individuals' interactions with the environment, such as diet and learning. Many characteristics involve both inheritance and environment.<br>**DCI: Variation of Traits**<br>The environment also affects the traits that an organism develops.<br>**CCC: Cause and Effect**<br>Cause and effect relationships are routinely identified and used to explain change. | Some characteristics of organisms result from environmental factors (e.g., lack of food or water). | Identify the needs of a plant or animal. | Distinguish between a plant with sufficient light and water and one where one of these is lacking OR an animal that is properly fed and getting sufficient exercise and one that is not. | Identify traits of a plant or animal that can be altered by its environment. | Predict the effect environmental factors will have on the traits of organisms of the same type (e.g., amount of food; amount of water; in the case of plants, amount of fertilizer). |
| **Life Science: LS 4 Biological Evolution: Unity and Diversity A. Evidence of Common Ancestry B. Natural Selection C. Adaptation D. Biodiversity and Humans** | | | | | | |
| **3-LS4-1**<br>Analyze and Interpret data from fossils to provide evidence of the organisms and environments in which they lived long ago. | **SEP: Analyzing and Interpreting Data**<br>Analyze and interpret data to make sense of phenomena.<br>**DCI: Evidence of Common Ancestry and Diversity**<br>Some plants and animals that once lived on Earth are no longer found anywhere.<br>Fossils provide evidence about the types of organisms that lived long ago and also about their environments.<br>**CCC: Scale, Proportion, and Quantity**<br>Some observable phenomena exist for a very short time and others for a very long period. | Fossils provide information about plants and animals that once lived and the environment in which they once lived. | Identify a fossil. | Identify whether the fossil was an animal or a plant. | Identify the environment (land or water, forest or desert) in which a fossil animal or plant lived. | Identify the fossil trait that supports the environment in which the animal or plant lived. (This may include illustrations.) |

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| **3-LS4-2**<br>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. | **SEP: Constructing Explanations and Designing Solutions**<br>Use evidence (e.g., observations, patterns) to support an explanation.<br>**DCI: Natural Selection**<br>Sometimes the differences in characteristics between individuals of the same species provide advantages in surviving, finding mates, and reproducing.<br>**CCC: Cause and Effect**<br>Cause and effect relationships are routinely identified and used to explain change. | Sometimes differences in the characteristics between individuals of the same species provide advantages. | Identify a characteristic of an individual plant or animal. | Identify the differences in the characteristics of individuals within a species. | Determine which variation of the characteristic is most helpful to the animals. | Classify variations as likely to be an advantage or disadvantage to an animal or plant's survival. |
| **3-LS4-3**<br>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. | **SEP: Engaging in Argument from Evidence**<br>Construct an argument with evidence.<br>**DCI: Adaptation**<br>For any particular environment, some kinds of organisms survive well, some survive less well, and some cannot survive at all.<br>**CCC: Cause and Effect**<br>Cause and effect relationships are routinely identified and used to explain change. | Sometimes the differences in characteristics between individuals of the same species provide advantages in a particular habitat. | Identify an organism in a habitat. | Identify the features of a habitat, including the organisms living in it. | Determine the characteristics an organism needs to survive in a particular habitat. | Interpret data to provide evidence that some organisms of a species can survive well in a habitat because their needs are met, and some organisms of that species cannot survive because their needs are not met. |
| **3-LS4-4**<br>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. | **SEP: Engaging in Argument from Evidence**<br>Make a claim about the merit of a solution to a problem by citing relevant evidence.<br>**DCI: Ecosystem Dynamics, Functioning, and Resilience**<br>When an environment changes, some organisms die, others move to new locations, yet others move into the environment, and some die.<br>**DCI: Biodiversity and Humans**<br>Populations live in a variety of habitats, and changes in those habitats affect the organisms living there.<br>**CCC: Systems and System Models**<br>A system can be described in terms of its components and their interactions. | When an environment changes, the organisms in the environment are impacted, some positively and others negatively. | Identify how the environment changed after a natural or manmade event. | Identify an organism(s) that will be affected by a change in an environment. | Determine if a change in the environment is likely to have a positive or negative impact on a particular organism. | Given a simple data table, determine if a solution to the environmental change was effective (i.e., Did replanting trees lead to more birds being present?) |

| Earth Space Science ESS 1 Earth's Place in the Universe ❖ A. The Universe and Its Stars ❖ B. Earth and the Solar System ❖ C. The History of Planet Earth | | | | | | |
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| **4-ESS1-1**<br>Identify evidence from patterns in rock formations and fossils in rock layers to support an explanation for changes in a landscape over time. | **SEP: Constructing Explanations and Designing Solutions**<br>Identify the evidence that supports particular points in an explanation.<br>**DCI: The History of Planet Earth**<br>Patterns of rock formations reveal changes over time due to Earth forces, such as earthquakes. The presence and location of fossil types indicate the order in which rock layers were formed.<br>**CCC: Patterns**<br>Patterns can be used as evidence to support an explanation. | Patterns of rock formations and locations of fossils in rock layers reveal changes over time. | Identify that there are different rock layers in Earth and that fossils can be found in some rock layers. | Identify that the lower rock layers are the oldest rock layers. | Determine the environment of a given rock layer based on fossil evidence. | Determine a change that occurred in an environment based on the patterns/evidence found in the rock layers. |
| **5-ESS1-1**<br>Support an argument that differences in the apparent brightness of the sun compared to other stars is due to their relative distances from Earth. | **SEP: Engaging in Argument from Evidence**<br>Support an argument with evidence, data, or a model.<br>**DCI: The Universe and Its Stars**<br>The sun is a star that appears larger and brighter than other stars because it is closer. Stars range greatly in their distance from Earth.<br>**CCC: Patterns; Scale, Proportion, and Quantity**<br>Natural objects exist, from the very small to the immensely large. | The universe has many stars. Some are brighter than the sun but appear less bright because of their distance from Earth. | Identify the sun as a star. | Demonstrate an understanding of the fact that a luminous object close to a person appears much brighter and larger than a similar object that is very far away from a person (e.g., nearby streetlights appear bigger and brighter than distant streetlights). | Use data to show that the closer a star is to Earth, the brighter the star appears. | Use data to determine which of two equally bright stars is closest to Earth based upon their apparent brightness. |
| **5-ESS1-2**<br>Represent data in graphical displays to reveal patterns of daily changes in the length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky. | **SEP: Analyzing and Interpreting Data**<br>Represent data in tables and various graphical displays (bar graphs and pictographs) to reveal patterns that indicate relationships.<br>**DCI: Earth and the Solar System**<br>The orbits of Earth around the sun and of the moon around Earth, together with the rotation of Earth about its axis, cause observable patterns. These include day and night; daily changes in the length and direction of shadows; and different positions of the sun, moon, and stars at different times of the day, month, and year.<br>**CCC: Patterns; Scale, Proportion, and Quantity**<br>Similarities and differences in patterns can be used to sort, classify, communicate, and analyze simple rates of change for natural phenomena. | Phases of the moon and shadows follow a regular pattern. | Identify a shadow, the moon, and the sun. | Identify that the size of a shadow changes.<br>Identify that the appearance of the moon changes. | Use data to identify patterns in the size of shadows. Use data to identify patterns in the phases of the moon. | Use data to identify patterns in the size of shadows including the relationship between the shadow and the position of the sun.<br>Use data to identify a future phase of the moon. |

| Earth Space Science ESS 2 Earth Systems ❖ A. Earth Materials and Systems ❖ B. Plate Tectonics and Large-Scale System Interactions ❖ C. The Roles of Water in Earth's Surface Processes ❖ D. Weather and Climate ❖ E. Biogeology | | | | | | |
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| **3-ESS2-1**<br>Represent data in tables and graphical displays to describe typical weather conditions expected during a particular season. | **SEP: Analyzing and Interpreting Data**<br>Represent data in tables and various graphical displays (bar graphs and pictographs) to reveal patterns that indicate relationships.<br>**DCI: Earth Systems: Weather and Climate**<br>Scientists record patterns of the weather across different times and areas so that they can make predictions about what kind of weather might happen next.<br>**CCC: Patterns**<br>Patterns of change can be used to make predictions. | Use data to identify weather patterns. | Identify weather (e.g., sunny, windy, rainy). | Identify common weather factors such as temperature, precipitation, sky cover (clear, partly cloudy, very cloudy). | Use a simple graphical display or data table (limited to 3 or 4 data points) to identify a factor such as the time of the year when it rained the most or when it was the hottest. | Recognize that weather predictions can be made based upon patterns but that they are not always accurate. |
| **3-ESS2-2**<br>Obtain and combine information to describe climates in different regions of the world. | **SEP: Obtaining, Evaluating, and Communicating Information**<br>Obtain and combine information from books and other reliable media to explain phenomena.<br>**DCI: Earth Systems: Weather and Climate**<br>Climate describes a range of an area's typical weather conditions and the extent to which those conditions vary over years.<br>**CCC: Patterns**<br>Patterns of change can be used to make predictions. | Describe typical weather conditions expected during a particular season in different parts of the world. | Given illustrations, identify winter, spring, summer or fall based on "typical" conditions in many parts of the world (in temperate climates such as much of the mainland US). | Identify the temperature, precipitation, and other weather conditions as components of climate. | Describe the climate of a region of the world using weather data (Can include. using data to predict the weather of a region of the world at a given time of year given the climate.) | Identify differences between the climates found in two regions of the world (e.g., Vermont and Arizona or Florida). |
| **4-ESS2-1**<br>Make observations and/or measurements to provide evidence of the effects of weathering or the rate of erosion by water, ice, wind, or vegetation. | **SEP: Planning and Carrying Out Investigations; Analyzing and Interpreting Data**<br>Make observations and/or measurements to produce data as evidence for an explanation.<br>**DCI: Earth Materials and Systems**<br>Rainfall helps to shape the land and affects the types of living things found in a region. Water, ice, wind, living organisms, and gravity break rocks, soils, and sediments into smaller particles and move them around.<br>**DCI: Biogeology**<br>Living things affect the physical characteristics of their regions.<br>**CCC: Patterns; Cause and Effect**<br>Cause and effect relationships are routinely identified, tested, and used to explain change. | Erosion and weathering reshape the landscape over time. | Identify erosion and/or weathering. (For this group of students, differentiating between weathering and erosion is probably not important.) | Identify a source of erosion and weathering that can cause changes to the landscape. | Describe changes to the landscape caused by erosion and/or weathering. | Given a scenario, predict the effects of weathering and erosion on a landscape. |

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| **4-ESS2-2**<br>Analyze and interpret data from maps to describe patterns of Earth's features. | **SEP: Analyzing and Interpreting Data**<br>Analyze and interpret data to make sense of phenomena using logical reasoning.<br>**DCI: Plate Tectonics and Large-Scale System Interactions**<br>The locations of mountain ranges, deep ocean trenches, ocean floor structures, earthquakes, and volcanoes occur in patterns. Most earthquakes and volcanoes occur along the boundaries between continents and oceans. Major mountain chains form inside continents or near their edges. Maps can help locate the different features of the Earth.<br>**CCC: Patterns; Cause and Effect**<br>Patterns can be used as evidence to support an explanation. | Interpret data from maps of plate boundaries, mountain ranges, volcanoes, and earthquakes to identify patterns. | Identify a volcano, an earthquake, or a mountain range. | Identify the locations of volcanos, earthquake sites, and mountain ranges given a map. | Use a map key to identify the pattern of earthquakes, mountain ranges, or volcanos relative to plate boundaries. | Predict a likely site of a future earthquake or volcano given a map showing plate boundaries. |
| **5-ESS2-1**<br>Develop a model using an example to describe ways in which the geosphere, biosphere, hydrosphere, and/or atmosphere interact. | **SEP: Developing and Using Models**<br>Develop a model using an example to describe a scientific principle.<br>**DCI: Earth Materials and Systems**<br>Earth's major systems are the geosphere, the hydrosphere, the atmosphere, and the biosphere. These systems interact in multiple ways to affect Earth's surface materials and processes. The ocean supports a variety of ecosystems and organisms, shapes landforms, influences climate.<br>**CCC: Systems and System Models**<br>A system can be described in terms of its components and their interactions. | Earth's systems (geosphere, biosphere, hydrosphere, and atmosphere) interact in multiple ways. | Given a visual, identify the system. | Given a visual, identify the two systems interacting with one another. | Given a model, identify the result of the interaction of the two Earth systems. | Develop a model showing the interaction of two Earth systems. |
| **5-ESS2-2**<br>Describe and graph the amounts of salt water and fresh water in various reservoirs to provide evidence about the distribution of water on Earth. | **SEP: Using Mathematics and Computational Thinking**<br>Describe and graph quantities such as area and volume to address scientific questions.<br>**DCI: The Roles of Water in Earth's Surface Processes**<br>Nearly all of Earth's available water is in the ocean. Most fresh water is in glaciers or underground; only a tiny fraction is in streams, lakes, wetlands, and the atmosphere.<br>**CCC: Scale, Proportion, and Quantity; Systems and System Models**<br>Standard units are used to measure and describe physical quantities such as weight and volume. | The majority of the water found on Earth is saltwater. Fresh water is limited. | Identify a body of water. | Identify where fresh water and saltwater are found. | Use data to show that the ocean contains most of Earth's water. | Use data to determine the amount of salt water and fresh water on Earth. |

| Earth Space Science: ESS 3 Earth and Human Activity ❖ A. Natural Resources ❖ B. Natural Hazards ❖ C. Human Impacts on Earth Systems ❖ D. Global Climate Change | | | | | | |
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| **3-ESS3-1**<br>Make a claim about the merit of a design solution that reduces the impacts of a weather-related hazard. | **SEP: Engaging in Argument from Evidence**<br>Make a claim about the merit of a solution to a problem by citing relevant evidence.<br>**DCI: Natural Hazards**<br>A variety of natural hazards results from natural processes. Humans cannot eliminate natural hazards but can take steps to reduce their impacts.<br>**CCC: Cause and Effect**<br>Cause and effect relationships are routinely identified, tested, and used to explain change. | Humans can take steps to reduce the impacts of natural weather-related hazards. | Identify a weather hazard (e.g., heavy rain, high winds, high surf). | Identify an impact of a weather hazard (e.g., heavy rain, high winds, high surf). | Identify ways to help reduce the impact of a weather hazard. | Using data, determine if a solution to reduce the impact of a weather hazard will help animals and plants remain safe. |
| **4-ESS3-1**<br>Obtain and combine information to describe that energy and fuels are derived from natural resources and that their uses affect the environment. | **SEP: Obtaining, Evaluating, and Communicating Information**<br>Obtain and combine information from books and other reliable media to explain phenomena.<br>**DCI: Natural Resources**<br>Energy and fuels that humans use come from natural sources, and their use affects the environment in multiple ways. Some resources are renewable, and others are not.<br>**CCC: Cause and Effect**<br>Cause and effect relationships are routinely identified and used to explain change. | The use of renewable and nonrenewable sources for energy and fuel affect the environment. | Identify an energy source that is used by people. | Determine whether an energy source is renewable or non-renewable. | Identify an effect that the use of a given energy source would have on the environment. | Use evidence to determine how the use of a particular energy source might impact the environment. |
| **4-ESS3-2**<br>Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans. | **SEP: Constructing Explanations and Designing Solutions**<br>Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design solution.<br>**DCI: Natural Resources; Natural Hazards**<br>A variety of hazards result from natural processes (e.g., earthquakes, tsunamis, volcanic eruptions). Humans cannot eliminate the hazards but can take steps to reduce their impacts.<br>**DCI: Designing Solutions to Engineering Problems**<br>Testing a solution involves investigating how well it performs under a range of likely conditions.<br>**CCC: Cause and Effect**<br>Cause and effect relationships are routinely identified, tested, and used to explain change. | Humans can take steps to reduce the impact of natural hazards. | Identify a natural hazard. | Identify the potential impact of a natural hazard (e.g., flooding after heavy rain or high surf). | Given a natural hazard, choose the design that would lessen the impact of the hazard (e.g., a raised house in an area prone to flooding). | Given two design solutions, explain why one of them will be more effective in reducing the impacts of a natural hazard. |

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| **5-ESS3-1**<br>Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment. | **SEP: Obtaining, Evaluating, and Communicating Information**<br>Obtain and combine information from books and/or other reliable media to explain phenomena or solutions to a design problem.<br>**DCI: Human Impacts on Earth Systems**<br>Human activities in agriculture, industry, and everyday life have had major effects on the land, vegetation, streams, ocean, air, and even outer space. But individuals and communities are doing things to help protect Earth's resources and environments.<br>**CCC: Systems and System Models**<br>A system can be described in terms of its components and their interactions. | Human activity can affect the environment, but steps can be taken to protect it. | Determine a source of pollution (e.g., litter, car exhaust). | Identify an effect of pollution on air quality or water quality. | Identify actions humans can take to protect the environment. | Determine a way to clean up the environment. |

# MIDDLE SCHOOL (Administered in Grade 8)

## VT Alternate Science – NGSS Middle School

| Next Generation Science Standards | | Essence Statements | Achievement-Level Descriptors | | | |
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| PE | SEP / DCI / CCC | | Beginning | Approaching | Meets | Exceeds |
| **Physical Science: PS 1 Matter and interactions ❖ A. Structure and Properties of Matter ❖ B. Chemical Reactions ❖ C. Nuclear Processes** | | | | | | |
| **MS-PS1-1**<br>Develop models to describe the atomic composition of simple molecules and extended structures. | **SEP: Developing and Using Models**<br>Develop a model to predict and/or describe phenomena.<br>**DCI: Structure and Properties of Matter**<br>Substances are made from different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms.<br>**CCC: Scale, Proportion, and Quantity**<br>Models can be used to study systems that are very large or very small. | Matter is made of very small pieces called atoms, and atoms join together to create molecules. | Recognize that all things (matter) can be broken up into smaller and smaller pieces until they eventually become too small to see, but even then, they still exist (e.g., mixing sugar and water and then separating them when the water evaporates). | Identify that the smallest parts of all molecules are atoms. | Classify molecules by make up: simple, single/multi-atom compounds **or** complex (e.g., sugar, plastics, or nylon). | Use models (e.g., pictures, 3D ball, stick structures) to explain that atoms can combine to form molecules, including those made up of the same type of atom (e.g., iron, oxygen). |
| **MS-PS1-2**<br>Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred. | **SEP: Analyzing and Interpreting Data**<br>Analyze and interpret data to determine similarities and differences.<br>**DCI: Structure and Properties of Matter**<br>Each pure substance has characteristic physical and chemical properties.<br>**DCI: Chemical Reactions**<br>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.<br>**CCC: Patterns**<br>Macroscopic patterns are related to the nature of microscopic and atomic-level structure. | Some substances, when mixed, interact to form new substances with new properties. | Identify the physical and/or chemical properties of a substance (e.g., shape, size). | Observe and identify examples of changes in substances. | Use data to support a claim that properties have changed, and a new substance has been formed. | Recognize that chemical changes involve changes in the molecules (atoms are rearranged), leading to a new substance with properties that are different from the properties of the original substances. |

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| **MS-PS1-3**<br>Gather and make sense of information to describe that synthetic materials come from natural resources and impact society. | **SEP: Obtaining, Evaluating, and Communicating Information**<br>Gather, read, and synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and methods used, and describe how they are supported by evidence.<br>**DCI: Structure and Properties of Matter**<br>Each pure substance has characteristic physical and chemical properties.<br>**DCI: Chemical Reaction**<br>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.<br>**CCC: Structure and Function**<br>Structures can be designed to serve particular functions by taking into account properties of different materials and how materials can be shaped and used. | Natural resources can be used to make materials useful to society. (Also see MS-PS1-2.) | Identify common natural resources. | Identify examples of materials that are made from natural resources (e.g., iron ore into steel, wood into furniture). | Identify the natural resources used to make a synthetic product (e.g., petroleum into plastics, aluminum into cans). | Using information from a short reading describe a synthetic material made from natural resources and its impact on society (e.g., use of plastics). |
| **MS-PS1-4**<br>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. | **SEP: Developing and Using Models**<br>Develop a model to predict and/or describe phenomena.<br>**DCI: Structure and Properties of Matter**<br>Gases and liquids are made of molecules that are moving about relative to each other. In a liquid, the molecules are constantly in contact with each other, while in a gas, they are widely spaced except when they happen to collide. In a solid, atoms are closely spaced and do not change relative locations. Changes of state can occur with variations in temperature.<br>**DCI: Definitions of Energy**<br>The temperature of a system is proportional to the average internal kinetic energy and potential energy per atom or molecule.<br>**CCC: Patterns; Cause and Effect**<br>Cause and effect relationships may be used to predict phenomena. | Matter exists in various states, including solid, liquid, and gas. The molecules behave differently in each state. The state of matter of a material can change when heat is added or removed. | Identify matter as a solid, liquid, or gas. | Use a model to identify the motion of an object's particles as its temperature changes. | Recognize that a source of heat or cooling can change the state of common materials (e.g., ice melts, water freezes) and the motion of the molecules changes when a change of state occurs. | Predict the change in particle motion and state of matter that will occur when heat is introduced or removed (i.e., use common occurrences including things such as chocolate getting softer). |

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| **MS-PS1-5**<br>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. | **SEP: Developing and Using Models**<br>Develop a model to describe unobservable mechanisms.<br><br>**DCI: Chemical Reactions**<br>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.<br>The total number of each type of atom is conserved, and, thus, the mass does not change.<br><br>**CC: Energy and Matter**<br>Matter is conserved because atoms are conserved in physical and chemical processes. | *The DCI in this PE is covered in MS-PS1-2 and MS-PS1-3.* | | | | |
| **MS-PS1-6**<br>Undertake a design project to construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes. | **SEP: Constructing Explanations and Designing Solutions**<br>Undertake a design project, engaging in the design cycle, to construct and/or implement a solution that meets specific design criteria and constraints.<br><br>**DCI: Chemical Reactions**<br>Some chemical reactions release energy; others store energy.<br>**ETS1.B: Developing Possible Solutions** *(Secondary)*<br>**ETS1.C: Optimizing the Design Solution** *(Secondary)*<br><br>**CCC: Energy and Matter**<br>The transfer of energy can be tracked as energy flows through a designed or natural system. | Some chemical reactions release heat; others absorb heat. | Identify properties that show a chemical reaction has created a new substance. | Identify that a temperature change indicates a chemical reaction has occurred when two substances have been mixed. | Use presented evidence to determine if a reaction has released or absorbed thermal energy. | Use data to determine if a proposed solution would solve a problem (i.e., use common objects, like chemical reactions that produce temperature changes in heat packs; chemical reactions that are used in ice packs).<br><br>(Data can be numbers or graphs.) |

**Physical Science: PS 2 Motion and Stability: Forces and Interactions ❖ A. Forces and Motion ❖ B. Types of Interactions ❖ C. Stability and Instability in Physical Systems**

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| **MS-PS2-1** Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects. | **SEP: Constructing and Designing Solutions** Apply scientific ideas or principles to design an object, tool, process, or system. **DCI: Forces and Motion** For any pair of interacting objects, the force exerted by the first object on the second object is equal in strength to the force that the second object exerts on the first, but in the opposite direction. **CCC: Systems and System Models** Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy and matter flows within systems. | When objects collide, they exert a force on each other, which will affect their motion (e.g., collisions between toy cars or between a toy car and a stationary object). | Identify that a force can cause or stop motion. | Identify an observation about the motion of two objects that collide. (Limited to a collision between a moving object and a stationary object.) | Use a model to predict how the motion of two moving objects (with different speeds) will change after they collide. | Conduct an investigation (simulation or simple data sets provided) to determine how the changing speed of objects affects the motion of the objects when they collide. |
| **MS-PS2-2** Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object. | **SEP: Planning and Carrying Out Investigations** Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim. **DCI: Forces and Motion** The motion of an object is determined by the sum of the forces acting on it. The greater the mass of the object, the greater the force needed to achieve the same change in motion. **CCC: Stability and Change** Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales. | Unbalanced forces cause a change in motion. The amount of change depends upon the size of the force and mass of the object. (Also see MS-PS3-1.) | Identify that an object changed position due to an outside factor (e.g., a bowling ball hits a pin, and the pin moves). | Identify that a force (push/pull) is needed to change an object's motion. | Predict how the motion of an object will change when acted on by forces of different sizes or when objects have different masses. | Use data from an investigation where two objects with different masses are acted on by a series of forces to reach conclusions. |
| **MS-PS2-3** Ask questions about data to determine the factors that affect the strength of electrical and magnetic forces. | **SEP: Asking Questions and Defining Problems** Ask questions that can be investigated within the scope of the classroom and outdoor environment with available resources, and, when appropriate, frame a hypothesis based on observations and scientific principles. **DCI: Types of Interactions** Electric and magnetic (electromagnetic) forces can be attractive or repulsive, and their sizes depend on the magnitudes of the charges, currents, or magnetic strengths involved, and on the distances between the interacting objects. **CCC: Cause and Effect** Cause and effect relationships may be used to predict phenomena in natural or designed systems. | Some forces, such as magnetic forces, act at a distance (push/pull) without physical contact with an object. | Identify a magnet as something that exerts an attractive force on some materials. | Sort objects based on whether they are attracted by a magnet. | Use data to make statements about the effect of distance on the interactions between magnets. | Identify a question that could be answered by a scientific investigation involving one or more magnets. |

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| **MS-PS2-4**<br>Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects. | **SEP: Engaging in Argument from Evidence**<br>Construct and present oral and written arguments supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.<br>**DCI: Types of Interactions**<br>Gravitational forces are always attractive. There is a gravitational force between any two masses, but it is very small except when one or both of the objects have a large mass (e.g., Earth and the sun).<br>**CCC: Systems and System Models**<br>Models can be used to represent systems and their interactions—such as inputs and processes. | Gravitational force exists between any two objects. The size of the force depends upon the mass of the object. | Recognize that objects fall to the ground when dropped. | Use a model to illustrate that the effect of Earth's gravity on the motion of an object is the same anywhere on the Earth, toward the center of the planet. | Use a model to demonstrate the effects of Earth's gravitational force (e.g., a ball thrown into the air falls toward Earth due to the gravitational force of Earth being larger). | Analyze and interpret data to describe and predict the effects of gravitational force of two objects with large mass (e.g., Earth and the sun). |
| **MS-PS2-5**<br>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. | **SEP: Planning and Carrying Out Investigations**<br>Conduct an investigation and evaluate the experimental design to produce data to serve as the basis for evidence that can meet the goals of the investigation.<br>**DCI: Types of Interactions**<br>Forces that act at a distance (e.g., electric, magnetic, and gravitational) can be explained by fields that extend through space and can be mapped by their effect on a test object (e.g., a charged object or a ball, respectively).<br>**CCC: Cause and Effect**<br>Cause and effect relationships may be used to predict phenomena in natural or designed systems. | The behavior of magnets varies with changes in orientation, distance, and the strength of the magnet. (Gravitational forces are largely addressed in MS-PS2-4.) | Identify the "poles" of a bar magnet. | Recognize that like poles repel each other and unlike poles attract. | Relate the orientation of magnets and the distance between them to the behavior of the magnets. | Use data from an experiment to explain the effect of changing the orientation of two magnets or changing the distance between two magnets. |

| Physical Science: PS 3 Energy ❖ A. Definitions of Energy ❖ B. Conservation of Energy and Energy Transfer ❖ C. Relationship Between Energy and Forces ❖ D. Energy and Chemical Processes in Everyday Life | | | | | | |
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| **MS-PS3-1**<br>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. | **SEP: Analyzing and Interpreting Data**<br>Construct and interpret graphical displays of data to identify linear and nonlinear relationships.<br><br>**DCI: Definitions of Energy**<br>Kinetic energy is proportional to the mass of the moving object and grows with the square of its speed.<br><br>**CCC: Scale, Proportion, and Quantity**<br>Proportional relationships among different types of quantities provide information about the magnitude of properties and processes. | Kinetic energy (motion energy) is proportional to the mass of the object. Kinetic energy increases as speed increases. | Identify mass and speed of an object. | Use mass data to identify the object with the greatest mass or use speed data to determine which object moves the fastest. | Use mass or speed data to determine the object with the greatest kinetic energy. | Use graphical data to identify that kinetic energy changes as mass or speed increases (e.g., two objects with different masses moving at the same speed or two objects with the same mass moving at different speeds, or a single object whose speed changes). |
| **MS-PS3-2**<br>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. | **SEP: Developing and Using Models**<br>Develop a model to describe unobservable mechanisms.<br><br>**DCI: Definitions of Energy**<br>A system of objects may also contain stored (potential) energy, depending on the objects' relative positions.<br>**DCI: Relationship Between Energy and Forces**<br>When two objects interact, each one exerts a force on the other that can cause energy to be transferred to or from the object.<br><br>**CCC: Systems and System Models**<br>Models can be used to represent systems and their interactions—such as inputs, processes, and outputs—and energy and matter flows within systems. | The DCI is covered in MS-ESS1-2. | | | | |

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| **MS-PS3-3**<br>Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer. | **SEP: Constructing Explanations and Designing Solutions**<br>Apply scientific ideas or principles to design, construct, and test a design of an object, tool, process, or system.<br>**DCI: Definitions of Energy**<br>Temperature is a measure of the average kinetic energy of particles of matter. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present.<br>**DCI: Conservation of Energy and Energy Transfer**<br>Energy is spontaneously transferred out of hotter regions or objects and into colder ones.<br>**CCC: Energy and Matter**<br>The transfer of energy can be tracked as energy flows through a system. | Heat can be transferred from one object to another. Humans have invented devices to "manage" this transfer. | Identify objects that are hot and cold. | Identify "things" used to keep something hot or cold (e.g., a jacket keeps you warm, but taking it off will make you colder). | Realize that heat can be transferred (e.g., if ice is added to a cup of water or if water in a pot is heated on a stove). | Use data to identify the "tool" that is most efficient at keeping something hot or cold (e.g., different types of coolers or thermos bottles). |
| **MS-PS3-4**<br>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. | **SEP: Planning and Carrying Out Investigations**<br>Plan an investigation and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim.<br>**DCI: Definitions of Energy**<br>Temperature is a measure of the average kinetic energy of particles of matter.<br>**DCI: Conservation of Energy and Energy Transfer**<br>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.<br>**CCC: Scale, Proportion, and Quantity**<br>Proportional relationships among different types of quantities provide information about the magnitude of properties and processes. | Temperature can be used to measure the amount of heat transferred. (Also see MS-PS3-3.)<br><br>(Temperature is the measure of the average kinetic energy of matter.) | Determine the relative heat of objects when compared to each other. | Use temperature data to determine when an object has changed in temperature due to heat source exposure. | Use temperature data to determine the temperature changes of objects of the same material but different masses when heat is applied for a certain period of time. | Draw conclusions using data from an experiment involving adding two cold objects (e.g., ice) of different masses to separate pails of hot water and recording the temperature change of the water over time. |

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| **MS-PS3-5**<br>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. | **SEP: Engaging in Argument from Evidence**<br>Construct, use, and present oral and written arguments supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon.<br><br>**DCI: Conservation of Energy and Energy Transfer**<br>When the motion energy of an object changes, there is inevitably some other change in energy at the same time.<br><br>**CCC: Energy and Matter**<br>Energy can take different forms (e.g., energy in fields, thermal energy, kinetic energy). | When the motion energy of an object changes, the object may gain or lose energy.<br><br>(Motion energy refers to kinetic energy.) | Recognize that the motion energy of an object can change (e.g., realize that a ball will eventually slow down and stop when you roll it on the ground). | Identify the motion energy transfer in presented examples (e.g., a ball that was moving begins to slow down, so this means that energy was transferred from the object). | Predict what will happen to the motion energy between two similar objects when one collides with the other (e.g., a ball rolling down a hill collides with a ball that is at rest at the bottom of the hill). | Use data from an experiment to determine the reasoning behind motion energy being transferred to or from an object (e.g., when two balls collide, one begins to move due to motion energy being transferred to it). |
| **Physical Science: PS 4 Waves and Their Applications in Technologies ❖ A. Wave Properties ❖ B. Electromagnetic Radiation ❖ C. Information Technologies and Instrumentation** | | | | | | |
| **MS-PS4-1**<br>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. | **SEP: Using Mathematics and Computational Thinking**<br>Use mathematical representations to describe and/or support scientific conclusions and design solutions.<br><br>**DCI: Wave Properties**<br>A simple wave has a repeating pattern with a specific wavelength, frequency, and amplitude.<br><br>**CCC: Patterns**<br>Graphs and charts can be used to identify patterns in data. | Mechanical waves (water, sound, waves in a rope at the gym) have a repeating pattern, including amplitude, which reflects the energy of the wave.<br><br>(Note: tsunamis should not be used as examples.) | Give/identify examples of waves. | Identify a property of a wave (e.g., frequency, amplitude, wavelength). | Compare wave diagrams to identify differences in wavelength and amplitude. | Use data to show that greater water wave height (i.e., amplitude) results in agreater force and more impact if it strikes shore or another object. |
| **MS-PS4-2**<br>Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials. | **SEP: Developing and Using Models**<br>Develop and use a model to describe phenomena.<br><br>**DCI: Wave Properties**<br>A sound wave needs a medium through which it is transmitted.<br>**DCI: Electromagnetic Radiation**<br>When light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on the object's material.<br>The path that light travels can be traced as straight lines, except at surfaces between different transparent materials (e.g., air and water, air and glass) | Light waves can be reflected, refracted (transmitted), or absorbed by different materials. | Recognize that light travels through some objects and not others. | Use observations to identify transparent materials. | Use models to recognize that light can be reflected, absorbed, or transmitted (light passes through the object). | Use models to describe how light behaves when striking transparent, translucent, and opaque materials. (Transparent can be a regular glass window, translucent can be a plastic milk |

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| | where the light path bends.<br><br>**CCC: Structure and Function**<br>Structures can be designed to serve particular functions by taking into account properties of different materials and how materials can be shaped and used. | | | | | jug, and opaque can be a door.) |
| **MS-PS4-3**<br>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. | **SEP: Obtaining, Evaluating, and Communicating Information**<br>Integrate qualitative scientific and technical information in written text with that contained in media and visual displays to clarify claims and findings.<br><br>**DCI: Information Technologies and Instrumentation**<br>Digitized signals (sent as wave pulses) are a more reliable way to encode and transmit information.<br><br>**CCC: Structure and Function**<br>Structures can be designed to serve particular functions. | Technological advances have improved our ability to communicate information. | Identify different means of communicating information (e.g., email, newspaper, letter). | Identify examples of digital technologies used to communicate information (e.g., digital scales or thermometer, "smart phones," audio recordings). | Identify a benefit of a digital technology used to communicate information. | Given a short reading or scenario, evaluate advantages or disadvantages of various means of communication. |
| **Life Science: LS 1 From Molecules to Organisms: Structures and Processes ❖ A. Structure and Function ❖ B. Growth and Development of Organisms ❖ C. Organization for Matter and Energy Flow in Organisms ❖ D. Information Processing** | | | | | | |
| **MS-LS1-1**<br>Conduct an investigation to provide evidence that living things are made of cells: either one cell or many different numbers and types of cells. | **SEP: Planning and Carrying Out Investigations**<br>Conduct an investigation to produce data to serve as the basis for evidence that meet the goals of an investigation.<br><br>**DCI: Structure and Function**<br>All living things are made up of cells, which are the smallest units that can be said to be alive. An organism may consist of one single cell (unicellular) or many different numbers and types of cells (multicellular).<br><br>**CCC: Scale, Proportion, and Quantity**<br>Phenomena that can be observed at one scale may not be observable at another scale. | All living things are made up of cells, which are the smallest units that can be said to be alive. | Identify living and nonliving things. | Recognize that the cell is the smallest living unit. | Recognize that all living things are made up of one or more cells. | Recognize that many organisms have many different types of cells (e.g., skin cells, blood cells, muscle cells, brain cells). |

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| **MS-LS1-2** Develop and use a model to describe the function of a cell as a whole and ways the parts of cells contribute to the function. | **SEP: Developing and Using Models** Develop and use a model to describe phenomena.<br><br>**DCI: Structure and Function**<br>Within cells, special structures are responsible for particular functions, and the cell membrane forms the boundary that controls what enters and leaves the cell.<br><br>**CCC: Structure and Function**<br>Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the relationships among their parts. | Cells are made up of parts that work together. Cells have different parts with various functions. | Identify cells as the basic component of all living things. | Identify parts of a plant cell and/or animal cell (e.g., nucleus, chloroplast, mitochondria, cell membrane, cell wall). | Identify the function of one or more of the following cell parts: nucleus, chloroplast, mitochondria, cell membrane, and cell wall. | Use a model to describe how the functions of the parts of a plant or animal cell contribute to the cell as a whole. (The model can be a scenario like a school or a factory.) |
| **MS-LS1-3** Use argument supported by evidence for how the body is a system of interacting sub-systems composed of groups of cells. | **SEP: Engaging in Argument from Evidence**<br>Use an oral and written argument supported by evidence to support or refute an explanation or a model for a phenomenon.<br><br>**DCI: Structure and Function**<br>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.<br><br>**CCC: Systems and System Models**<br>Systems may interact with other systems; they may have sub-systems and be a part of larger complex systems. | The body is a group of systems that work together to carry out body functions. Within the systems, groups of cells form tissues and organs. | Identify a major organ in the body (e.g., brain, heart, lungs). | Recognize that organs have specialized functions (e.g., the heart pumps blood). | Recognize that groups of cells create tissues. Tissues come together to create organs, and multiple organs create organ systems. | Use a model to demonstrate how organs are connected in major organ systems (e.g., circulatory, excretory, digestive, respiratory, muscular, or nervous systems). |

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| **MS-LS1-4**<br>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. | **SEP: Engaging in Argument from Evidence**<br>Use an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for aphenomenon.<br><br>**DCI: Structure and Function; Growth and Development of Organisms**<br>Animals engage in characteristic behaviors that increase the odds of reproduction. Plants reproduce in a variety of ways, sometimes depending on animal behavior and specialized features for reproduction.<br><br>**CCC: Cause and Effect**<br>Phenomena may have more than one cause, and some cause and effect relationships in systems can be described only by using probability. | Animals exhibit behaviors, and plants have characteristics that contribute to successful reproduction.<br><br>(Human reproduction is not an appropriate topic.) | Identify animal behaviors that contribute to their survival. | Match plant structural adaptations to survival needs. | Use observations to match structural adaptations to survival needs of plants in an environment. | Read a short passage on animal behaviors that affect plant reproduction and identify the behavior that assists plants. |
| **MS-LS1-5**<br>Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms. | **SEP: Constructing Explanations and Designing Solutions**<br>Construct a scientific explanation based on evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do in the future.<br><br>**DCI: Growth and Development of Organisms**<br>Genetic factors as well as local conditions affect the growth of the adult plant.<br><br>**CCC: Cause and Effect**<br>Phenomena may have more than one cause, and some cause and effect relationships in systems can be described only using probability. | An organism's growth is affected by environmental factors. | Identify a characteristic of an organism's habitat or environment. | Identify environmental factors that can influence an organism's growth (e.g., availability of food, water, sunlight). | Use data to identify environmental factors that lead to optimum organism growth (e.g., number of trees for camouflage, nest building). | Use data to explain an increase or decrease in organism growth in a specific environment. |

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| **MS-LS1-6**<br>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. | **SEP: Constructing Explanations and Designing Solutions**<br>Construct a scientific explanation based on evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do in the future.<br>**DCI: Organization for Matter and Energy Flow in Organisms**<br>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.<br>**DCI: Energy in Chemical Processes and Everyday Life**<br>The chemical reaction by which plants produce complex food molecules (sugars) requires an energy input (i.e., from sunlight) to occur. In this reaction, carbon dioxide and water combine to form carbon-based organic molecules and release oxygen.<br>**CCC: Energy and Matter**<br>Within a natural system, the transfer of energy drives the motion and/or cycling of matter. | Plants take in matter (in the form of carbon dioxide and water), and use energy from the sun to produce food, and release oxygen into the environment through photosynthesis. | Recognize that plants need light and water to live. | Recognize that light energy (sunlight), water, and carbon dioxide are necessary for plants to make food. | Recognize that in photosynthesis, light energy (sunlight) is used to combine carbon dioxide and water to produce oxygen, that is released, and food molecules which can be used or stored by the plant. | Use a model to describe that the processes of photosynthesis and respiration are necessary for plant survival. |
| **MS-LS1-7**<br>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. | **SEP: Developing and Using Models**<br>Develop a model to describe unobservable mechanisms.<br>**DCI: Organization for Matter and Energy Flow in Organisms**<br>Within individual organisms, food moves through a series of chemical reactions in which it is broken down and rearranged to form new molecules, to support growth, or to release energy.<br>**DCI: Energy in Chemical Processes and Everyday Life**<br>Cellular respiration in plants and animals involves chemical reactions with oxygen that release stored energy. In these processes, complex molecules containing carbon react with oxygen to produce carbon dioxide and other materials.<br>**CCC: Energy and Matter**<br>Matter is conserved because atoms are conserved in physical and chemical processes. | Food moves through different processes to form new molecules that support growth and release energy. (Photosynthesis is addressed in MS-LS1-6.) | Recognize that organisms eat to survive. | Recognize that food must be broken down by chewing and digesting so that the nutrients can be absorbed by the organism. | Recognize that food molecules are broken down and put back together during digestion to be useful to the organism (e.g., support growth and/or release energy). | Use data related to diet to develop a possible explanation behind two organisms of the same species being different sizes. |

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| **MS-LS1-8**<br>Gather and synthesize information that sensory receptors respond to stimuli by sending messages to the brain for immediate behavior or storage as memories. | **SEP: Obtaining, Evaluating, and Communicating Information**<br>Gather, read, and synthesize information from multiple appropriate sources. Assess the credibility, accuracy, and possible bias of each publication and methods used, and describe how they are supported or not supported by evidence.<br>**DCI: Information Processing**<br>Each sense receptor responds to different inputs, transmitting them as signals that travel along nerve cells to the brain. The signals are then processed in the brain, resulting in immediate behaviors or memories.<br>**CCC: Cause and Effect**<br>Cause and effect relationships may be used to predict phenomena in natural systems. | Sensory organs respond to inputs and send signals to the brain, and the body responds and/or remembers. | Identify the five senses. | Identify the inputs that each of the senses responds to. | Describe that information received by the senses is transmitted to the brain and leads to a memory and/or an immediate response. | Given a scenario that describes a response to a stimulus, explain the process behind the response. |
| **Life Science: LS 2 Ecosystems: Interactions, Energy, and Dynamics ❖ A. Interdependent Relationships in Ecosystems ❖ B. Cycles of Matter and Energy Transfer in Ecosystems ❖ C. Ecosystem Dynamics, Functioning, and Resilience ❖ D. Social Interactions and Group Behavior** | | | | | | |
| **MS-LS2-1**<br>Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem. | **SEP: Analyzing ad Interpreting Data**<br>Analyze and interpret data to provide evidence for phenomena.<br>**DCI: Interdependent Relationships in Ecosystems**<br>Organisms are dependent on their environmental interactions with other living things and with nonliving factors. In any ecosystem, organisms with similar requirements for food, water, oxygen, or other resources may compete with each other for limited resources, access to which consequently constrains their growth and reproduction. Growth of organisms and population increases are limited by access to resources.<br>**CCC: Cause and Effect**<br>Cause and effect relationships may be used to predict phenomena in natural or designed systems. | Organisms are dependent on interactions in their environment, including other living things and the physical environment. | Identify an organism or environmental factor in a given ecosystem (e.g., plant, rainfall, moving water). | Identify factors in an ecosystem that can impact an organism or a population of organisms (e.g., presence of a predator or lack of rainfall). | Identify if a population increases or decreases as a result of a change in the ecosystem. | Describe how the availability of resources in a habitat changes when a population changes (e.g., more food, increased competition). |
| **MS-LS2-2**<br>Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems. | **SEP: Constructing Explanations and Designing Solutions**<br>Construct an explanation that includes qualitative or quantitative relationships between variables that predict phenomena.<br>**DCI: Interdependent Relationships in Ecosystems**<br>Predatory interactions may reduce the number of organisms or eliminate whole populations of organisms. Mutually beneficial interactions may become | There are a variety of interactions in an ecosystem that may be predatory, competitive, or mutually beneficial. | Identify an example of an organism interacting with its environment. Examples include eating other organisms, drinking | Identify an interaction between two organisms within an ecosystem. | Describe interactions among organisms across multiple ecosystems (e.g., how a predatory, land-based animal | Describe patterns of interactions, including those which are predatory, competitive, and mutually beneficial. |

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| | so interdependent that each organism requires the other for survival. Although the species involved in these interactions vary across ecosystems, the patterns of interactions of organisms with their environments, both living and nonliving, are shared.<br><br>**CCC: Patterns**<br>Patterns can be used to identify cause and effect relationships. | | water, eating plants, using plants for shelter (e.g., nests, beaver dams), and using the sun's warmth. | | interacts with prey in water ecosystems). | |
| **MS-LS2-3**<br>Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem. | **SEP: Developing and Using Models**<br>Develop a model to describe phenomena.<br><br>**DCI: Cycle of Matter and Energy Transfer in Ecosystems**<br>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. The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem.<br><br>**CCC: Energy and Matter**<br>The transfer of energy can be tracked as energy flows through a natural system. | Food webs are models that demonstrate how matter and energy is transferred between living things (producers, consumers, decomposers) and nonliving parts of an ecosystem. | Identify parts of a food web (producer, consumer, decomposer). | Complete a food web given a set of common organisms. | Complete a food web showing the flow of energy between living organisms and nonliving parts of an ecosystem. | Develop a model to describe the cycling and flow of energy in living organisms and nonliving parts of an ecosystem. |
| **MS-LS2-4**<br>Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations. | **SEP: Engaging in Argument from Evidence**<br>Construct an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.<br><br>**DCI: Ecosystem Dynamics, Functioning, and Resilience**<br>Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations.<br><br>**CCC: Stability and Change**<br>Small changes in one part of a system might cause large changes in another part. | Ecosystems can change over time. Changes to any physical or biological component of an ecosystem can lead to shifts in all its populations. | Identify an ecosystem (e.g., desert, forest, tundra). | Identify the biological and physical components of an ecosystem (e.g., a bear would be a biological component, rainfall would be an ecological component). | Use data to determine the effect on a population when a resource is limited due to environmental conditions. | Predict what would happen to the populations in an ecosystem when a new species is introduced, a predator is removed, or there is a physical change in the environment. |
| **MS-LS2-5**<br>Evaluate competing design solutions for maintaining | **SEP: Engaging in Argument from Evidence**<br>Evaluate competing design solutions based on jointly developed and agreed-upon design criteria.<br><br>**DCI: Ecosystem Dynamics, Functioning, and Resilience** | DCIs are addressed in MS-LS2-4. | | | | |

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| biodiversity and ecosystem services. | Biodiversity describes the variety of species found in Earth's terrestrial and oceanic ecosystems. The completeness or integrity of an ecosystem's biodiversity is often used as a measure of its health.<br>**DCI: Biodiversity and Humans**<br>Changes in biodiversity can influence humans' resources, such as food, energy, and medicines, as well as ecosystem services that humans rely on—for example, water purification and recycling. *(Secondary)*<br>**DCI: Developing Possible Solutions**<br>There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. *(Secondary)*<br>**CCC: Stability and Change**<br>Small changes in one part of a system might cause large changes in another part. | | | | | |
| **Life Science: LS 3 Heredity, Inheritance and Variation of Traits ❖ A. Inheritance of Traits ❖ B. Variation of Traits** | | | | | | |
| **MS-LS3-1**<br>Develop and use a model to describe why structural changes to genes (mutations) located on chromosomes may affect proteins and may result in harmful, beneficial, or neutral effects to the structure and function of an organism. | **SEP: Developing and Using Models**<br>Develop and use a model to describe phenomena.<br>**DCI: Inheritance of Traits**<br>Genes are located in the chromosomes of cells, with each chromosome pair containing two variants of each of many distinct genes. Each distinct gene chiefly controls the production of specific proteins, which in turn affects the traits of the individual. Changes to genes can result in changes to proteins, which can affect the structures and functions of the organism and, thereby, change traits.<br>**DCI: Variation of Traits**<br>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.<br>**CCC: Structure and Function**<br>Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the composition and relationships among their parts; thus, complex systems can be analyzed to determine how they function. | Structural changes to genes lead to mutations that may be helpful or harmful. | Identify a gene and the location of a gene (e.g., hair color, eye color; genes are located in all cells except for red blood cells). | Recognize that genes create proteins that the body needs. | Recognize that changes to gene structures cause changes to the proteins that they create and may lead to the development of new traits that may be helpful or harmful. | Given a scenario, recognize that any variation in the structure and function of an organism is the result of a genetic mutation. |

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| **MS-LS3-2**<br>Develop and use a model to describe why asexual reproduction results in offspring with identical genetic information and sexual reproduction results in offspring with genetic variation. | **SEP: Developing and Using Models**<br>Develop and use a model to describe phenomena.<br><br>**DCI: Growth and Development of Organisms**<br>Organisms reproduce, either sexually or asexually, and transfer their genetic information to their offspring. *(Secondary)*<br>**DCI: Inheritance of Traits**<br>Variations of inherited traits between parent and offspring arise from genetic differences that result from the subset of chromosomes (and therefore, genes) inherited.<br>**DCI: Variation of Traits**<br>In sexually reproducing organisms, each parent contributes half of the genes acquired (at random) by the offspring. Individuals have two of each chromosome and, hence, two alleles of each gene, one acquired from each parent. These versions may be identical or may differ from each other.<br>**CCC: Cause and Effect**<br>Cause and effect relationships may be used to predict phenomena in natural systems. | All organisms reproduce, either sexually and/or asexually.<br><br>Asexual reproduction occurs from a single organism.<br><br>Sexual reproduction leads to offspring that inherit traits from both their parents. | Identify that all living organisms reproduce. | Differentiate between asexual and sexual reproduction. | Use a model to describe why asexual reproduction differs from sexual reproduction. | Use data to show why sexual reproduction leads to trait variation among offspring. |
| **Life Science: LS 4 Biological Evolution: Unity and Diversity ❖ A. Evidence of Common Ancestry ❖ B. Natural Selection ❖ C. Adaptation ❖ D. Biodiversity and Humans** | | | | | | |
| **MS-LS4-1**<br>Analyze and interpret data for patterns in the fossil record that document the existence, diversity, extinction, and change of life forms throughout the history of life on Earth under the assumption that natural laws operate today as in the past. | **SEP: Analyzing and Interpreting Data**<br>Analyze and interpret data to determine similarities and differences in findings.<br><br>**DCI: Evidence of Common Ancestry and Diversity**<br>The collection of fossils and their placement in chronological order (e.g., through the location of the sedimentary layers in which they are found or through radioactive dating) is known as the fossil record. It documents the existence, diversity, extinction, and change of many life forms throughout the history of life on Earth.<br><br>**CCC: Patterns**<br>Graphs, charts, and images can be used to identify patterns in data. | Fossils and their placement in rock layers provide information about the age of fossils and how living things have changed over time. | Identify a fossil. | Identify the relative age of fossils based upon their location in rock layers (e.g., fossils found in a rock layer below another rock layer are older). | Match a fossil to a similar organism found on Earth today or identify that organism as extinct. | Use patterns in fossil data or pictorial information to explain how an organism changed over time. |

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| **MS-LS4-2**<br>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. | **SEP: Constructing Explanations and Designing Solutions**<br>Apply scientific ideas to construct an explanation for real-world phenomena, examples, or events.<br>**DCI: Evidence of Common Ancestry and Diversity**<br>Anatomical similarities and differences between various organisms living today, and between them and organisms in the fossil record, enable the reconstruction of evolutionary history and the inference of lines of evolutionary descent.<br>**CCC: Patterns**<br>Patterns can be used to identify cause and effect relationships. | There are anatomical similarities and differences between past and present-day organisms. These enable the inference of lines of evolutionary descent. (Also see MS-LS4-1.) | Identify organisms that are similar to each other (e.g. dolphins and whales, cats and lions, dogs and foxes). | Match an anatomical structure of a living organism to a similar fossil. | Compare fossils with present-day organisms with similar characteristics. | Compare and contrast similarities and differences among related modern organisms and with those in the fossil record (e.g., ancient birds, an eagle, a pigeon). |

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| **MS-LS4-3**<br>Analyze displays of pictorial data to compare patterns of similarities in embryological development across multiple species to identify relationships not evident in the fully formed anatomy. | **SEP: Analyzing and Interpreting Data**<br>Analyze displays of data to identify linear and nonlinear relationships.<br><br>**DCI: Evidence of Common Ancestry and Diversity**<br>Comparison of the embryological development of different species also reveals similarities that show relationships not evident in the fully formed anatomy.<br><br>**CCC: Patterns**<br>Graphs, charts, and images can be used to identify patterns in data. | This Achievement Expectation will not be assessed at the middle school level. | | | | |
| **MS-LS4-4**<br>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. | **SEP: Constructing Explanations and Designing Solutions**<br>Construct an explanation that includes qualitative or quantitative relationships between variables that describe phenomena.<br><br>**DCI: Natural Selection**<br>Natural selection leads to the predominance of certain traits in a population and the suppression of others.<br><br>**CCC: Cause and Effect**<br>Phenomena may have more than one cause, and some cause and effect relationships in systems can be described only using probability. | Natural selection favors organisms that have traits that increase the likelihood of survival and reproduction in a specific environment. (Also see MS-LS3-2 and other PEs.) | Identify a trait. | Identify a trait that helps individuals survive and reproduce in a specific environment (e.g., speed, strength, size). | Explain that some traits help individuals in a population to survive and reproduce in a specific environment (e.g., ability of a cactus to survive a drought better than a fern). | Explain changes in the population size, given data showing a variation of traits within a population in a specific environment (the population size should change based on the trait). |

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| **MS-LS4-5**<br>Gather and synthesize information about technologies that have changed the way humans influence the inheritance of desired traits in organisms. | **SEP: Obtaining, Evaluating, and Communicating Information**<br>Gather, read, and synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and methods used, and describe how they are supported or not supported by evidence.<br><br>**DCI: Natural Selection**<br>In *artificial* selection, humans have the capacity to influence certain characteristics of organisms by selective breeding. One can choose desired parental traits determined by genes, which are then passed on to offspring.<br><br>**CCC: Cause and Effect**<br>Phenomena may have more than one cause, and some cause and effect relationships in systems can be described only using probability. | Humans have the ability to influence the traits that organisms have through selective breeding. | Identify that traits are passed from parent to offspring from the organism's parent. | Identify the undesired and desired traits of an organism (e.g., size, taste, color). | Recognize selective breeding to be a process that allows the desirable traits to be chosen. | Given a small passage, determine how a desired trait was acquired. |
| **MS-LS4-6**<br>Use mathematical representations to support explanations of how natural selection may lead to increases and decreases of specific traits in populations over time. | **SEP: Using Mathematics and Computational Thinking**<br>Use mathematical representations to support scientific conclusions and design solutions.<br><br>**DCI: Adaptation**<br>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.<br><br>**CCC: Cause and Effect**<br>Phenomena may have more than one cause, and some cause and effect relationships in systems can be described only using probability. | Natural selection may lead to increases and decreases of specific traits in populations. | Identify the traits of an animal or plant. | Identify the differences in traits among members of the same animal or plant species (e.g., black, white, and gray mice). | Given a description of an environment, determine if a trait will increase or decrease in a specific population over time. | Given data, predict future population size based upon the survival of organisms with favorable traits (e.g., faster predators, camouflaged prey). |

| Earth Space Science ESS 1 Earth's Place in the Universe ❖ A. The Universe and Its Stars ❖ B. Earth and the Solar System ❖ C. The History of Planet Earth | | | | | | |
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| **MS-ESS1-1**<br>Develop and use a model of the Earth-sun-moon system to describe the cyclic patterns of lunar phases, eclipses of the sun and moon, and seasons. | **SEP: Developing and Using Models**<br>Develop and use a model to describe phenomena.<br>**DCI: The Universe and Its Stars**<br>Patterns of the apparent motion of the sun, the moon, and stars in the sky can be observed, described, predicted, and explained with models.<br>**DCI: Earth and the Solar System**<br>This model of the solar system can explain eclipses of the sun and the moon. Earth's spin axis is fixed in direction over the short term but tilted relative to its orbit around the sun. The seasons are a result of that tilt and are caused by the differential intensity of sunlight on different areas of Earth across the year.<br>**CCC: Patterns**<br>Patterns can be used to identify cause-and-effect relationships. | Models of the Earth-sun-moon system can describe patterns of day and night, seasons, and lunar phases. | Identify the sun, Earth, and moon in a model. | Identify day, night, and the four seasons using a model or diagram. | Use a model to identify Earth's seasons and relate them to Earth's tilt and revolution around the sun. | Use a model of the Earth-sun-moon system to explain day and night, seasons, and/or phases of the moon. |
| **MS-ESS1-2**<br>Develop and use a model to describe the role of gravity in the motions within galaxies and the solar system. | **SEP: Developing and Using Models**<br>Develop and use a model to describe phenomena.<br>**DCI: The Universe and Its Stars**<br>Earth and its solar system are part of the Milky Way galaxy, which is one of many galaxies in the universe.<br>**DCI: Earth and the Solar System**<br>The solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them.<br>The solar system appears to have formed from a disk of dust and gas, drawn together by gravity.<br>**CCC: Systems and System Models**<br>Models can be used to represent systems and their interactions. | The solar system consists of the sun, planets, and their moons. Gravity is the attractive force between objects in the system. | Identify gravity as the force that pulls objects together (e.g., dropped objects fall toward the ground). | Identify that the solar system consists of the sun, planets, and moons. | Describe the motions of all objects in the solar system that occur due to the gravitational force of the sun. | Describe that, in addition to the gravitational force of the sun, each individual planet also has gravitational force (e.g., the motions of moons around the planets and the role of gravity in these motions). |

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| **MS-ESS1-3** Analyze and interpret data to determine scale properties of objects in the solar system. | **SEP: Analyzing and Interpreting Data**<br>Analyze and interpret data to determine similarities and differences in findings.<br><br>**DCI: Earth and the Solar System**<br>The solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them.<br><br>**CCC: Scale, Proportion, and Quantity**<br>Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small. | The solar system consists of the sun, planets, and their moons. The properties of these objects can be observed at various scales. | Recognize that Earth is part of the solar system. | Locate the sun, Earth, and Earth's moon in a diagram of the solar system. | Use data to order the planets based on their size or distance from the sun. | Compare and contrast the scale properties of objects in the solar system, including scale drawings. |
| **MS-ESS1-4** Construct a scientific explanation based on evidence from rock strata for how the geologic timescale is used to organize Earth's 4.6-billion-year-old history. | **SEP: Constructing Explanations and Designing Solutions**<br>Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do in the future.<br><br>**DCI: The History of Planet Earth**<br>The geologic time scale interpreted from rock strata provides a way to organize Earth's history. Analyses of rock strata and the fossil record provide only relative dates, not an absolute scale.<br><br>**CCC: Scale, Proportion, and Quantity**<br>Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small. | Rock layers and fossils provide a way to organize Earth's history. | Recognize rock layers and fossils. | Identify the youngest and oldest rock layers based upon their position in a column. | Identify the relative age of fossils based on their locations in a column of rock layers. | Use data to estimate the age of a fossil in a rock layer. |
| **Earth Space Science ESS 2 Earth Systems ❖ A. Earth Materials and Systems ❖ B. Plate Tectonics and Large-Scale System Interactions ❖ C. The Roles of Water in Earth's Surface Processes ❖ D. Weather and Climate ❖ E. Biogeology** | | | | | | |
| **MS-ESS2-1** Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process. | **SEP: Developing and Using Models**<br>Develop and use a model to describe phenomena.<br><br>**DCI: Earth's Materials and Systems**<br>All Earth processes are the result of energy flowing and matter cycling within and among the planet's systems. This energy is derived from the sun and Earth's hot interior. The energy that flows and matter that cycles produce chemical and physical changes in Earth's materials and living organisms.<br><br>**CCC: Stability and Change** | Earth materials cycle through processes such as the rock cycle and the water cycle. | Identify Earth materials (e.g., water, rocks, minerals, soils). | Identify the rock cycle and different type of rocks (sedimentary, igneous, metamorphic). Identify stages in the water cycle. | Describe how heat from Earth's core powers the rock cycle. Describe how heat from the sun powers the water cycle. | Use models to describe the importance of the heat from Earth's core or the sun's energy to drive Earth processes. |

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| | Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and processes at different scales, including the atomic scale. | | | | | |
| **MS-ESS2-2**<br>Construct an explanation based on evidence for how | **SEP: Constructing Explanations and Designing Solutions**<br>Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe nature operate today as they did in the past and will continue to do in the future.<br><br>**DCI: Earth's Materials and Systems**<br>The planet's systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth's history and will determine its future.<br><br>**DCI: The Roles of Water in Earth's Surface Processes**<br>Water's movements—both on the land and underground—cause weathering and erosion, which change the land's surface features and create underground formations.<br><br>**CCC: Scale, Proportion, and Quantity**<br>Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small. | Fast and slow processes (geoscience processes) shape and reshape the surface of the Earth. | Identify that the Earth's surface features change over time. | Classify processes as slow or fast (e.g., erosion and weathering, landslides and earthquakes). | Recognize that surface processes such as erosion, movement, weathering, and the deposition of sediment can modify surface features, such as mountains, or create new features, such as canyons. | Given a scenario, describe which process (weathering, erosion, deposition) contributed to the change of Earth's surface. |
| **MS-ESS2-3**<br>Analyze and interpret data on the distribution of fossils and rocks, continental shapes, and seafloor structures to provide evidence of past plate motions. | **SEP: Analyzing and Interpreting Data**<br>Analyze and interpret data to provide evidence for phenomena.<br><br>**DCI: The History of the Planet Earth**<br>Tectonic processes continually generate new ocean sea floor at ridges and destroy old sea floor at trenches. *(Secondary)*<br>**DCI: Plate Tectonics and Large-Scale System Interactions**<br>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.<br><br>**CCC: Patterns**<br>Patterns in rates of change and other numerical relationships can provide information about natural systems. | Maps of ancient land and water patterns, as well as investigations of rocks and fossils, show that the surface of the Earth consists of plates, which have moved, collided, and spread apart. | Identify that the Earth is divided into plates. | Identify plate movement. | Recognize how continent shapes fit together as evidence of plate motions (e.g., South America and Africa fit together like puzzle pieces). | Use fossil evidence to describe how continental and sea floor structures have changed over time. |

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| **MS-ESS2-4**<br>Develop a model to describe the cycling of water though Earth's systems driven by energy from the sun and the force of gravity. | **SEP: Developing and Using Models**<br>Develop a model to describe unobservable mechanisms.<br>**DCI: The Roles of Water in Earth's Surface Processes**<br>Water continually cycles among land, ocean, and atmosphere via transpiration, evaporation, condensation and crystallization, and precipitation, as well as downhill flows on land. Global movements of water and its changes in form are propelled by sunlight and gravity.<br>**CCC: Energy and Matter**<br>Within a natural or designed system, the transfer of energy drives the motion and/or cycling of matter. | Driven by the force of gravity and energy from the sun, water continually cycles through Earth's systems: among land, ocean, and atmosphere. | Identify bodies of water on the earth. | Identify the parts of the water cycle. | Use a model of the water cycle to explain the role of the sun in the water cycle. | Use a model of the water cycle to explain the cycling of water through the Earth's systems. |
| **MS-ESS2-5**<br>Collect data to provide evidence for how the motions and complex interactions of air masses result in changes in weather conditions. | **SEP: Planning and Carrying Out Investigations**<br>Collect data to produce data to serve as the basis for evidence to answer scientific questions or test design solutions under a range of conditions.<br>**DCI: The Roles of Water in Earth's Surface Processes**<br>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.<br>**DCI: Weather and Climate**<br>Because these patterns are so complex, weather can be predicted only probabilistically.<br>**CCC: Cause and Effect**<br>Cause and effect relationships may be used to predict phenomena in natural or designed systems. | The movement of air masses causes changes in weather, including temperature, precipitation, and wind. | Identify a weather condition (e.g., sunny, rainy). | Use objects and pictures to identify local weather conditions and patterns. | Use observational data to identify and describe weather conditions to predict local weather patterns. | Describe how the movement of air masses causes changes in weather, including temperature, precipitation, and wind. |
| **MS-ESS2-6**<br>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. | **SEP: Developing and Using Models**<br>Develop and use a model to describe phenomena.<br>**DCI: The Roles of Water in Earth's Surface Processes**<br>Variations in density due to variations in temperature and salinity drive a global pattern of interconnected ocean currents.<br>**DCI: Weather and Climate**<br>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. | Climates vary and are influenced by interactions involving sunlight, the ocean, the atmosphere, and landforms. | Identify a feature of a climate. | Match a climate to an area or region (e.g., Antarctica is an icy climate, northern Africa is a desert climate). | Describe how climate is determined in an area based on location, shape of land, and distance from water. | Use models to explain how climate is determined in an area (e.g., latitude, elevation, shape of land, distance from water, global wind patterns). |

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| | The ocean exerts a major influence on weather and climate by absorbing energy from the sun, releasing it over time, and globally redistributing it through ocean currents.<br><br>**CCC: Systems and System Models**<br>Cause and effect relationships may be used to predict phenomena in natural or designed systems. | | | | | |
| **Earth Space Science ESS 3 Earth and Human Activity A. Natural Resources B. Natural Hazards C. Human Impacts on Earth Systems D. Global Climate Change** | | | | | | |
| **MS-ESS3-1**<br>Construct a scientific explanation based on evidence for how the uneven distributions of Earth's minerals, energy, and groundwater resources are the result of past and current geoscience processes. | **SEP: Constructing Explanations and Designing Solutions**<br>Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do in the future.<br><br>**DCI: Natural Resources**<br>Humans depend on Earth's land, oceans, atmosphere, and biosphere for many different resources. Minerals, fresh water, and biosphere resources are limited, and many are not renewable or replaceable over human lifetimes. These resources are distributed unevenly around the planet as a result of past geologic processes.<br><br>**CCC: Cause and Effect**<br>Cause and effect relationships may be used to predict phenomena in natural or designed systems. | Humans depend on a variety of natural resources for survival. These come from various parts of the world, and many are not renewable. | Identify a natural resource. | Identify the locations of natural resources used in daily life (e.g., water, food, metals, fuel for vehicles). | Use data to explain why specific resources are limited. | Describe how the use of nonrenewable resources changes how much of the resources remain for future use. |
| **MS-ESS3-2**<br>Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects. | **SEP: Analyzing and Interpreting Data**<br>Analyze and interpret data to determine similarities and differences in findings.<br><br>**DCI: Natural Hazards**<br>Mapping the history of natural hazards in a region, combined with an understanding of related geologic forces, can help forecast the locations and likelihoods of future events.<br><br>**CCC: Patterns**<br>Graphs, charts, and images can be used to identify patterns in data. | Natural hazards include volcanic eruptions, earthquakes, tsunamis, severe weather, hurricanes, tornados, landslides, floods, and forest fires. | Identify examples of a natural hazard. | Identify locally relevant natural hazards. | Classify natural hazards as predictable or not yet predictable. | Associate a technology or safety measure with a given natural hazard to mitigate the effect. |

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| | | Data from these events can be used to prevent the effects of future events. | | | | |
| **MS-ESS3-3**<br>Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment. | **SEP: Constructing Explanations and Designing Solutions**<br>Apply scientific principles to design an object, tool, process, or system.<br><br>**DCI: Earth and Human Activity; Human Impacts on Earth Systems**<br>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.<br>Typically, as human populations and consumption of natural resources increase, so do the negative impacts on Earth, unless the activities and technologies involved are engineered otherwise.<br><br>**CCC: Cause and Effect**<br>Relationships can be classified as causal or correlational, and correlation does not necessarily imply causation. | Human activities can alter the environment in positive and negative ways. | Identify the needs of organisms in a specific environment. | Identify human actions that can alter the environment. | Match human activities with their effect on the Earth. | Given a scenario, determine a way to solve an environmental problem caused by human activity. |
| **MS-ESS3-4**<br>Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems. | **SEP: Engaging in Argument from Evidence**<br>Construct an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.<br><br>**DCI: Human Impacts on Earth Systems**<br>Typically, as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth, unless the activities and technologies involved are engineered otherwise.<br><br>**CCC: Cause and Effect**<br>Cause and effect relationships may be used to predict phenomena in natural or designed systems. | Human populations and the resources they use impact Earth systems. | Recognize resources that humans need to survive. | Describe ways in which human activity uses natural resources. | Use evidence to link an environmental change to human population increase. | Predict the effect of human population increase on an environment. |

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| **MS-ESS3-5**<br>Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century. | **SEP: Asking Questions and Defining Problems**<br>Ask questions to identify and clarify evidence of an argument.<br><br>**DCI: Global Climate Change**<br>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.<br><br>**DCI: Stability and Change**<br>Stability might be disturbed either by sudden events or gradual changes that accumulate over time. | Human activities are major factors that have led to a rise in global temperatures over the past century. | Identify human activities that have an impact on the environment. | Match human activities to possible factors causing gradual temperature changes. | Identify a question that could be answered using data that depicts rising temperatures over the last 100 years. | Identify ways in which rising temperatures could have an impact on your area. |

# High School (Aligned with the Next Generation Science Standards)

## VT Alternate Science – NGSS High School

| Next Generation Science Standards | | Essence Statements | Achievement-Level Descriptors | | | |
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| PE | SEP / DCI / CCC | | Beginning | Approaching | Meets | Exceeds |
| **Physical Science: PS 1 Matter and Interactions ❖ A. Structure and Properties of Matter ❖ B. Chemical Reactions ❖ C. Nuclear Processes** | | | | | | |
| **HS-PS1-1. Matter and its Interactions** 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. | **SEP: Developing and Using Models**<br>Modeling in 9–12 builds on K–8 and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds.<br>Use a model to predict the relationships between systems or between components of a system.<br>**DCI: Structure and Properties of Matter**<br>Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons.<br>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.<br>**CCC: Patterns**<br>Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. | Matter is made up of single and complex molecules, and within molecules there are atoms. | Identify that atoms are the smallest parts of all molecules. | Identify the elements present in a simple molecule ($O_2$) or complex molecule (NaCl or $CO_2$). | Use a model to show how atoms combine to form simple molecules ($O_2$) or complex molecules (NaCl or $CO_2$). | Use models (e.g., pictures, diagrams, 3-D balls, sticks) to explain how atoms can combine to form simple molecules ($O_2$) and complex molecules (NaCl or $CO_2$). |
| **HS-PS1-2. Matter and its Interactions** Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties. | **SEP: Constructing Explanations and Designing Solutions**<br>Constructing explanations and designing solutions in 9-12 builds on K-8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.<br>Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, and peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.<br>**DCI: Structure and Properties of Matter**<br>The Periodic Table orders elements horizontally by the number of protons in | Chemical reactions happen because of the interactions of the outermost electrons. | Identify the parts of an atom. | Identify that electrons are located outside the nucleus. | Explain the patterns of the periodic table. (metals react with nonmetals/where they're located/more protons in nucleus move horizontally) | Use the periodic table to determine if a chemical reaction would occur. |

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| | 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<br><br>**DCI: Chemical Reactions**<br><br>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.<br><br>**CCC: Patterns**<br><br>Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. | | | | | |
| **HS-PS1-3. Matter and its Interactions**<br>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. | **SEP: Planning and Carrying Out Investigations**<br><br>Planning and carrying out investigations in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models.<br><br>Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.<br><br>**DCI: Structure and Properties of Matter**<br><br>The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms.<br><br>**CCC: Patterns**<br>Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. | The properties of substances are controlled by the strengths and types of forces inside an atom. | Identify a state of matter. | Identify the properties of matter (e.g., melting point, boiling point, pressure, surface tension). | Use data about different materials to recognize that some bonds are stronger than others (e.g., super glue vs. welding to repair broken metal). | Use data to determine which substances have stronger bonds (e.g., boiling point of water vs. boiling point of olive oil) |
| **HS-PS1-4 Matter and its Interactions**<br>Develop a model to illustrate that the release or absorption of energy from a chemical reaction | **SEP: Developing and Using Models**<br><br>Modeling in 9–12 builds on K–8 and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds.<br><br>Develop a model based on evidence to illustrate the relationships between systems or between components of a system. | Chemical reactions affect the energy change in a molecule by either absorbing energy or releasing energy. | Identify a reaction that requires energy to occur (e.g., photosynthesis, baking bread) | Identify a reaction that has either released energy or absorbed energy. (e.g., lightning a match, cooking an egg) | Use a model to determine whether energy is released or absorbed in a chemical reaction system. | Predict the rate of a reaction if more or less energy was available for use. (e.g., ice would melt faster, water would boil faster) |

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| system depends upon the changes in total bond energy. | **DCI: Structure and Properties of Matter**<br><br>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.<br><br>**DCI: Chemical Reactions**<br><br>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.<br><br>**CCC: Energy and Matter**<br><br>Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. | | | | | |
| **HS-PS1-5. Matter and its Interactions** Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on | **SEP: Constructing Explanations and Designing Solutions**<br>Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.<br>Apply scientific principles and evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects.<br><br>**DCI: Chemical Reactions**<br>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. | Chemical reactions can be sped up by increasing the amount of reactants or by increasing the temperature. | Identify the reactants in a chemical reaction. | Demonstrate that a reaction rate can be increased when factors change. | Identify that increasing the temperature or the amount of reactants speeds up a chemical reaction. | Use evidence from an investigation to explain how changing the amount of reactant or the temperature changes the speed of the reaction. |

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| the rate at which a reaction occurs. | **CCC: Patterns**<br>Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. | | | | | |
| **HS-PS1-6 Matter and its Interactions**<br>Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium. | **SEP: Constructing Explanations and Designing Solutions**<br>Constructing explanations and designing solutions in 9–12 builds on K– 8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.<br>Refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.<br>**DCI: Chemical Reactions**<br>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.<br>**DCI: Optimizing the Design Solution**<br>Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (tradeoffs) may be needed. (secondary)<br>**CCC: Stability and Change**<br>Much of science deals with constructing explanations of how things change and how they remain stable. | Once a chemical reaction is in equilibrium, making a change in a variable (e.g., pressure, concentration, temperature) will affect both the products and reactants so it can remain in equilibrium. | Identify the changes during a chemical reaction. | Identify the conditions present in a chemical reaction. | Explain that changes in the conditions of a reaction result in changes in the amount of product produced. | Predict what would happen to either the reactants or the products of a reaction when a condition is changed. |
| **HS-PS1-7. Matter and its Interactions**<br>Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction. | **SEP: Using Mathematics and Computational Thinking**<br>Mathematical and computational thinking at the 9–12 level builds on K–8 and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.<br>Use mathematical representations of phenomena to support claims.<br>**DCI: Chemical Reactions** | When substances change, mass is conserved (i.e., the masses before and after the reaction are present in different forms). | Identify a chemical reaction. | Identify a substance that changes in a chemical reaction. | Recognize that, when chemicals change, new substances are formed after the reaction with equivalent mass/atoms before and after the chemical reaction. | Use data and/or mathematical computation to support a claim that mass is conserved in a chemical reaction. |

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| | 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.<br><br>**CCC: Energy and Matter**<br>The total amount of energy and matter in closed systems is conserved. | | | | | |
| **HS-PS1-8. Matter and it's Interactions** 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. | **SEP: Developing and Using Models**<br><br>Modeling in 9–12 builds on K–8 and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds.<br><br>Develop a model based on evidence to illustrate the relationships between systems or between components of a system.<br><br>**DCI: Nuclear Processes**<br><br>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.<br><br>**CCC: Energy and Matter**<br><br>In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved. | Nuclear processes, like fusion, fission and radioactive decay, include the release or absorption of energy. | Recognize the center of an atom. | Identify models of fission, fusion and radioactive decay. (Note: Models at this level may include plastic building blocks or ping pong balls.) | Determine what nuclear process releases or absorbs energy. | Complete a model that illustrates fusion, fission, or radioactive decay. (Note: Models at this level may include numerical models or radiometric ages of rocks and fossils.) |
| **Physical Science: PS 2 Motion and Stability: Forces and Interactions ❖ A. Forces and Motion ❖ B. Types of Interactions ❖ C. Stability and Instability in Physical Systems** | | | | | | |
| **HS-PS2-1. Motion and Stability: Forces and Interactions** 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 | **SEP: Analyzing and Interpreting Data**<br><br>Analyzing data in 9–12 builds on K–8 and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data.<br><br>Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution.<br><br>**DCI: Forces and Motion**<br><br>Newton's second law accurately predicts changes in the motion of macroscopic objects. | The motion of an object depends on the interaction of an applied force, how much mass an object has, and the acceleration of the object. | Identify how an applied force can move an object. (e.g., direction, big force, little force) | Compare objects and identify which object would take more force to move. | Recognize the relationship between force and an object's mass and acceleration. | Use mathematical data to support that the amount of force an object has changes when its mass or acceleration is changed. |

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| acceleration. | **CCC: Cause and Effect**<br><br>Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. | | | | | |
| **HS-PS2-2. Motion and Stability: Forces and Interactions**<br>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. | **SEP: Using Mathematics and Computational Thinking**<br><br>Mathematical and computational thinking at the 9–12 level builds on K–8 and progresses to using algebraic thinking and analysis; a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms; and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.<br><br>Use mathematical representations of phenomena to describe explanations.<br><br>**DCI: Forces and Motion**<br><br>Momentum is defined for a particular frame of reference; it is the mass times the velocity of the object.<br><br>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.<br><br>**CCC: Systems and System Models**<br><br>When investigating or describing a system, the boundaries and initial conditions of the system need to be defined. | The more momentum an object has, the harder it is to stop, because an object's momentum is related to how much mass it has, and its velocity. | Recognize that a force is needed to change an object's velocity (e.g., rolling a ball vs. throwing a ball). | Demonstrate what happens to an object's velocity if its mass is increased (e.g., throwing a paper cup vs. throwing a baseball). | Identify an example of the law of momentum conservation by using graphical or visual displays (e.g., carts on a frictionless track). | Compare two objects' mathematical data and determine which object would have more momentum.<br><br>*Data can include masses slightly different and drastically different velocities, or velocities slightly different and drastically different masses. |

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| **HS-PS2-3. Motion and Stability: Forces and Interactions** Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision. * | **SEP: Constructing Explanations and Designing Solutions**<br>Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.<br>Apply scientific ideas to solve a design problem, taking into account possible unanticipated effects.<br>**DCI: Forces and Motion**<br>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.<br>**DCI: Defining and Delimiting an Engineering Problem**<br>Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. (secondary)<br>**DCI: Optimizing the Design Solution**<br>Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed. (secondary)<br>**CCC: Cause and Effect**<br>Systems can be designed to cause a desired effect. | When objects collide, they exert forces on each other, which affects their motion. Some objects minimize force (e.g., bumper on a car, helmet on a football player). | Identify a collision. | Identify ways to minimize the force in a collision (e.g., bumper, helmet, air bags in cars). | Use models to predict how impact is minimized when protective components are included. | Use data to describe the best device that will reduce impact in a collision. |
| **HS-PS2-4. Motion and Stability: Forces and Interactions** Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects. | **SEP: Using Mathematics and Computational Thinking**<br>Mathematical and computational thinking at the 9–12 level builds on K–8 and progresses to using algebraic thinking and analysis; a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms; and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.<br>Use mathematical representations of phenomena to describe explanations.<br>**DCI: Types of Interactions**<br>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.<br>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 | Objects can feel gravitational and electrical forces over distances, and the strength of the force they feel is inversely proportional to their distance. | Recognize that objects can be attracted to each other. | Identify gravity and its effect on objects. | Compare the effects of two forces when applied to a third. (e.g., a balloon might stick to a wall with static, but will ultimately fall to the ground) | Use mathematical data to identify that gravitational force is always constant (e.g., dropping a feather and a bowling ball in a vacuum). |

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| | magnetic fields cause electric fields.<br><br>**CCC: Patterns**<br>Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. | | | | | |
| **HS-PS2-5. Motion and Stability: Forces and Interactions**<br>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. | **SEP: Planning and Carrying out Investigations**<br>Planning and carrying out investigations to answer questions or test solutions to problems in 9–12 builds on K–8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical and empirical models.<br><br>Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.<br><br>**DCI: Types of Interactions**<br>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. (HS-PS2-4)<br><br>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.<br><br>**DCI: Definitions of Energy**<br>"Electrical energy" may mean energy stored in a battery or energy transmitted by electric currents. (secondary)<br><br>**CCC: Cause and Effect**<br>Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. | DCIs covered in HS-PS2-4 and HS-PS3-1 where SEP and CCC are more appropriate. | | | | |
| **HS-PS2-6. Motion and Stability: Forces and Interactions**<br>Communicate scientific and technical information about why the molecular- | **SEP: Obtaining, Evaluating, and Communicating Information**<br>Obtaining, evaluating, and communicating information in 9–12 builds on K–8 and progresses to evaluating the validity and reliability of the claims, methods, and designs.<br><br>Communicate scientific and technical information (e.g., about the process of development and the design and performance of a proposed process or system) in multiple formats (including oral, graphical, textual and mathematical). | Different materials have different molecular structures and properties which determine different material characteristics. | Identify properties that a material has. (e.g., flexibility, durability, etc.) | Compare and contrast two materials and their properties (e.g., metals and plastics). (Note: This comparison may be a numerical or pictorial comparison.) | Evaluate two different materials and their properties to determine their functionality. | Communicate data that supports a claim about which material is more useful when designing a given object or structure, or when solving a given |

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| level structure is important in the functioning of designed materials. | **DCI: Types of Interactions**<br>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.<br><br>**CCC: Structure and Function**<br>Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem. | | | | | engineering problem. |
| **Physical Science: PS 3 Energy ❖ A. Definitions of Energy ❖ B. Conservation of Energy and Energy Transfer ❖ C. Relationship Between Energy and Forces ❖ D. Energy and Chemical Processes in Everyday Life** | | | | | | |
| **HS-PS3-1. Energy**<br>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. | **SEP: Using Mathematics and Computational Thinking**<br>Mathematical and computational thinking at the 9–12 level builds on K–8 and progresses to using algebraic thinking and analysis; a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms; and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.<br><br>Create a computational model or simulation of a phenomenon, designed device, process, or system.<br><br>**DCI: Definitions of Energy**<br>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.<br><br>**DCI: Conservation of Energy and Energy Transfer**<br>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.<br><br>Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems.<br><br>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.<br><br>The availability of energy limits what can occur in any system. | When the energy of a component within a system changes, the total amount of energy of that system is conserved. (Either energy is transported or transferred between systems). | Identify an example where the energy of a system changes (e.g., pushing a ball down a ramp, raising a book up). | Recognize how a component has changed when there has been an energy change. (e.g., ball moves faster, ramp is steeper) | Use a model that demonstrates changes in energy flows in relation to other components of the model. | Use mathematical data (e.g., simple equations, graphs, or tables) to show that the energy of a system has been conserved despite an observed change in energy. |

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| | **CCC: Systems and System Models**<br><br>Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models. | | | | | |
| **HS-PS3-2. Energy** Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative positions of particles (objects.) | **SEP: Developing and Using Models**<br>Modeling in 9–12 builds on K–8 and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds.<br><br>Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system.<br><br>**DCI: Definitions of Energy**<br>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.<br><br>At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy.<br><br>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.<br><br>**CCC: Energy and Matter**<br>Energy cannot be created or destroyed; it only moves between one place and another place, between objects and/or fields, or between systems. | An object's height and motion can affect its gravitational potential energy and kinetic energy at the macroscopic level. | Identify a source of energy and the type of energy it represents. (e.g., sun—light energy, fire—thermal energy) | Recognize that different types of energy can be classified as either kinetic or potential energy. | Use a model that shows how kinetic or potential energy in a system can change. (e.g., moving faster, moving higher) | Compare two system models and explain which system has more kinetic or potential energy. |
| **HS-PS3-3. Energy** Design, build, and refine a device that works within given constraints to convert one form of energy into another | **SEP: Constructing Explanations and Designing Solutions**<br>Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.<br><br>Design, evaluate, and/or refine a solution to a complex real-world problem based on scientific knowledge, student-generated sources of evidence, | Energy can be converted from one form to another, but some devices that convert one form of energy to another | Identify different types of energy (e.g., motion, sound, light, thermal) | Identify an energy conversion. | Identify steps in a model of a device showing the transformations of energy that occur (e.g., dams, solar cells, solar ovens, | Using data, determine the efficiency of an energy conversion. |

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| form of energy. | prioritized criteria, and tradeoff considerations.<br><br>**DCI: Definitions of Energy**<br>At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy.<br>**DCI: Energy in Chemical Processes**<br>Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment.<br>**DCI: Defining and Delimiting an Engineering Problem**<br>Criteria and constraints also include satisfying any requirements set by society such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. *(secondary)*<br><br>**CCC: Energy and Matter**<br>Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. | may be better than others (e.g., cost, efficiency). | | | generators, turbines). | |
| **HS-PS3-4. Energy**<br>Plan and conduct an investigation that 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). | **SEP: Planning and Carrying Out Investigations**<br>Planning and carrying out investigations to answer questions or test solutions to problems in 9–12 builds on K–8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models.<br><br>Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.<br><br>**DCI: Conservation of Energy and Energy Transfer**<br>Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems.<br><br>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).<br><br>**DCI: Energy in Chemical Processes**<br>Although energy cannot be destroyed, it can be converted to less useful forms — for example, to thermal energy in the surrounding environment.<br><br>**CCC: Systems and System Models**<br>When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models. | A liquid or object with more heat energy will transfer from one object to another in order to become more stable. (e.g., hotter objects cooling down to the environment) | Compare the relative temperature of two substances (warm vs. cool). | Compare qualitatively the temperature of two substances before and after combining. | Use data to evaluate the temperature of two different substances before and after combining. | Predict what more (mass) of a substance would do to the transfer of heat to another substance. |

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| **HS-PS3-5. Energy**<br>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. | **SEP: Developing and Using Models**<br>Modeling in 9–12 builds on K–8 and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds.<br>Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system.<br><br>**DCI: Relationship Between Energy and Forces**<br>When two objects interacting through a field change relative position, the energy stored in the field is changed.<br><br>**CCC: Cause and Effect**<br>Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system. | When two objects interact in a magnetic field, forces between the objects change due to their interaction. | Recognize that like poles repel each other and unlike poles attract each other. | Demonstrate how the orientation of magnets and the distance between them affects the behavior of the magnets. | Model magnetic behavior based on force (e.g., stronger magnets versus weaker magnets; number of paper clips one magnet can hold versus another). | Explain the effect of one magnet on the behavior of another magnet when distance or force is changed in an investigation. |
| **Physical Science: PS 4 Waves and Their Applications in Technologies ❖ A. Wave Properties ❖ B. Electromagnetic Radiation ❖ C. Information Technologies and Instrumentation** | | | | | | |
| **HS-PS4-1. Waves and their Applications in Technologies for Information Transfer**<br>Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media. | **SEP: Using Mathematics and Computational Thinking**<br>Mathematical and computational thinking at the 9-12 level builds on K-8 and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.<br>Use mathematical representations of phenomena or design solutions to describe and/or support claims and/or explanations.<br><br>**DCI: Wave Properties**<br>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.<br><br>**CCC: Cause and Effect**<br>Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. | Mechanical waves (water, sound, waves in a rope at the gym) have repeating patterns (including amplitude, frequency, wavelength) that are impacted by the media (e.g., air, water) through which they travel. | Identify different media that waves travel through (e.g., air, water, solid objects). | Identify a property of a wave (e.g., frequency, amplitude, wavelength). | Identify differences in frequency, wavelength, and amplitude by comparing wave diagrams | Use data to explain how a medium impacts a wave's behavior when the wave travels through that medium (e.g., seismic waves, gelatin, ropes) by using data. |

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| **HS-PS4-2. Waves and their Applications in Technologies for Information Transfer** Evaluate questions about the advantages of using a digital transmission and storage of information. | **SEP: Asking Questions and Defining Problems** Asking questions and defining problems in grades 9–12 builds from grades K–8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations. Evaluate questions that challenge the premise(s) of an argument, the interpretation of a data set, or the suitability of a design. **DCI: Wave Properties** 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. **CCC: Stability and Change** Systems can be designed for greater or lesser stability. | Technological advances have improved our ability to store and transmit information. There are advantages and disadvantages to digital transmission and storage. | Identify different types of digital resources (e.g., emails, text). | Identify how information can be stored reliably in computer memory. | Identify an advantage or disadvantage of a specific digital information technology. | Compare advantages and disadvantages of various means of digital information. |
| **HS-PS4-3. Waves and their Applications in Technologies for Information Transfer** 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. | **SEP: Engaging in Argument from Evidence** Engaging in argument from evidence in 9– 12 builds on K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science. Evaluate the claims, evidence, and reasoning behind currently accepted explanations or solutions to determine the merits of arguments. **DCI: Wave Properties** [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.) **DCI: 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. | DCIs are covered in HS-PS4-2 and HS-PS4-4 where they are more appropriately tied to their SEPs and CCCs. | | | | |

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| | **CCC: Systems and System Models**<br>Models (e.g., physical, mathematical, and computer models) can be used to simulate systems and interactions — including energy, matter and information flows — within and between systems at different scales. | | | | | |
| **HS-PS4-4. Waves and their Applications in Technologies for Information Transfer**<br>Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter. | **SEP: Obtaining, Evaluating and Communicating Information**<br>Obtaining, evaluating, and communicating information in 9–12 builds on K–8 and progresses to evaluating the validity and reliability of the claims, methods, and designs.<br><br>Evaluate the validity and reliability of multiple claims that appear in scientific and technical texts or media reports, verifying the data when possible<br><br>**DCI: Electromagnetic Radiation**<br>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.<br><br>**CCC: Cause and Effect**<br>Cause and effect relationships can be suggested and predicted for complex natural and human-designed systems by examining what is known about smaller scale mechanisms within the system. | The size of an electromagnetic wave will have varying degrees of effects- from giving off thermal energy (longer wavelengths and light) to damaging living cells (shorter wavelengths e.g., UV, X-rays, Gamma). | Identify that waves can come in varying wavelengths and amplitudes. | Identify the source of different waves (e.g., light from the sun, sound from a speaker). | Compare two waves and their wavelengths to determine which wave has more thermal energy. | Recognize that as the size of the wavelength increases, the less easily it is absorbed by matter and the less thermal energy it releases. |
| **HS-PS4-5. Waves and their Applications in Technologies for Information Transfer**<br>Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with | **SEP: Obtain, Evaluate, and Communicating Information**<br>Obtaining, evaluating, and communicating information in 9–12 builds on K–8 and progresses to evaluating the validity and reliability of the claims, methods, and designs.<br><br>Communicate technical information or ideas (e.g., about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).<br><br>**DCI: Energy in Chemical Processes**<br>Solar cells are human-made devices that likewise capture the sun's energy and produce electrical energy. (secondary)<br>**DCI: Wave Properties**<br>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. | Large amounts of information can be produced and stored digitally and transmitted over distances by electromagnetic waves. | Identify how common technological devices are used for different purposes. | Identify common devices which use light or sound waves to transmit information (e.g., remote control, wireless modem). | Use evidence to show how some devices use light and sound waves to transmit and capture information. | Compare and evaluate how two different machines use EM and sound waves differently. |

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| matter to transmit and capture information and energy. | **DCI: Electromagnetic Radiation**<br>Photoelectric materials emit electrons when they absorb light of a high-enough frequency.<br>**DCI: Information Technologies and Instrumentation**<br>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.<br><br>**CCC: Cause and Effect**<br>Systems can be designed to cause a desired effect. | | | | | |

# VT Alternate Science – NGSS High School

| Next Generation Science Standards | | Essence Statements | Achievement-Level Descriptors | | | |
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| **PE** | **SEP / DCI / CCC** | | **Beginning** | **Approaching** | **Meets** | **Exceeds** |
| **Life Science: LS 1 From Molecules to Organisms: Structures and Processes ❖ A. Structure and Function ❖ B. Growth and Development of Organisms ❖ C. Organization for Matter and Energy Flow in Organisms ❖ D. Information Processing** | | | | | | |
| **HS-LS1-1** 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. | **SEP: Constructing Explanations and Designing Solutions** Construct an explanation based on valid and reliable evidence. **DCI: Structure and Function** Systems of specialized cells within organisms help them perform essential functions. All cells contain genetic information in the form of DNA molecules. **CCC: Structure and Function** Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem. | Living things are made up of a variety of types of cells that have different functions. In all organisms, the function of a cell is determined by its DNA, which is found in the cell's nucleus. | Identify that living things are made up of cells. | Identify the nucleus as the control center of a cell for determining the function of a cell. Recognize that DNA is found in the nucleus of the cell. | Identify that the DNA in a cell's nucleus is the genetic code that creates proteins that determine a cell's function. | Identify that body tissues are systems of specialized cells with similar functions (e.g., skin cells, muscle cells, brain cells) that use specific DNA structures. |
| **HS-LS1-2** Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms. | **SEP: Developing and Using Models** Use a model to illustrate the relationships between systems or between components of a system. **DCI: Structure and Function** 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. **CCC: Systems and System Models** Models (e.g., physical, computer) can be used to simulate systems. | Living organisms have systems that work together to maintain life. These systems, and the organs that make them up, carry out specific functions. | Identify a body system. | Identify major organ(s) in a body system and its function. | Identify the function of a body system, its major organ(s), and another system with which it interacts to maintain life. | Explain or model how two body systems work together to maintain life. |

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| **HS-LS1-3**<br>Plan and conduct investigations to provide evidence that feedback mechanisms maintain homeostasis. | **SEP: Planning and Carrying Out Investigations**<br>Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.<br><br>**DCI: Structure and Function**<br>Feedback mechanisms maintain a living system's internal conditions within certain limits, allowing it to remain alive and functional.<br><br>**CCC: Stability and Change**<br>Feedback (negative or positive) can stabilize or destabilize a system. | Organisms respond to stimuli to maintain homeostasis. | Identify stimuli that lead to reactions in a living system (e.g., temperature, amount of light present, sounds, smells). | Identify ways the body reacts to stimuli to maintain homeostasis (e.g., sweating when hot, increasing heart rate and breathing during exercise, pupils reacting to light). | Use data (graphical or in a table) to identify changes in body systems during exercise or other activities. (Graphs should show the body's response and a return to homeostasis.) | Identify the correct sequence of steps necessary in an investigation to show how an organism reacts to stimuli (e.g., eye reacting to light, heart or lungs reacting to exercise). |
| **HS-LS1-4**<br>Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms. | **SEP: Developing and Using Models**<br>Use a model to illustrate the relationships between systems or between components of a system.<br><br>**DCI: Growth and Development of Organisms**<br>In organisms, individual cells grow and then divide via a process called mitosis, thus allowing the organism to grow. The organism begins as a single cell (fertilized egg) that divides successively to produce many cells. Cellular division and differentiation produce and maintain a complex organism.<br><br>**CCC: Systems and System Models**<br>Models (e.g., physical, computer models) can be used to simulate systems. | Cell division and differentiation, which occur through a process called mitosis, enable growth and the replacement of dead or damaged cells. | Identify that cells divide. | Identify a model of the cellular division process. | Use a model to illustrate how cellular division contributes to the growth and development of the organism. | Explain how cellular division contributes to the growth and development of the organism. |
| **HS-LS1-5**<br>Use a model to illustrate how photosynthesis | **SEP: Developing and Using Models**<br>The process of photosynthesis converts light energy to stored chemical energy by converting carbon dioxide and water into sugars plus released oxygen. | Plants produce their food through a process called photosynthesis. | Identify that plants make their own food with energy from the sun. | Recognize the purpose of photosynthesis. | Identify what a plant uses (e.g., sunlight, water) and what a plant produces (e.g., | Use a model (using words or pictures) to explain the |

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| transforms light energy into stored chemical energy. | **DCI: Organization for Matter and Energy Flow in Organisms**<br>The process of photosynthesis converts light energy to stored chemical energy by converting carbon dioxide and water into sugars plus released oxygen.<br><br>**CCC: Energy and Matter**<br>Changes of energy and matter in a system can be described in terms of energy and matter flowing into, out of, and within that system. | Photosynthesis uses light energy to convert carbon dioxide and water into sugars and releases oxygen. | | | food, oxygen) during photosynthesis (e.g., fill in the missing part of the model). | overall process of photosynthesis. |
| **HS-LS1-6**<br>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. | **SEP: Constructing Explanations and Designing Solutions**<br>Construct an explanation based on valid and reliable evidence.<br><br>**DCI: Organization for Matter and Energy Flow in Organisms**<br>Sugar molecules 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.<br><br>**CCC: Energy and Matter**<br>Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. | Sugar molecules contain carbon, hydrogen, and oxygen. Explain how they are used to make amino acids and other carbon-based molecules. | Identify the simple molecule that organisms need for survival. | Recognize that plants and animals rely on sugar molecules to create other molecules necessary for survival. | Confirm or revise a description of the process of creating other molecules from sugar molecules. | Explain how the elements that make up sugar molecules can be used to form other molecules (e.g., amino acids, DNA, proteins). |
| **HS-LS1-7**<br>Use a model to illustrate that cellular respiration is a chemical process that results in the bonds of food molecules and oxygen molecules being broken and the bonds in new compounds being formed, resulting in a net transfer of energy. | **SEP: Developing and Using Models**<br>Use a model based on evidence to illustrate the relationships between systems or between components of a system.<br><br>**DCI: Organization for Matter and Energy Flow in Organisms**<br>As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products.<br>Because 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.<br><br>**CCC: Energy and Matter** | Cellular respiration involves the transfer of energy from consumed food to the organism. | Identify the reasons why consumers need food and air.<br><br>(Note: exclude plants; photosynthesis is addressed in HS LS1-5.) | Identify the molecules that are involved in cellular respiration. | Use a model of cellular respiration to illustrate the input and output of the process. | Given a scenario, describe how food and oxygen molecules are used in the process of cellular respiration. |

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| | Energy cannot be created or destroyed; it only moves between one place and another place, between objects and/or fields, or between systems. | | | | | |
| **Life Science: LS 2 Ecosystems: Interactions, Energy, and Dynamics ❖ A. Interdependent Relationships in Ecosystems ❖ B. Cycles of Matter and Energy Transfer in Ecosystems ❖ C. Ecosystem Dynamics, Functioning, and Resilience ❖ D. Social Interactions and Group Behavior** | | | | | | |
| **HS-LS2-1**<br>Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales. | **SEP: Using Mathematics and Computational Thinking**<br>Use mathematical and/or computational representations of phenomena or design solutions to support explanations.<br><br>**DCI: Interdependent Relationships in Ecosystems**<br>Ecosystems have carrying capacities, which limit 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.<br><br>**CCC: Scale, Proportion and Quantity; Stability and Change**<br>The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. | Ecosystems have carrying capacities that are determined by factors that limit the numbers of organisms and populations they can support.<br><br>Dynamic equilibrium exists in organisms, populations, and ecosystems. | Identify the organisms that interact in a specific ecosystem. | Identify the factor(s) that could affect the equilibrium in an ecosystem (e.g., population increases or decreases, immigration or emigration, invasive species). | Use data to determine if the food supply present in an ecosystem can sustain a specified increase in the populations eating that particular food. | Use data (including graphical representations) to describe a change in the population of an organism or a change in the resources found in a specific ecosystem. |
| **HS-LS2-2**<br>Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales. | **SEP: Using Mathematics and Computational Thinking**<br>Use mathematical representations of phenomena or design solutions to support and revise explanations.<br><br>**DCI: Interdependent Relationships in Ecosystems**<br>Ecosystems have carrying capacities, limit the numbers of organisms and populations they can support. These limits result from such factors as the availability of 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 of species in any given ecosystem. Interactions within an ecosystem can keep its numbers and types of organisms relatively constant under stable conditions. If a modest disturbance to an ecosystem occurs, it may return more or less to its original status. Extreme fluctuations in conditions can challenge the functioning of ecosystems.<br><br>**DCI: Ecosystem Dynamics, Functioning, and Resilience**<br>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 | Dynamic equilibrium exists in organisms, populations, and ecosystems.<br><br>Interactions within a stable ecosystem keep the numbers and types of organisms relatively constant. If a modest disturbance to an ecosystem occurs, the ecosystem normally returns to its original status. | Identify the needs of a common plant or animal. | Recognize the interdependence of two or more organisms in an ecosystem. | Use data to explain the patterns and/or trends between population size and the availability of resources. | Use a graphical representation to describe how the population of an organism changes over time if an environmental factor changes. |

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| | occurs, it may return to its 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.<br><br>**CCC: Scale, Proportion and Quantity**<br>Using the concept of orders of magnitude allows one to understand how a model at one scale relates to a model at another scale. | Extreme changes can challenge the functioning of an ecosystem. | | | | |
| **HS-LS2-3**<br>Construct and revise an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions. | **SEP: Constructing Explanations and Designing Solutions**<br>Construct an explanation based on valid and reliable evidence.<br><br>**DCI: Cycles of Matter and Energy Transfer in Ecosystems**<br>Photosynthesis and cellular respiration (including anaerobic processes) provide most of the energy for life processes<br><br>**CCC: Energy and Matter**<br>Energy drives the cycling of matter within and between systems | DCI and CCC are covered through HS-LS2.4, where SEP is more appropriate.<br><br>Aerobic and anaerobic conditions are unnecessary complications for this group of students. | | | | |
| **HS-LS2-4**<br>Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem. | **SEP: Using Mathematics and Computational Thinking**<br>Use mathematical representations of phenomena or design solutions to support claims.<br><br>**DCI: Cycles of Matter and Energy Transfer in Ecosystems**<br>Plants are in 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. Therefore, there are generally fewer organisms at higher levels of a food web.<br>The matter (chemical elements) passes through food webs and into and out of the atmosphere and soil.<br>At each link in an ecosystem, matter and energy are conserved.<br><br>**CCC: Energy and Matter**<br>Energy cannot be created or destroyed; it only moves between one place and another place. | Matter and energy flow through a food web (ecosystem) with only a small fraction transferred from one level to another. | Identify that matter cycles and energy flows through a food chain. | Identify the types of matter and energy that flow through a food web. | Diagram the movement of matter and energy through a food web (ecosystem). | Given an example of a food web, explain why there are more producers than consumers in an ecosystem. |
| **HS-LS2-5**<br>Develop a model to illustrate the role of photosynthesis and | **SEP: Developing and Using Models**<br>Develop a model based on evidence to illustrate the relationships between systems or components of a system. | Photosynthesis and cellular respiration result in the | Identify what a plant needs to make its own food. | Recognize the purpose/importance of photosynthesis | Identify that the outputs of photosynthesis are the inputs of | Describe the link between photosynthesis and |

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| cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere | **DCI: Cycles of Matter and Energy Transfer in Ecosystems; Energy in Chemical Processes**<br>Photosynthesis and cellular respiration are important components of the carbon cycle.<br>The main way that solar energy is captured and stored on Earth is through the process of photosynthesis.<br><br>**CCC: Systems and System Models**<br>Models (e.g., physical, mathematical, computer) can be used to simulate systems and interactions—including energy, matter and information flows—within and between systems. | movement of matter and energy. | | and respiration to plants. | respiration, and the outputs of respiration are the inputs of photosynthesis. | cellular respiration in the carbon cycle. |
| **HS-LS2-6**<br>Evaluate 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. | **SEP: Engaging in Argument from Evidence**<br>Evaluate the claims, evidence, and reasoning behind currently accepted explanations or solutions to determine the merits of arguments.<br><br>**DCI: Ecosystem Dynamics, Functioning, and Resilience**<br>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.<br><br>**CCC: Stability and Change**<br>Science deals with constructing explanations of how things change and how they remain stable. | Changes in the environment, including physical or biological factors, can lead to temporary or permanent changes to an ecosystem. | Differentiate between biotic and abiotic factors of an ecosystem. | Identify how an abiotic factor affects and changes a population (e.g., sunlight, water, soil). | Classify natural and human-initiated changes in the physical environment that could affect a population. | Describe how a change can affect the physical and biological environment and, in turn, affect the populations in an ecosystem. |
| **HS-LS2-7**<br>Design, evaluate, and refine a solution for reducing the impact of human activities on the environment and biodiversity. | **SEP: Constructing Explanations and Designing Solutions**<br>Design and refine a solution to a real-world problem based on scientific knowledge, student-generated sources of evidence, and tradeoff considerations.<br><br>**DCI: Ecosystem Dynamics Functioning and Resilience; Biodiversity and Humans; Developing Possible Solutions**<br>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.<br>Humans depend on the living world for the resources and other benefits provided by biodiversity. | Human activity can change the environment. Some changes are harmful, but humankind can also take steps to preserve and restore the environment. | Identify human activities that can be harmful to the Earth. | Identify human activities that can be harmful to the Earth and match the human activity with its effect on the Earth. | Identify human activities that can have a negative effect on the Earth and then identify a solution that reduces its impact on the environment. | Describe a solution to reduce the impact of human activities on the environment. |

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| | **CCC: Stability and Change**<br>Much of science deals with constructing explanations of how things change and how they remain stable. | | | | | |
| **HS-LS2-8**<br>Evaluate evidence for the role of group behavior on individuals' and species' chances to survive and reproduce. | **SEP: Engaging in Argument from Evidence**<br>Evaluate the evidence behind currently accepted explanations to determine the merits of arguments.<br><br>**DCI: Social Interactions and Group Behavior**<br>Group behavior has evolved because membership can increase the chances of survival for individuals and their genetic relatives.<br><br>**CCC: Cause and Effect**<br>Evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. | Group behavior has evolved because it can increase the chances of survival. | Identify potential threats to a population of animals. | Identify a group behavior that helps an animal species survive. | Given a group behavior, describe how that behavior helps individuals and species to survive and reproduce. | Use data (pictorial, graphical, or tabular) to illustrate the positive impact of group behavior on an animal's species. |
| **Life Science: LS 3 Heredity, Inheritance and Variation of Traits ❖ A. Inheritance of Traits ❖ B. Variation of Traits** | | | | | | |
| **HS-LS3-1**<br>Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring. | **SEP: Asking Questions and Defining Problems**<br>Ask questions that arise from examining models or a theory to clarify relationships.<br><br>**DCI: Structure and Function; Inheritance of Trait**<br>All cells contain genetic information in the form of DNA molecules.<br>The instructions for forming species' characteristics are carried in DNA.<br><br>**CCC: Cause and Effect**<br>Evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. | DNA contains genetic information that is passed from parent (cell or organism) to offspring.<br><br>The instructions for forming species' traits (characteristics) are carried in DNA. | Identify the traits (characteristics) of an organism. | Recognize that chromosomes, which are made up of DNA, as a set of instructions (code) that determine traits (characteristics). | Describe how traits (characteristics) are passed from one generation to the next through DNA. | Describe how changes in DNA can result in changed traits in the offspring. |
| **HS-LS3-2**<br>Make and defend a claim based on evidence that inheritable genetic variations may result from (1) new genetic combinations | **SEP: Engaging in Argument from Evidence**<br>Make and defend a claim based on evidence about the natural world that reflects scientific knowledge and student-generated evidence.<br><br>**DCI: Variation of Traits**<br>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. | Sexual reproduction involves chromosomes from two individuals of the same species and the process of meiosis, which leads to new | Recognize that traits are determined by genetic information (DNA) that is kept in the chromosome. | Identify a reason why two siblings can have different characteristics even though they have the same parents. | Identify the causes of genetic variation. | Given a scenario, explain why reproduction may or may not result in offspring with different traits. |

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| through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors. | Environmental factors also affect expression of traits, and hence affect the probability of occurrences of traits in a population.<br><br>**CCC: Cause and Effect**<br>Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. | combinations and variation of traits. Genetic variations may also result from replication errors or mutations. | | | | |
| **HS-LS3-3**<br>Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population. | **SEP: Analyzing and Interpreting Data; Engaging in Argument from Evidence**<br>Apply concepts of statistics and probability to scientific and engineering questions and problems, using digital tools when feasible.<br><br>**DCI: Variation of Traits**<br>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.<br><br>**CCC: Scale, Proportion, and Quantity**<br>Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth). | Covered through HS-LS3-2, where the SEP is more appropriate. | | | | |
| **Life Science: LS 4 Biological Evolution: Unity and Diversity ❖ A. Evidence of Common Ancestry ❖ B. Natural Selection ❖ C. Adaptation ❖ D. Biodiversity and Humans** | | | | | | |
| **HS-LS4-1**<br>Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence. | **SEP: Obtaining, Evaluating, and Communicating Information**<br>Communicate scientific information (e.g., about phenomena and/or the process of development and the design and Achievement of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).<br><br>**DCI: Evidence of Common Ancestry and Diversity**<br>Genetic information, like the fossil record, provides evidence of evolution. DNA sequences vary among species.<br>Lines of descent can be inferred by comparing the DNA sequences of different organisms.<br><br>**CCC: Patterns**<br>Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. | Multiple sources of evidence indicate that many organisms found on Earth are related and can be traced back to common ancestors that lived very long ago. | Identify two present-day species of organisms that have similar anatomical structures (e.g., pigeons and myna birds, cows and horses). | Identify a fossil organism and a present-day organism that have the similar anatomical structures. | Identify multiple ways to determine the ancestry of an organism (e.g., fossils, DNA sequence). | Using descriptions and pictures, describe the evolved development pattern from a fossil to a present-day organism. |

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| **HS-LS4-2**<br>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. | **SEP: Constructing Explanations and Designing Solutions**<br>Construct an explanation based on valid and reliable evidence.<br><br>**DCI: Natural Selection; Adaptation**<br>Natural selection occurs only if (1) there is both variation in the genetic information between organisms in a population and (2) there is trait variation that leads to differences in Achievement among individuals.<br>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, (3) competition for an environment's limited supply of the resources, and (4) the ensuing proliferation of those organisms that are better able to survive and reproduce in that environment.<br><br>**CCC: Cause and Effect**<br>Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. | Evolution explains the change due to natural selection across successive generations in a biological population. | Identify evolution as a process that results in species developing beneficial characteristics. | Recognize that evolution results in species developing new characteristics that increase the chances of survival. | Determine which factor(s) (e.g., an inherited genetic variation, limited resources, organisms that were more fit to survive in an environment) resulted in a specific adaptation within a species. | Given a scenario (e.g., limited resources), describe an adaptation that a specific species may develop and pass on to future generations. |
| **HS-LS4-3**<br>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. | **SEP: Analyzing and Interpreting Data**<br>Apply concepts of statistics and probability (including determining function fits to data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible.<br><br>**DCI: Natural Selection; Adaptation**<br>The traits that positively affect survival are more likely to be reproduced and, thus, are more common in the population.<br>Natural selection leads to a population dominated by organisms that are anatomically, behaviorally, and physiologically well suited to survive in a specific environment.<br>Adaptation also means that the distribution of traits in a population can change when conditions change. | Organisms' traits that increase an organism's chances of survival are more likely to be reproduced and, thus, become more common in the population. | Identify that some organisms survive better in certain environments. | Identify an advantageous inheritable trait. | Given a scenario of similar organisms with different traits, explain why an organism will likely survive based on the given environment (e.g., birds with different-shaped beaks trying to eat insects). | Use data (pictorial, graphical, or tabular) to explain why there is an increased probability of individual organisms exhibiting an advantageous trait over time. |

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| | **CCC: Patterns**<br>Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. | | | | | |
| **HS-LS4-4**<br>Construct an explanation based on evidence for how natural selection leads to adaptation of populations. | **SEP: Constructing Explanations and Designing Solutions**<br>Construct an explanation based on valid and reliable evidence.<br>**DCI: Adaptation**<br>Natural selection leads to adaptation in a population of organisms, well suited to survive 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.<br>**CCC: Cause and Effect**<br>Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. | Natural selection is a process whereby possessing beneficial traits results in a higher survival rate and more offspring, leading to adaptations in a population. | Identify a trait. | Identify a trait that would give an organism a better chance of survival in a specific environment. | Explain why organisms with beneficial traits are more likely to survive and reproduce. | Describe how over time, populations become better adapted to a specific environment. |
| **HS-LS4-5**<br>Evaluate the evidence supporting claims that changes in environmental conditions may result in (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species. | **SEP: Engaging in Argument from Evidence**<br>Evaluate the evidence behind currently accepted explanations or solutions to determine the merits of arguments.<br>**DCI: Adaptation**<br>Changes in the physical environment have 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.<br>**CCC: Cause and Effect**<br>Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. | Changes in an ecosystem determine the survival of some organisms over others and could result in the emergence of new species. | Identify the survival needs of the organisms present in a specific environment. | Identify a gradual change in a specific environment (e.g., deforestation, fishing, fertilizer application, drought, or flood). | Explain how gradual change in the environment can cause changes in organisms. | Use data to predict what will happen to specific species over time based on an environmental change. |
| **HS-LS4-6**<br>Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity. | **SEP: Using Mathematics and Computational Thinking**<br>Create or revise a simulation of a phenomenon, designed device, process, or system.<br>**DCI: Adaptation; Biodiversity and Humans** | Humans propose solutions to correct changes in the physical environment. Some of these solutions work, and some do | Identify a human activity that negatively impacts another species. | Identify other species that have been significantly impacted by human activity (i.e., endangered or extinct species). | Use data (pictorial, graphical, or tabular) to determine the effectiveness of a strategy to protect a species. | Use data (pictorial, graphical, or tabular) to determine alternative ways for humans to continue an activity without |

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| | Changes in the physical environment have contributed to the expansion of some species, the emergence of new species as populations diverge, and the decline and sometimes the extinction of some species.<br>**DCI: Biodiversity and Humans**<br>Humans depend on the living world for the resources and other benefits provided by biodiversity. But human activity is also having adverse impacts on biodiversity through overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change.<br>**CCC: Cause and Effect**<br>Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. | not work. Some of the solutions may favor some species but harm others, sometimes leading to extinction. | | | | negatively affecting another species. |

## VT Alternate Science – NGSS High School

| Next Generation Science Standards | | Essence Statements | Achievement-Level Descriptors | | | |
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| PE | SEP / DCI / CCC | | Beginning | Approaching | Meets | Exceeds |
| **Earth Space Science ESS 1 Earth's Place in the Universe ❖ A. The Universe and Its Stars ❖ B. Earth and the Solar System ❖ C. The History of Planet Earth** | | | | | | |
| **HS-ESS1-1. Earth's Place in the Universe**<br>Develop a model based on evidence to illustrate the life span of 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. | **SEP: Developing and Using Models**<br>Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s).<br>Develop a model based on evidence to illustrate the relationships between systems or between components of a system.<br>**DCI: The Universe and Its Stars**<br>The star called the sun is changing and will burn out over a lifespan of approximately 10 billion years.<br>**DCI: Energy in Chemical Processes and Everyday Life**<br>Nuclear Fusion processes in the center of the sun release the energy that ultimately reaches Earth as radiation. (secondary)<br>**CCC: Scale, Proportion, and Quantity**<br>The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. | Energy from the sun reaches the Earth. | Recognize the sun as a source of energy in the solar system. | Recognize that energy from the sun reaches the Earth. | Use a model to show that the energy released from the sun's core warms the Earth and provides the surface of the Earth with light. | Explain how energy released from the sun's core warms the Earth and provides the surface of the Earth with light. |

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| **HS-ESS1-2. Earth's Place in the Universe** 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. | **SEP: Constructing Explanations and Designing Solutions**<br>Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.<br>Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.<br>**DCI: The Universe and Its Stars**<br>The study of stars' light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth.<br>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.<br>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.<br>**DCI: Electromagnetic Radiation**<br>Atoms of each element emit and absorb characteristic frequencies of light. These characteristics allow identification of the presence of an element, even in microscopic quantities. (secondary)<br>**CCC: Energy and Matter**<br>Energy cannot be created or destroyed–only moved between one place and another place, between objects and/or fields, or between systems. | The expansion of the universe from its origins can be explained in multiple ways, one of which is the motion of distant galaxies. | Identify that we live in a galaxy which is one of many galaxies in the universe. | List a tool or method scientists use to provide evidence that the universe is expanding. | Use evidence to explain that the motion of distant galaxies is one way we know that the universe is expanding from its origin. | Explain pictorial or graphical data representing the expansion of the universe from its origin based on the motion of distant galaxies. |
| **HS-ESS1-3. Earth's Place in the Universe** Communicate scientific ideas about the way stars, over their life cycle, produce elements. | **SEP: Obtaining, Evaluating, and Communicating Information**<br>Obtaining, evaluating, and communicating information in 9–12 builds on K–8 experiences and progresses to evaluating the validity and reliability of the claims, methods, and designs.<br>Communicate scientific ideas (e.g., about phenomena and/or the process of development and the design and Achievement of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).<br>**DCI: The Universe and Its Stars**<br>The study of stars' light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth. | Stars, throughout their life cycles, produce elements. | Differentiate stars from other celestial bodies (e.g., planets, moons, comets). | Identify the elements produced over the life cycle of a star. | Use a model to explain that stars produce elements (including hydrogen, helium, and iron) during their life cycles. | Use a model to explain that the elements stars produce during their life cycles get larger and heavier. |

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| | 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.<br><br>**CCC: Energy and Matter**<br>In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved. | | | | | |
| **HS-ESS1-4. Earth's Place in the Universe** Use mathematical or computational representations to predict the motion of orbiting objects in the solar system. | **SEP: Using Mathematics and Computational Thinking**<br>Mathematical and computational thinking in 9–12 builds on K–8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.<br>Use mathematical or computational representations of phenomena to describe explanations.<br><br>**DCI: Earth and the Solar System**<br>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.<br><br>**CCC: Scale, Proportion, and Quantity**<br>Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth). | Data can be used to predict the motion of orbiting objects in the solar system. | Identify objects that have orbits in the solar system. | Recognize that the moon is in orbit around Earth.<br>Recognize that Earth is in orbit around the sun. | Use data to predict the motion of an object in the solar system with a consistent orbit. | Use data to compare orbits in our solar system. |
| **HS-ESS1-5. Earth's Place in the Universe** 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. | **SEP: Engaging in Argument from Evidence**<br>Engaging in argument from evidence in 9–12 builds on K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science.<br>Evaluate evidence behind currently accepted explanations or solutions to determine the merits of arguments.<br><br>**DCI: The History of Planet Earth**<br>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.<br>**DCI: The History of Planet Earth** | The theory of plate tectonics and evidence from movements of continental and oceanic plates can be used to explain the ages of crustal rocks. | Recognize that Earth's crust is divided into tectonic plates. | Recognize that the tectonic plates move toward each other, move away from each other, or slide next to each other. | Explain that the youngest rocks are formed as tectonic plates move apart. | Use evidence to show the ages of crustal rocks near and far from a divergent boundary (e.g., rocks closest to the boundary are youngest). |

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| | 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. (ESS2.B Grade 8 GBE) (secondary)<br>**DCI: The History of Planet Earth**<br>Spontaneous radioactive decays follow a characteristic exponential decay law. Nuclear lifetimes allow radiometric dating to be used to determine the ages of rocks and other materials. (secondary)<br>**CCC: Patterns**<br>Empirical evidence is needed to identify patterns. | | | | | |
| **HS-ESS1-6. Earth's Place in the Universe**<br>Apply scientific reasoning and evidence from ancient Earth materials, meteorites, and other planetary surfaces to construct an account of Earth's formation and early history. | **SEP: Constructing Explanations and Designing Solutions**<br>Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.<br>Apply scientific reasoning to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion.<br>**DCI: The History of Planet Earth**<br>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.<br>**DCI: Nuclear Processes**<br>Spontaneous radioactive decays follow a characteristic exponential decay law. Nuclear lifetimes allow radiometric dating to be used to determine the ages of rocks and other materials. (secondary)<br>**CCC: Stability and Change**<br>Much of science deals with constructing explanations of how things change and how they remain stable. | Ancient Earth materials, lunar rocks, asteroids, and meteorites can be used as evidence to understand how the Earth formed. | Recognize that Earth is part of a solar system with planetary bodies. | Identify the similarities and differences between Earth and other orbiting bodies. (e.g., shape, size, orbit, moons) | Identify different pieces of information that could support Earth's early history. (e.g., asteroid craters on Earth and Mars) | Compare pieces of data that would support an explanation of Earth's early history and formation (e.g., plate subduction). |

| Earth Space Science ESS 2 Earth's Systems ❖ A. Earth Materials and Systems ❖ B. Plate Tectonics and Large-Scale System Interactions ❖ C. The Roles of Water in Earth's Surface Processes ❖ D. Weather and Climate ❖ E. Biogeology | | | | | | |
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| **HS-ESS2-1. Earth's Systems**<br>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. | **SEP: Developing and Using Models**<br>Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s).<br>Develop a model based on evidence to illustrate the relationships between systems or between components of a system.<br>**DCI: Earth Materials and Systems**<br>Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes.<br>**DCI: Plate Tectonics and Large-Scale System Interactions**<br>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.<br>**CCC: Stability and Change**<br>Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible. | Changes to Earth's continental and ocean-floor features are caused by Earth's internal and surface processes over time. | Identify surface processes that change Earth's features. | Identify both surface and internal processes that change Earth's features. | Use models to demonstrate the results of Earth's surface and internal processes (e.g., mountains, valleys, sea mounts, volcanoes). | Use a model to determine which of Earth's surface or internal process formed a specific feature. |
| **HS-ESS2-2. Earth's Systems**<br>Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems. | **SEP: Analyzing and Interpreting Data**<br>Analyzing data in 9–12 builds on K–8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data.<br>Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution.<br>**DCI: Earth Materials and Systems**<br>Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. | Earth's systems (geosphere, biosphere, atmosphere, and hydrosphere) are interconnected and changes to one will cause changes to others. | Identify a part of an Earth System (e.g., ocean in hydrosphere, plants in biosphere). | Identify two systems that are interacting with each other (e.g., weather, greenhouse effect). | Use data to show that a change in one system affected another. (e.g., removal of forests reduces sink of atmospheric carbon) | Predict a change that will occur in a system when a change happens to another system. |

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| | **DCI: Weather and Climate**<br><br>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 reradiation into space.<br><br>**CCC: Stability and Change**<br><br>Feedback (negative or positive) can stabilize or destabilize a system. | | | | | |
| **HS-ESS2-3. Earth's Systems**<br>Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection. | **SEP: Developing and Using Models**<br><br>Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s).<br><br>Develop a model based on evidence to illustrate the relationships between systems or between components of a system.<br><br>**DCI: Earth Materials and Systems**<br><br>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.<br><br>**DCI: Plate Tectonics and Large-Scale System Interactions**<br><br>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.<br><br>**CCC: Energy and Matter**<br><br>Energy drives the cycling of matter within and between systems. | Temperature and density changes in the interior of the Earth lead to the cycling of matter through thermal convection which causes the mantle and Earth's plates to move. | Identify the different layers of the Earth and their temperatures and densities. | Compare how temperature and density change as you move towards the center of the Earth (i.e., density and temperature increase overall toward the center of Earth). | Use a model of the Earth's interior to explain a convection current. | Describe how a convection current can drive the motion of the mantle and plates. |

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| **HS-ESS2-4. Earth's Systems**<br>Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate. | **SEP: Developing and Using Models**<br><br>Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s).<br><br>Use a model to provide mechanistic accounts of phenomena.<br><br>**DCI: Earth and the Solar System**<br><br>Cyclical changes in the shape of Earth's orbit around the sun, together with changes in the tilt of the planet's axis of rotation, both occurring over hundreds of thousands of years, have altered the intensity and distribution of sunlight falling on the earth. These phenomena cause a cycle of ice ages and other gradual climate changes. (secondary)<br><br>**DCI: Earth Materials and System**<br><br>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.<br><br>**DCI: Weather and Climate**<br><br>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 reradiation into space.<br><br>**CCC: Cause and Effect**<br><br>Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. | There are different causes of climate change, some slow (e.g., cyclic changes in the Earth's orbit around the Sun, tectonic activity) and some abrupt (e.g., volcanic ash clouds, human activities). | Recognize the differences between geographical climates (e.g., Minnesota versus Florida, desert versus rainforest). | Recognize climate changes have occurred (e.g., a change in average temperature, precipitation patterns, glacial ice volumes, sea levels). | Use a model to identify the different reasons that a climate can change. | Change a model to show how a climate would change if something in the environment changes (e.g., more atmospheric pollution is added, more sun is reflected back to the sky). |

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| **HS-ESS2-5. Earth's Systems**<br>Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes. | **SEP: Planning and Carrying Out Investigations**<br>Planning and carrying out investigations in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models.<br>Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.<br><br>**DCI: The Roles of Water in Earth's Surface Processes**<br>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.<br><br>**CCC: Structure and Function**<br>The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials. | Water affects Earth's materials and changes surface processes. | Identify the properties of water. | Identify the effect that water has on Earth's materials. | Use a model to explain how water changes Earth's materials and surface processes through erosion. | Use data to predict how water changes surface processes on Earth over time. |
| **HS-ESS2-6. Earth's Systems**<br>Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere. | **SEP: Developing and Using Models**<br>Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s).<br>Develop a model based on evidence to illustrate the relationships between systems or between components of a system.<br><br>**DCI: Weather and Climate**<br>Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen.<br>Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate. | Describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere. | Identify a cycle as a series of events that regularly repeats in the same order. | Identify a cycle that involves carbon. | Describe the cycling of carbon using a model. | Use data to describe changes in the amount of carbon in the atmosphere due to human activities. |

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| | **CCC: Energy and Matter**<br>The total amount of energy and matter in closed systems is conserved. | | | | | |
| **HS-ESS2-7. Earth's Systems**<br>Construct an argument based on evidence about the simultaneous coevolution of Earth's systems and life on Earth. | **SEP: Engaging in Argument from Evidence**<br>Engaging in argument from evidence in 9–12 builds on K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science.<br>Construct an oral and written argument or counter arguments based on data and evidence.<br><br>**DCI: Weather and Climate**<br>Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen.<br>**DCI: Biogeology**<br>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.<br><br>**CCC: Stability and Change**<br>Much of science deals with constructing explanations of how things change and how they remain stable. | Changes in Earth's systems and life on Earth occur simultaneously. | Identify Earth's systems (biosphere, hydrosphere, atmosphere, geosphere). | Identify cause and effect relationships between Earth's systems and life on Earth. | Explain how life on Earth changes as Earth's systems change. (Note: limit to common occurrences and simple cause/effect relationships.) | Predict how the biosphere will change as one of Earth's systems changes. |
| **Earth Space Science ESS 3 Earth and Human Activity A. Natural Resources B. Natural Hazards C. Human Impacts on Earth Systems D. Global Climate Change** | | | | | | |
| **HS-ESS3-1. Earth and Human Activity**<br>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. | **SEP: Constructing Explanations and Designing Solutions**<br>Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific knowledge, principles, and theories.<br>Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.<br><br>**DCI: Natural Resources**<br>Resource availability has guided the development of human society.<br>**DCI: Natural Hazards** | Human activity can be influenced by the availability of natural resources and occurrence of natural hazards. | Identify natural resources. | Recognize that a pattern exists between the availability of natural resources and human activity. | Describe how the availability of natural resources and/or the occurrence of natural hazards influence human activity. | Predict human activity based on the availability of natural resources and the occurrence of natural hazards. |

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| | 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.<br><br>**CCC: Cause and Effect**<br><br>Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. | | | | | |
| **HS-ESS3-2. Earth and Human Activity** Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios. | **SEP: Engaging in Argument from Evidence**<br><br>Engaging in argument from evidence in 9– 12 builds on K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about natural and designed world(s). Arguments may also come from current scientific or historical episodes in science.<br><br>Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and logical arguments regarding relevant factors (e.g., economic, societal, environmental, ethical considerations).<br><br>**DCI: Natural Resources**<br><br>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.<br><br>**DCI: Developing Possible Solutions**<br><br>When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. (secondary)<br><br>**CCC: N/A** | All types of resources have associated costs and considerations, including environmental, societal, economic and ethical risks and costs. | Identify a source of a natural resource (e.g., Decaying plants and animals is the source of natural gas and oil, the sun is the source for solar power). | Identify a human impact on the environment when utilizing a resource (e.g., mining for ore has an impact on environment, fishing may catch apex predators). | Identify a solution that would help manage resources that will reduce the human impact on the environment. | When given constraints, compare two solutions around managing resources and identify the best one that would reduce human impact. |
| **HS-ESS3-3. Earth and Human Activity** Create a computational simulation to illustrate the relationships among management of natural resources, | **SEP: Using Mathematics and Computational Thinking**<br><br>Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.<br>Create a computational model or simulation of a phenomenon, designed device, process, or system. | The sustainability of human societies and living resources that we use and need requires responsible management of natural resources. | Identify a natural resource. | Identify ways in which humans use living and natural resources. | Identify steps that can be taken to sustain human populations and living resources. | Use data to illustrate how the management of natural resources promotes the sustainability of human populations and |

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| the sustainability of human populations, and biodiversity. | **DCI: Human Impacts on Earth Systems**<br>The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources.<br>**CCC: Stability and Change**<br>Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible. | | | | | biodiversity. |
| **HS-ESS3-4. Earth and Human Activity**<br>Evaluate or refine a technological solution that reduces impacts of human activities on natural systems. * | **SEP: Constructing Explanations and Designing Solutions**<br>Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific knowledge, principles, and theories.<br>Design or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.<br>**DCI: Human Impacts on Earth Systems**<br>Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude ecosystem degradation.<br>**DCI: Developing Possible Solutions** | Technology can be used to reduce the impacts of human activities on natural systems. | Identify human actions that can affect natural systems. | Identify technologies that can reduce the effect of human activities on natural systems. | Predict how given technologies (e.g., recycling plants, devices to reduce emissions) will reduce the effect of human activities on natural systems based on a scenario. | Explain how technology (e.g., solar energy, wind turbines) can reduce the effect of human activities on natural systems. |

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| | When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. (secondary)<br><br>**CCC: Stability and Change**<br>Feedback (negative or positive) can stabilize or destabilize a system. | | | | | |
| **HS-ESS3-5. Earth and Human Activity**<br>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. | **SEP: Analyzing and Interpreting Data**<br>Analyzing data in 9–12 builds on K–8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data.<br>Analyze data using computational models in order to make valid and reliable scientific claims.<br>**SEP: Connections to Nature of Science: Scientific Investigations Use a Variety of Methods**<br>Science investigations use diverse methods and do not always use the same set of procedures to obtain data.<br>New technologies advance scientific knowledge.<br>**SEP: Scientific Knowledge is Based on Empirical Evidence**<br>Science knowledge is based on empirical evidence.<br>Science arguments are strengthened by multiple lines of evidence supporting a single explanation.<br><br>**DCI: Global Climate Change**<br>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.<br><br>**CCC: Stability and Change**<br>Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible. | Data and evidence forecast the current and future rates of global or regional change that impact Earth's systems. | Recognize patterns of change on Earth's systems. | Identify trends in climate data. | Predict environmental change based on current climate data. | Analyze data to explain the future rates of change in Earth's systems based on current trends. |
| **HS-ESS3-6. Earth and Human Activity**<br>Use a computational representation to illustrate the relationships among Earth systems and how those relationships are | **SEP: Using Mathematics and Computational Thinking**<br>Mathematical and computational thinking at the 9-12 level builds on K-8 and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.<br>Use mathematical representations of phenomena or design solutions to describe and/or support claims and/or explanations. | Illustrate the relationships among Earth's systems and how those relationships are influenced due to human activity. | Identify human activities that can influence Earth's systems. | Use simple data (graphical or pictorial) to show how human activities can influence Earth's systems over time. | Use a model to explain the influence of two or more human activities on Earth's systems. | Use a model or data to predict how a human activity might influence an Earth system. |

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| being modified due to human activity. | **DCI: Weather and Climate**<br>Current models predict that, although future regional climate changes will be complex and varied, average global temperatures will continue to rise. The outcomes predicted by global climate models strongly depend on the amounts of human-generated greenhouse gases added to the atmosphere each year and by the ways in which these gases are absorbed by the ocean and biosphere. (secondary)<br>**DCI: Global Climate Change**<br>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.<br><br>**CCC: Systems and System Models**<br>When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models. | | | | | |