PUBLIC COMMENT VERSION

With TRACKED CHANGES from December 2013 version

Massachusetts Science and Technology/Engineering Standards

Pre-Kindergarten to Grade 8 and Introductory High School Courses

Based on the *Next Generation Science Standards*

September 22, 2015 Draft

Table of Contents

Pre-Kindergarten

Pre-K: Earth and Space Sciences

PreK-ESS1. Earth's Place in the Universe
PreK-ESS1-1(MA). Demonstrate awareness that the moon can be seen in the daytime and at night, and of the different apparent shapes of the moon over a month. [Clarification Statement: The names of moon phases or sequencing of moon phases is not expected.]
PreK-ESS1-2(MA). Observe and use evidence to describe that the sun is in different places in the sky during the day.

PreK-ESS2. Earth's Systems
PreK-ESS2-1(MA). Raise questions and engage in discussions about how different types of local environments (including water) provide homes for different kinds of living things.
PreK-ESS2-2(MA). Observe and classify non-living materials, natural and human made, in their local environment.
PreK-ESS2-3(MA). Explore and describe different places water is found in the local environment.
PreK-ESS2-4(MA). Use simple instruments to collect and record data on elements of daily weather, including sun or clouds, wind, snow or rain, and higher or lower temperature.
PreK-ESS2-5(MA). Describe how local weather changes from day to day and over the seasons and recognize patterns in those changes. [Clarification Statement: Descriptions of the weather can include sunny, cloudy, rainy, warm, windy, and snowy.]
PreK-ESS2-6(MA). Provide examples of the impact of weather on living things. [Clarification statement: Make connections between the weather and what they wear and can do and the weather and the needs of plants and animals for water and shelter.]

PreK-ESS3. Earth and Human Activity
PreK-ESS3-1(MA). Engage in discussion and raise questions using examples about local resources (including soil and water) humans use to meet their needs.
PreK-ESS3-2(MA). Observe and discuss the impact of people's activities on the local environment.

PreK: Life Science

PreK-LS1 From Molecules to Organisms: Structures and Processes
PreK-LS1-1(MA). Compare, using descriptions and drawings, the external body parts of animals (including humans) and plants and explain functions of some of the observable body parts. [Clarification Statement: Examples can include comparison of humans having two legs and horses four, but both use legs to move.]
PreK-LS1-2(MA). Recognize that all plants and animals grow and change over time.
PreK-LS1-3(MA). Explain that most animals have five senses they use to gather information about the world around them.
PreK-LS1-4(MA). Use their five senses in their exploration and play to gather information.

PreK-LS2 Ecosystems: Interactions, Energy, and Dynamics
PreK-LS2-1(MA). Use evidence from animals and plants to define several characteristics of living things that distinguish them from non-living things.
PreK-LS2-2(MA). Using evidence from the local environment explain how familiar plants and animals meet their needs where they live. [Clarification Statement: Basic needs include water, food, air, shelter, and, for most plants, light. Examples of evidence can include squirrels gathering nuts for the winter and plants growing in the presence of sun and water. The local environment includes the area around the student's school, home, or adjacent community.]
PreK-LS2-3(MA). Give examples from the local environment of how animals and plants are dependent on one another to meet their basic needs.

PreK-LS3 Variation of Traits
PreK-LS3-1(MA). Use observations to explain that young plants and animals are like but not exactly like their parents. [Clarification Statement: Examples of observations include puppies that look

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similar but not exactly the same as their parents.]

PreK-LS3-2(MA). Use observations to recognize differences and similarities among themselves and their friends.

PreK: Physical Sciences

PreK-PS1. Matter and Its Interactions

PreK-PS1-1(MA). Raise questions and investigate the differences between liquids and solids and develop awareness that a liquid can become a solid and vice versa.

PreK-PS1-2(MA). Investigate natural and human-made objects to describe, compare, sort, and classify objects based on observable physical characteristics, uses, and whether something is manufactured or occurs in nature.

PreK-PS1-3(MA). Differentiate between the properties of an object and those of the material of which it is made.

PreK-PS1-4(MA). Recognize through investigation that physical objects and materials can change under different circumstances. [Clarification Statement: Changes include building up or breaking apart, mixing, dissolving, and changing state.]

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PreK-PS2. Motion and Stability: Forces and Interactions

PreK-PS2-1(MA). Using evidence, discuss ideas about what is making something move the way it does and how some movements can be controlled.

PreK-PS2-2(MA). Through experience, develop awareness of factors that influence whether things stand or fall. [Clarification Statement: Examples of factors in children's construction play include using a broad foundation when building, considering the strength of materials, and using balanced weight distribution in a block building.]

PreK-PS4. Waves and Their Applications in Technologies for Information Transfer

PreK-PS4-1(MA). Investigate sounds made by different objects and materials and discuss explanations about what is causing the sounds. Through play and investigations, identify ways to manipulate different objects and materials that make sound to change volume and pitch.

PreK-PS4-2(MA). Connect daily experience and investigations to demonstrate the relationships between the size and shape of shadows, the objects creating the shadow, and the light source.

Kindergarten

Kindergarten: Earth and Space Sciences

K-ESS2 Earth's Systems
K-ESS2-1. Use and share quantitative observations of local weather conditions to describe patterns over time. [Clarification Statements: Examples of quantitative observations could include numbers of sunny, windy, and rainy days in a month, and relative temperature. Quantitative observations should be limited to whole numbers.]
K-ESS2-2. Construct an argument supported by evidence for how plants and animals (including humans) can change the environment. [Clarification Statement: Examples of plants and animals changing their environment could include a squirrel digging holes in the ground and tree roots that break concrete.]

K-ESS3 Earth and Human Activity
K-ESS3-2. Obtain information about the purpose of weather forecasting to prepare for, and respond to, different types of local weather.
K-ESS3-3. Communicate solutions to reduce the amount of natural resources an individual uses.* [Clarification Statement: Examples of solutions could include reusing paper to reduce the number of trees cut down and recycling cans and bottles to reduce the amount of plastic or metal used.]
[Note: K-ESS3-1 from NGSS is not included.]

Kindergarten: Life Science

K-LS1 From Molecules to Organisms: Structures and Processes
K-LS1-1. Observe and communicate that animals (including humans) and plants need food, water, and air to survive. Animals get food from plants or other animals. Plants make their own food and need light to live and grow.
K-LS1-2(MA). Recognize that all plants and animals have a life cycle in which (a) most plants begin as seeds, develop and grow, make more seeds, and die, and (b) animals are born, develop and grow, produce young, and die.

Kindergarten: Physical Science

K-PS1 Matter and its Interactions
K-PS1-1(MA). Investigate and communicate the idea that different kinds of materials can be a solid or liquid depending on temperature. [Clarification Statements: Materials chosen must exhibit solid and liquid states in a reasonable temperature range for Kindergarten students (e.g., 0-80°F), such as water, crayons, or glue sticks. Only a qualitative description of temperature, such as hot, warm, and cool, is expected.]

K-PS2 Motion and Stability: Forces and interactions
K-PS2-1. Compare the effects of different strengths or different directions of pushes and pulls on the motion of an object. [Clarification Statement: Examples of pushes or pulls could include a string attached to an object being pulled, a person pushing an object, a person stopping a rolling ball, and two objects colliding and pushing on each other. Comparisons should be on different relative strengths or different directions, not both at the same time. Non-contact pushes or pulls such as those produced by magnets are not expected.]
[Note: K-PS2-2 from NGSS is not included.]

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K-PS3 Energy
K-PS3-1. Make observations to determine that sunlight warms materials on Earth's surface. [Clarification Statements: Examples of materials on Earth's surface could include sand, soil, rocks, and water. Measures of temperature should be limited to relative measures such as warmer/cooler.]
K-PS3-2. Use tools and materials to design and build a prototype of a structure that will reduce the warming effect of sunlight on an area.*

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Grade 1

Grade 1: Earth and Space Sciences

1-ESS1 Earth's Place in the Universe
1-ESS1-1. Use observations of the sun, moon, and stars to describe that each appears to rise in one part of the sky, appears to move across the sky, and appears to set.
1-ESS1-2. Analyze provided data to identify relationships among seasonal patterns of change, including sunrise and sunset time changes, seasonal temperature and rainfall or snowfall patterns, and seasonal changes to the environment. [Clarification Statement: Examples of seasonal changes to the environment can include foliage changes, bird migration, and differences in amount of insect activity.]

Grade 1: Life Science

1-LS1 From Molecules to Organisms: Structures and Processes
1-LS1-1. Use evidence to explain that (a) different animals use their body parts and senses in different ways to see, hear, grasp objects, protect themselves, move from place to place, and seek, find, and take in food, water, and air, and (b) plants have roots, stems, leaves, flowers, and fruits that are used to take in nutrients, water and air, produce food (sugar), and make new plants. [Clarification Statement: Descriptions are not expected to include mechanisms.]
1-LS1-2. Obtain information to compare ways in which the behavior of different animal parents and their offspring help the offspring to survive. [Clarification Statement: Examples of behaviors could include the signals that offspring make (such as crying, cheeping, and other vocalizations) and the responses of the parents (such as feeding, comforting, and protecting the offspring).]

1-LS3 Heredity: Inheritance and Variation of Traits
1-LS3-1. Use information from observations (first-hand and from media) to identify similarities and differences among individual plants or animals of the same kind. [Clarification Statements: Examples of observations could include leaves from the same kind of plant are the same shape but can differ in size. Inheritance, animals that undergo metamorphosis, or hybrids are not expected.]

Grade 1: Physical Science

1-PS4 Waves and their Applications in Technologies for Information Transfer
1-PS4-1. Demonstrate that vibrating materials can make sound and that sound can make materials vibrate. [Clarification Statement: Examples of vibrating materials that make sound could include tuning forks, a stretched string or rubber band, and a drum head. Examples of how sound can make materials vibrate could include holding a piece of paper near a speaker making sound and holding an object near a vibrating tuning fork.]
1-PS4-3. Conduct an investigation to determine the effect of placing materials that allow light to pass through them, allow only some light through them, block all the light, or redirect light when put in the path of a beam of light. [Clarification Statements: Effects can include some or all light passing through, creation of a shadow, and redirecting light. Quantitative measures are not expected.]
1-PS4-4. Use tools and materials to design and build a device that uses light or sound to send a signal over a distance.* [Clarification Statements: Examples of devices could include a light source to send signals, paper cup and string "telephones," and a pattern of drum beats. Technological details for how communication devices work are not expected.]
[Note: 1-PS4-2 from NGSS is not included.]

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Grade 1: Technology/Engineering

K-2-ETS1 Engineering Design
1.K-2-ETS1-1. Ask questions, make observations, and gather information about a situation people want to change in order to define a simple design problem that can be solved by developing or improving an object or tool.*
1.K-2-ETS1-2. Generate multiple solutions to a design problem and make a drawing (plan) to represent one or more of the solutions.*
[NOTE: K-2-ETS1-3 is found in Grade 2]

Grade 2

Grade 2: Earth and Space Sciences

2-ESS1 Earth's Place in the Universe
[Note: 2-ESS1-1 from NGSS is not included]

2-ESS2 Earth's Systems
2-ESS2-1. Compare the effectiveness of multiple solutions designed to slow or prevent wind or water from changing the shape of the land.* [Clarification Statement: Solutions to be compared could include different designs of dikes and windbreaks to hold back wind and water, and different designs for using shrubs, grass, and trees to hold back the land. Solutions can be generated or provided.] **2-ESS2-2. Map the shapes and types of landforms and bodies of water in an area.** [Clarification Statement: Examples of types of landforms can include hills, valleys, river banks, and dunes. Examples of water bodies can include streams, ponds, and rivers. Quantitative scaling in models is not expected.] **2-ESS2-3. Use examples obtained from informational sources to explain that water is found in the ocean, rivers and streams, lakes and ponds, and may be solid or liquid.** **2-ESS2-4(MA). Observe how blowing wind and flowing water can move Earth materials from one place to another and change the shape of a landform.** [Clarification Statement: Examples of types of landforms can include hills, valleys, river banks, and dunes.]

Grade 2: Life Science

2-LS2 Ecosystems: Interactions, Energy, and Dynamics
2-LS2-3(MA). Develop and use models to compare how plants and animals depend on their surroundings and other living things to meet their needs in the places they live. [Clarification Statement: Animals need food, water, air, shelter, and favorable temperature; plants need sufficient light, water, minerals, favorable temperature, and animals or other mechanisms to disperse seeds.] **[Note: 2-LS2-1 is included in other standards, including K-LS1-1 and 2-LS2-3(MA).]** **[Note: 2-LS2-2 from NGSS is not included.]**

2-LS4 Biological Evolution: Unity and Diversity
2-LS4-1. Use texts and media to compare (a) different kinds of living things in an area, and (b) differences in the kinds of living things living in different types of areas. [Clarification Statements: Examples of areas to compare can include temperate forest, desert, tropical rain forest, grassland, arctic, and aquatic. Specific animal and plant names in specific areas are not expected.]

Grade 2: Physical Science

2-PS1 Matter and its Interactions
2-PS1-1. Describe and classify different kinds of materials by observable properties of color, flexibility, hardness, texture, and absorbency. **2-PS1-2. Test different materials and analyze the data obtained to determine which materials have the properties that are best suited for an intended purpose.*** [Clarification Statements: Examples of properties could include, color, flexibility, hardness, texture, and absorbency. Data should focus on qualitative and relative observations.] **2-PS1-3. Analyze a variety of evidence to conclude that when a chunk of material is cut or broken into pieces, each piece is still the same material and, however small each piece is, has weight. Show that the material properties of a small set of pieces do not change when the pieces are used to build larger objects.** [Clarification Statement: Materials should be pure substances or microscopic mixtures that appear contiguous at observable scales. Examples of pieces could include blocks, building bricks, and other assorted small objects.] **2-PS1-4. Construct an argument with evidence that some changes to materials caused by heating or cooling can be reversed and some cannot.** [Clarification Statement: Examples of reversible changes could include materials such as water and butter at different temperatures. Examples of irreversible

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changes could include cooking an egg, freezing a plant leaf, and burning paper.]

2-PS3 Energy
2-PS3-1(MA). Design and conduct an experiment to show the effects of friction on the relative temperature and speed of objects that rub against each other. [Clarification Statements: Examples could include an object sliding on rough vs. smooth surfaces. Observations of temperature and speed should be qualitative.]

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Grade 2: Technology/Engineering

K-2-ETS1 Engineering Design
2.K-2-ETS1-3. Analyze data from tests of two objects designed to solve the same design problem to compare the strengths and weaknesses of how each object performs.*
[Note: K-2-ETS1-1 and K-2-ETS1-2 are found in Grade 1]

Grade 3

Grade 3: Earth and Space Sciences

3-ESS2 Earth's Systems
3-ESS2-1. Use graphs and tables of local weather data to describe and predict typical weather during a particular season in an area. [Clarification Statements: Examples of data could include average temperature, precipitation, wind direction, and wind speed. Graphical displays should focus on pictographs and bar graphs.] [State Assessment Boundary: Climate change is not expected in state assessment.]
3-ESS2-2. Obtain and summarize information about the climate of different regions of the world to illustrate that typical weather conditions over a year vary by region.

3-ESS3 Earth and Human Activity
3-ESS3-1. Evaluate the merit of a design solution that reduces the impacts of a weather-related hazard.* [Clarification Statement: Examples of design solutions to a weather-related hazard could include a barrier to prevent flooding, a wind-resistant roof, and a lightning rod.]

Grade 3: Life Science

3-LS1 From Molecules to Organisms: Structures and Processes
3-LS1-1. Use simple graphical representations to show that different types of organisms have unique and diverse life cycles. Describe that all organisms have birth, growth, reproduction, and death in common but there are a variety of ways in which these happen. [Clarification Statement: Examples can include different ways plants and animals are born (e.g., sprout from a seed, born from an egg), grow (e.g., increase in size and weight, produce new part), reproduce (e.g., develop seeds and spores, root runners, mate and lay eggs that hatch), and die (e.g., length of life). Plant life cycles should focus on those of flowering plants. Variation in organism life cycles should emphasize comparisons of the stages of each.] [State Assessment Boundary: Detailed descriptions of any one organism's cycle, the differences of "complete metamorphosis" and "incomplete metamorphosis", or details of human reproduction are not expected in state assessment.]

3-LS2 Ecosystems: Interactions, Energy, and Dynamics
[Note: 3-LS2-1 from NGSS is not included]

3-LS3 Heredity: Inheritance and Variation of Traits
3-LS3-1. Provide evidence, including through the analysis of data, that plants and animals have traits inherited from parents and that variation of these traits exist in a group of similar organisms. [Clarification Statement: Examples of inherited traits that vary can include the color of fur, shape of leaves, length of legs, and size of flowers. Focus should be on non-human examples.] [State Assessment Boundary: Genetic mechanisms of inheritance or prediction of traits are not expected in state assessment.]
3-LS3-2. Distinguish between inherited characteristics and those characteristics that result from a direct interaction with the environment. Give examples of characteristics of living organisms that are influenced by both inheritance and the environment. [Clarification Statement: Examples of the environment affecting a characteristic could include normally tall plants grown with insufficient water or light are stunted; a lizard missing a tail due to a predator; and, a pet dog that is given too much food and little exercise may become overweight. Focus should be on non-human examples.]

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3-LS4 Biological Evolution: Unity and Diversity
3-LS4-1. Use fossils to describe types of organisms and their environments that existed long ago and compare those to living organisms and their environments. Recognize that most kinds of plants and animals that once lived on Earth are no longer found anywhere. [Clarification Statement: Comparisons should focus on physical or observable features.] [State Assessment Boundary: Identification of specific fossils, identification of present plants and animals, dynamic processes, or genetics are not expected in state assessment.]
3-LS4-2. Use evidence to construct an explanation for how the variations in characteristics among individuals within the same species may provide advantages to these individuals in their survival and reproduction. [Clarification Statement: Examples can include rose bushes of the same species, one with slightly longer thorns than the other which may prevent its predation by deer; and, color variation within a species that may provide advantages so one organism may be more likely to survive and therefore more likely to leave offspring such as rock pocket mice. Examples of evidence could include needs and characteristics of the organisms and habitats involved.]
3-LS4-3. Construct an argument with evidence that in a particular environment some organisms can survive well, some survive less well, and some cannot survive. [Clarification Statement: Examples of evidence could include needs and characteristics of the organisms and habitats involved.]
3-LS4-4. Analyze and interpret data about changes in a habitat and describe how the changes may affect the ability of organisms that live in that habitat to survive and reproduce. [Clarification Statement: Changes should include changes to landforms, distribution of water, climate, and availability of resources. Changes in the habitat could range in time from a season to a decade. Data should be provided. While it is understood that ecological changes are complex the focus should be on a single change to the habitat.]
3-LS4-5(MA). Provide evidence to support a claim that the survival of a population is dependent upon reproduction. [State Assessment Boundary: Details of reproduction are not expected in state assessment.]

Grade 3: Physical Science

3-PS2 Motion and Stability: Forces and Interactions
3-PS2-1. Provide evidence to explain the effect of multiple forces, including friction, on an object. Include balanced forces that do not change the motion of the object and unbalanced forces that do change the motion of the object. [Clarification Statement: Descriptions of force magnitude should be qualitative and relative. Force due to gravity is appropriate but only as a force that pulls objects down.] [State Assessment Boundary: Quantitative force magnitude is not expected in state assessment. State assessment will be limited to one variable at a time: number, size, or direction of forces.]
3-PS2-3. Conduct an investigation to determine the nature of the forces between two magnets based on their orientations and distance relative to each other. [Clarification Statement: Focus should be on forces produced by magnetic objects that are easily manipulated.]
3-PS2-4. Define a simple design problem that can be solved by applying the use of the interactions between magnets.* [Clarification Statement: Examples of problems could include constructing a latch to keep a door shut and creating a device to keep two moving objects from touching each other.]
[Note: 3-PS2-2 from NGSS is not included.]

Grade 3: Technology/Engineering

3-5-ETS1 Engineering Design
3.3-5-ETS1-1. Define a simple design problem that reflects a need or a want. Include criteria for success and constraints on materials, time, or cost that a potential solution must meet.*
3.3-5-ETS1-2. Generate several possible solutions to a design problem. Compare each solution based on how well each is likely to meet the criteria and constraints of the design problem.*
3.3-5-ETS1-4(MA). Gather information using various informational resources on possible solutions to a design problem. Present different representations of a design solution. * [Clarification Statement: Examples of informational resources can include books, videos, and websites. Examples of representations can include graphic organizers, sketches, models, and prototypes.]
[Note: 3-5-ETS1-3 and 3-5-ETS1-5(MA) are found in Grade 4.]

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Grade 4

Grade 4: Earth and Space Sciences

4-ESS1 Earth's Place in the Universe
4-ESS1-1. Construct a claim with evidence that changes to a landscape due to erosion and deposition over long periods of time result in rock layers and landforms that can be interpreted today. Use evidence from a given landscape that includes simple landforms and rock layers to support a claim about the role of erosion or deposition in the formation of the landscape. [Clarification Statement: Examples of evidence and claims could include rock layers with shell fossils above rock layers with plant fossils and no shells, indicating a change from deposition on land to deposition in water over time; and, a canyon with rock layers in the walls and a river in the bottom, indicating that a river eroded the rock over time.] [State Assessment Boundaries: Specific details of the mechanisms of rock formation or specific rock formations and layers are not expected in state assessment. State assessment will be limited to relative time.]

4-ESS2 Earth's Systems
4-ESS2-1. Make observations and collect data to provide evidence that rocks, soils, and sediments are broken into smaller pieces through mechanical weathering and moved around through erosion by water, ice, wind, and vegetation. [Clarification Statement: Mechanical weathering can include frost wedging, abrasion, and tree root wedging. Erosion can include movement by blowing wind, flowing water, and moving ice.] [State Assessment Boundary: Chemical processes are not expected in state assessment.]
4-ESS2-2. Analyze and interpret maps of Earth's mountain ranges, deep ocean trenches, volcanoes, and earthquake epicenters to describe patterns of these features and their locations relative to boundaries between continents and oceans.

4-ESS3 Earth and Human Activity
4-ESS3-1. Obtain information to describe that energy and fuels humans use are derived from natural resources and that some energy and fuel sources are renewable and some are not. [Clarification Statements: Examples of renewable energy resources could include wind energy, water behind dams, and sunlight. Non-renewable energy resources are fossil fuels and nuclear materials.]
4-ESS3-2. Evaluate the design of a solution on its potential to reduce the impacts of an earthquake, flood, tsunami, or volcanic eruption on humans.* [Clarification Statement: Examples of solutions could include a proposal for an earthquake resistant building and improved monitoring of volcanic activity.]

Grade 4: Life Science

4-LS1From Molecules to Organisms: Structures and Processes
4-LS1-1. Construct an argument that animals and plants have internal and external structures that support their survival, growth, behavior, and reproduction. [Clarification Statement: External animal structures can include legs, wings, fins, feathers, trunks, claws, horns, and antennae. Animal organs can include eyes, ears, nose, heart, stomach, lung, brain, and skin. Plant structures can include leaves, roots, stems, bark, branches, and flowers.] [State Assessment Boundary: State assessment will be limited to macroscopic structures.] **[Note: 4-LS2-1 from NGSS is not included.]**

Grade 4: Physical Science

4-PS3 Energy
4-PS3-1. Use evidence to construct an explanation relating the speed of an object to the energy of that object. [State Assessment Boundary: Accounting for mass, quantitative measures of changes in the speed of an object, or any precise or quantitative definition of energy are not expected in state assessment.]
4-PS3-2. Make observations to show that energy can be transferred from place to place by sound,

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light, heat, and electric currents. [State Assessment Boundary: Quantitative measurements of energy are not expected in state assessment.]

4-PS3-3. Ask questions and predict outcomes about the changes in energy that occur when objects collide. [Clarification Statement: Changes in energy can include a change in the object's motion, position, and the generation of heat and/or sound.] [State Assessment Boundary: Analysis of forces or quantitative measurements of energy are not expected in state assessment.]

4-PS3-4. Apply scientific principles of energy and motion to test and refine a device that converts motion energy to electrical energy or uses stored energy to cause motion or produce light or sound.* [Clarification Statement: Sources of stored energy can include water in a bucket or a weight suspended at a height, and a battery.]

4-PS4 Waves and their Applications in Technologies for Information Transfer

4-PS4-1. Develop a model of a simple wave to communicate that waves (a) are regular patterns of motion along which energy travels, and (b) can differ in amplitude and wavelength. [Clarification Statement: Examples of models could include diagrams, analogies, and physical models using wire to illustrate wavelength and amplitude of waves. Focus is on mechanical waves (including sound).] [State Assessment Boundary: Interference effects, electromagnetic waves, non-periodic waves, or quantitative models of amplitude and wavelength are not expected in state assessment.]

4-PS4-2. Develop a model to describe that light must reflect off an object and enter the eye for the object to be seen. [State Assessment Boundary: Specific colors reflected and seen, the cellular mechanisms of vision, or how the retina works are not expected in state assessment.]

4-PS4-3. Develop and compare multiple ways to transfer information through encoding, sending, receiving, and decoding a pattern.* [Clarification Statement: Examples of solutions could include drums sending coded information through sound waves, using a grid of 1s and 0s representing black and white to send information about a picture, and using Morse code to send text.]

Grade 4: Technology/Engineering

Grade 4 3-5-ETS1 Engineering Design

4.3-5-ETS1-3. Plan and carry out tests of one or more elements of a model or prototype in which variables are controlled and failure points are considered to identify which elements need to be improved. Apply the results of tests to redesign a model or prototype.*

4.3-5-ETS1-5(MA). Evaluate relevant design features that must be considered in building a model or prototype of a solution to a given design problem.* [Clarification Statement: Examples of design features can include size, shape, and weight.]

[Note: 3-5-ETS1-1, 3-5-ETS1-2, and 3-5-ETS1-4(MA) are found in Grade 3.]

Grade 4 3-5-ETS3 Technological Systems

4.3-5-ETS3-1(MA). Recognize that technology is any modification of the natural or designed world done to fulfill human needs or wants. Use informational text to provide examples of modifications that are improvements to existing technologies and that are development of new technologies.*

4.3-5-ETS3-2(MA). Describe that technological products or devices are made up of parts. Use sketches or drawings to show how each part of a product or device relates to other parts in the product or device.*

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Grade 5

Grade 5: Earth and Space Sciences

5-ESS1 Earth's Place in the Universe
5-ESS1-1. Use observations, first-hand and from various media, to argue that the sun is a star that appears larger and brighter than other stars because it is closer to the Earth. [State Assessment Boundary: Other factors that affect apparent brightness (such as stellar masses, age, or stage) are not expected in state assessment.]
5-ESS1-2. Use a model to communicate Earth's relationship to the sun, moon, and stars that explain (a) why people on Earth experience day and night, (b) patterns in daily changes in length and direction of shadows over a day, and (c) changes in the apparent position of the sun, moon, and constellations at different times during a day, over a month, and over a year. [Clarification Statement: Any model used should illustrate that the Earth, sun, and moon are spheres; include orbits of the Earth around the sun and of the moon around Earth; and demonstrate Earth's rotation about its axis.] [State Assessment Boundary: Causes of lunar phases or seasons, or use of Earth's tilt are not expected in state assessment.]

5-ESS2 Earth's Systems
5-ESS2-1. Use a model to describe the cycling of water on Earth between the geosphere, biosphere, hydrosphere, and atmosphere through evaporation, precipitation, absorption, surface runoff, condensation, and transpiration. [State Assessment Boundary: Explanations of mechanisms that drive the cycle are not expected in state assessment.]
5-ESS2-2. Describe and graph the amounts and percentages of salt water in the ocean; fresh water in lakes, rivers, and ground water; and fresh water frozen in glaciers and polar ice caps to provide evidence about the availability of fresh water in Earth's biosphere. [Clarification Statement: Nearly all of Earth's available water is in the ocean; most fresh water is in glaciers or underground.] [State Assessment Boundary: Inclusion of the atmosphere is not expected in state assessment.]

5-ESS3 Earth and Human Activity
5-ESS3-1. Obtain and combine information about ways communities reduce the impact on the Earth's resources and environment by changing an agricultural, industrial, or community practice or process. [Clarification Statement: Examples of changed practices or processes include treating sewage, reducing the amounts of materials used, capturing polluting emissions from factories or power plants, and preventing runoff from agricultural activities.] [State Assessment Boundary: Social science aspects of practices such as regulation or policy are not expected in state assessment.]
5-ESS3-2(MA). Test a simple system designed to filter an impurity out of water and propose one change to the design to improve it.* [Clarification Statement: Examples of impurities could include particulates and bacteria.]

Grade 5: Life Science

5-LS1 From Molecules to Organisms: Structures and Processes
5-LS1-1. Ask testable questions about the process by which plants get the materials they need for growth and reproduction chiefly through their use of air, water, and energy from the sun to produce sugars and plant materials . [State Assessment Boundary: The chemical formula or details about the process of photosynthesis are not expected in state assessment.]

5-LS2 Ecosystems: Interactions, Energy, and Dynamics
5-LS2-1. Develop a model to describe the movement of matter among producers, consumers, decomposers, and the air and soil in the environment (a) show that plants produce sugars and plant materials, (b) show that animals can eat plants and/or other animals for food, and (c) show that some organisms, including fungi and bacteria, break down dead organisms and recycle some materials back to the air and soil. [Clarification Statement: Emphasis is on matter moving throughout the ecosystem.] [State Assessment Boundary: Molecular explanations, or distinctions among primary, secondary, and tertiary consumers are not expected in state assessment.]

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5-LS2-2(MA). Compare at least two designs for a composter to determine which is most likely to encourage decomposition of materials.* [Clarification Statement: Measures or evidence of decomposition should be on qualitative descriptions or comparisons.]

Grade 5: Physical Science

5-PS1 Matter and Its Interactions
5-PS1-1. Use a model of matter as made of particles too small to be seen to explain common phenomena involving gasses, and phase changes between gas and liquid and between liquid and solid. [Clarification Statement: Examples of common phenomena the model should be able to describe include adding air to expand a balloon, compressing air in a syringe, and evaporating water from a salt water solution.] [State Assessment Boundary: Atomic-scale mechanisms of evaporation and condensation or defining the unseen particles are not expected in state assessment.]
5-PS1-2. Measure and graph the weights of substances before and after a reaction or phase change to provide evidence that regardless of the type of change that occurs when heating, cooling, or combining substances, the total weight of matter is conserved. [Clarification Statement: Assume that reactions with any gas production are conducted in a closed system.] [State Assessment Boundary: Distinguishing mass and weight is not expected in state assessment.]
5-PS1-3. Make observations and measurements of substances to describe characteristic properties of each, including color, hardness, reflectivity, electrical conductivity, thermal conductivity, response to magnetic forces, and solubility. [Clarification Statement: Emphasis is on describing how each substance has a unique set of properties. Examples of substances could include baking soda and other powders, metals, minerals, and liquids.] [State Assessment Boundary: Density, distinguishing mass and weight, or specific tests or procedures are not expected in state assessment.]
5-PS1-4. Conduct an experiment to determine whether the mixing of two or more substances results in new substances with new properties.

5-PS2 Motion and Stability: Forces and Interactions
5-PS2-1. Support an argument with evidence that the gravitational force exerted by Earth on objects is directed toward the Earth's center. [State Assessment Boundary: Mathematical representations of gravitational force are not expected in state assessment.]

5-PS3 Energy
5-PS3-1. Use a model to describe that the food animals digest (a) contains energy that was once energy from the sun, and (b) provides energy and materials for body repair, growth, motion, body warmth, and reproduction. [Clarification Statement: Examples of models could include diagrams and flow charts.] [State Assessment Boundary: Details of photosynthesis or respiration are not expected in state assessment.]

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Comment [j6]: Dissolving is not appropriate for grade 5, and liquid-solid phase change was missing.

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Comment [j7]: Emphasis was on identifying substances, which is not the point. Edited to make the point that substances have unique sets of properties (which can be used to identify them).

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Grade 6

Grade 6: Earth and Space Sciences

Grade 6 MS-ESS1 Earth's Place in the Universe
6.**MS-ESS1-1a. Develop and use a model of the Earth-sun-moon system to explain the causes of lunar phases and eclipses of the sun and moon.** [Clarification Statement: Examples of models can be physical, graphical, or conceptual and should emphasize relative positions and distances.]
6.**MS-ESS1-4. Analyze and interpret rock layers and index fossils to determine the relative ages of rock formations. Use informational text to explain that these sources of evidence, along with radiometric dating, are used to construct the geologic time scale of Earth's history.** [Clarification Statement: Analysis includes Laws of Superposition and Crosscutting Relationships limited to minor displacement faults that offset layers. Not all organisms are fossilized.] [State Assessment Boundary: Strata sequences that have been reordered or overturned, names of specific periods or epochs and events within them, or specifics of radiometric dating are not expected in state assessment.]
6.**MS-ESS1-5(MA). Use graphical displays to illustrate that the Earth and its solar system are part of the Milky Way galaxy, which is one of billions of galaxies in the universe.** [Clarification Statement: Graphical displays can include maps, charts, graphs, and data tables.]
[Note: MS-ESS1-1b and MS-ESS1-2 are found in Grade 8. MS-ESS1-3 and MS-ESS1-6 from NGSS are not included.]

Grade 6 MS-ESS2 Earth's Systems
6.**MS-ESS2-3. Analyze and interpret maps showing the distribution of fossils and rocks, continental shapes, and seafloor structures to provide evidence that Earth's plates have moved great distances, collided, and spread apart.** [Clarification Statement: Maps may show similarities of rock and fossil types on different continents, the shapes of the continents (including continental shelves), and the locations of ocean structures (such as ridges, fracture zones, and trenches).] [State Assessment Boundary: Mechanisms for plate motion or paleomagnetic anomalies in oceanic and continental crust are not expected in state assessment.]
[Note: MS-ESS2-2 and MS-ESS2-4 are found in Grade 7. MS-ESS2-1, MS-ESS2-5, and MS-ESS2-6 are found in Grade 8.]

Grade 6: Life Science

Grade 6 MS-LS1 From Molecules to Organisms: Structures and Processes
6.**MS-LS1-1. Provide evidence that organisms (unicellular and multicellular) are made of cells.** [Clarification Statement: Evidence can be drawn from multiple types of organisms, such as plants, animals, and bacteria.]
6.**MS-LS1-2. Develop and use a model to describe how parts of cells contribute to the cellular functions of obtaining nutrients and water from its environment, disposing of waste, and producing energy.** [Clarification Statement: Emphasis of functions is on basic survival needs. Parts of cells include (a) the nucleus which regulates a cell's activities, (b) chloroplasts are the site of photosynthesis which produces necessary glucose and oxygen, (c) mitochondria are the site of cellular respiration (energy released from food), (d) vacuoles store materials, including water, nutrients, and waste, (e) the cell membrane is a selective barrier that enables nutrients to enter the cell and wastes to be expelled, and (f) the cell wall provides structural support to some types of cells.] [State Assessment Boundary: Specific biochemical steps or chemical processes, ATP, active transport through the cell membrane, or identifying or comparing different types of cells are not expected in state assessment.]
[Note: MS-LS1-3, MS-LS1-4, MS-LS1-5, and MS-LS1-7 are found in Grade 7. MS-LS1-6 and MS-LS1-8 from NGSS are not included.]

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Grade 6 MS-LS4 Biological Evolution: Unity and Diversity
6.MS-LS4-1. Analyze and interpret evidence from the fossil record to infer patterns of environmental change resulting in extinction and changes to life forms throughout the history of the Earth. [Clarification Statement: Examples of evidence include sets of fossils that indicate a specific type of environment, anatomical structures that indicate the function of an organism in the environment, and fossilized tracks that indicate behavior of organisms.] [State Assessment Boundary: Names of individual species, geological eras in the fossil record, or mechanisms for extinction or speciation are not expected in state assessment.] **6.MS-LS4-2. Construct an argument using anatomical structures to support evolutionary relationships among and between fossil organisms and modern organisms.** [Clarification Statement: Evolutionary relationships include (a) some organisms have similar traits with similar functions because they were inherited from a common ancestor, (b) some organisms have similar traits that serve similar functions because they live in similar environments, and (c) some organisms have traits inherited from common ancestors that no longer serve their original function because their environments are different than their ancestors' environments.] **[Note: MS-LS4-4 and MS-LS4-5 are found in Grade 8. MS-LS4-3 and MS-LS4-6 from NGSS are not included.]**

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Comment [j9]: Moved this list to CS so they did not obscure the point of the standard. Maintained it as an inclusive list (i.e.).

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Grade 6: Physical Science

Grade 6 MS-PS1 Matter and Its Interactions
6.MS-PS1-6. Plan and conduct an experiment involving exothermic and endothermic chemical reactions to measure and describe the release or absorption of thermal energy. [Clarification Statement: Emphasis is on describing transfer of energy to and from the environment. Examples of chemical reactions could include dissolving ammonium chloride or calcium chloride.] **6.MS-PS1-7(MA). Use a particulate model of matter to explain that density is the amount of matter (mass) in a given volume. Apply proportional reasoning to describe, calculate, and compare relative densities of different materials.** **6.MS-PS1-8(MA). Conduct an experiment to show that many materials are mixtures of pure substances that can be separated into their component pure substances.** [Clarification Statement: Examples of common mixtures include salt water, oil and vinegar, milk, concrete, and air.] **[Note: MS-PS1-1, MS-PS1-2, MS-PS1-4, MS-PS1-5, and MS-PS1-9(MA) are found in Grade 8. MS-PS1-3 from NGSS is not included.]**

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Comment [j10]: Changed focus – rate and concentration is not the appropriate idea for gr. 6 (that is in HS-PS1-5 + 1-6).

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Comment [j11]: Changed to put this in the application context rather than just calculating density.

Deleted: Measure the mass and volume of regular and irregular shaped objects and calculate their density

Grade 6 MS-PS2 Motion and Stability: Forces and Interactions
6.MS-PS2-4. Use evidence to support the claim that gravitational forces between objects are attractive and are only noticeable when one or both of the objects have a very large mass. [Clarification Statement: Examples of objects with very large masses include the Earth, Sun, and other planets.] [State Assessment Boundary: Newton's Law of Gravitation or Kepler's Laws are not expected in state assessment.] **[Note: MS-PS2-3 and MS-PS2-5 are found in Grade 7. MS-PS2-1 and MS-PS2-2 are found in Grade 8.]**

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Grade 6 MS-PS4 Waves and Their Applications in Technologies for Information Transfer
6.MS-PS4-1. Use diagrams of a simple wave to explain that a wave has a repeating pattern with a specific amplitude, frequency, and wavelength. [State Assessment Boundary: Electromagnetic waves are not expected in state assessment. State assessment will be limited to standard repeating waves.]
6.MS-PS4-2. Use diagrams and other models to show that both light rays and mechanical waves are reflected, absorbed, or transmitted through various materials. [Clarification Statement: Materials may include solids, liquids, and gasses. Mechanical waves (including sound) need a material (medium) through which they are transmitted. Examples of models could include drawings, simulations, and written descriptions.] [State Assessment Boundary: State assessment will be limited to qualitative applications.]
6.MS-PS4-3. Present qualitative scientific and technical information to support the claim that digitized signals (sent as wave pulses representing 0s and 1s) can be used to encode and transmit information. [State Assessment Boundary: Binary counting or the specific mechanism of any given device are not expected in state assessment.]

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Grade 6: Technology/Engineering

Grade 6 MS-ETS1 Engineering Design
6.MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution. Include potential impacts on people and the natural environment that may limit possible solutions.*
6.MS-ETS1-5(MA). Create visual representations of solutions to a design problem. Accurately interpret and apply scale and proportion to visual representations.* [Clarification Statements: Examples of visual representations can include sketches, scaled drawings, and orthographic projections. Examples of scale can include ¼" = 1'0" and 1 cm = 1 m.]
6.MS-ETS1-6(MA). Communicate a design solution to an intended user, including design features and limitations of the solution. [Clarification Statement: Examples of intended users can include students, parents, teachers, manufacturing personnel, engineers, and customers.]
[Note: MS-ETS1-2, MS-ETS1-4, and MS-ETS1-7(MA) are found in Grade 7. MS-ETS1-3 from NGSS is not included.]

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Grade 6 MS-ETS2 Materials, Tools, and Manufacturing
6.MS-ETS2-1(MA). Analyze and compare properties of metals, plastics, wood, and ceramics, including flexibility, ductility, hardness, thermal conductivity, electrical conductivity, and melting point.
6.MS-ETS2-2(MA). Given a design task, select appropriate materials based on specific properties needed in the construction of a solution. [Clarification Statement: Examples of materials can include metals, plastics, wood, and ceramics.]
6.MS-ETS2-3(MA). Choose and safely use appropriate measuring tools, hand tools, fasteners, and common power tools used to construct a prototype.* [Clarification Statement: Examples of measuring tools include a tape measure, a meter stick, and a ruler. Examples of hand tools include a hammer, a screwdriver, a wrench, and pliers. Examples of fasteners include nails, screws, nuts and bolts, staples, glue, and tape. Examples of common power tools include jig saw, drill, and sander.]
[Note: MS-ETS2-4(MA), MS-ETS2-5(MA), and MS-ETS2-6(MA) are found in Grade 8.]

Comment [j12]: Adjusted properties to be consistent across standards.

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Comment [j13]: Deleted MS-ETS2-4(MA) as it was too broad and disconnected from any progression. Did not add substantively to what students need for success in middle school or high school.

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Grade 7

Grade 7: Earth and Space Sciences

Grade 7 MS-ESS2 Earth's Systems

7.MS-ESS2-2. Construct an explanation based on evidence for how Earth's surface has changed over scales that range from microscopic to global in size. [Clarification Statement: Examples of processes occurring over large spatial scales include plate motion and ice ages. Examples of changes occurring over small spatial scales include earthquakes and seasonal weathering and erosion.]

7.MS-ESS2-4. Develop a model to explain how the energy of the sun and Earth's gravity drive the cycling of water, including changes of state, as it moves through multiple pathways in Earth's hydrosphere. [Clarification Statement: Examples of models can be conceptual or physical.] [State Assessment Boundary: A quantitative understanding of the latent heats of vaporization and fusion is not expected in state assessment.]

[Note: MS-ESS2-3 is found in Grade 6. MS-ESS2-1, MS-ESS2-5, and MS-ESS2-6 are found in Grade 8.]

Grade 7 MS-ESS3 Earth and Human Activity

7.MS-ESS3-1. Analyze and interpret data to explain that the Earth's mineral and fossil fuel resources are unevenly distributed as a result of geologic processes. [Clarification Statement: Examples of uneven distributions of resources can include petroleum (locations of the burial of organic marine sediments and subsequent geologic traps), and metal ores (locations of past volcanic and hydrothermal activity associated with subduction zones).]

7.MS-ESS3-2. Obtain and communicate information on how data from past geologic events are analyzed for patterns and used to forecast the location and likelihood of future catastrophic events. [Clarification Statement: Geologic events include earthquakes, volcanic eruptions, floods, and landslides. Examples of data typically analyzed can include the locations, magnitudes, and frequencies of the natural hazards.] [State Assessment Boundary: Analysis of data or forecasting is not expected in state assessment.]

7.MS-ESS3-4. Construct an argument supported by evidence that human activities and technologies can be engineered to mitigate the negative impact of increases in human population and per capita consumption of natural resources on the environment. [Clarification Statement: Arguments should be based on examining historical data such as population graphs, natural resource distribution maps, and water quality studies over time. Examples of negative impacts can include changes to the amount and quality of natural resources such as water, mineral, and energy supplies.]

[Note: MS-ESS3-5 is found in Grade 8. MS-ESS3-3 from NGSS has been merged with MS-ESS3-4.]

Grade 7: Life Science

Grade 7 MS-LS1 From Molecules to Organisms: Structures and Processes

7.MS-LS1-3. Construct an argument supported by evidence that the body systems interact to carry out essential functions of life. Identify examples of where different types of cells work together to form specialized tissues, which in turn join to form organs which work together to form the body systems. [Clarification Statement: Emphasis is on the function and interactions of the body systems, not specific body parts or organs. Body systems to be included are the circulatory, digestive, respiratory, excretory, muscular/skeletal, and nervous systems. Essential functions of life include obtaining nutrients, energy, water, and oxygen; removing wastes; responding to stimuli; maintaining internal conditions; and, growing. An example of interacting systems could include an artery depending on the proper function of elastic tissue and smooth muscle to deliver the proper amount of blood within the circulatory system.] [State Assessment Boundary: The mechanism of one body system independent of others, comparing different types of cells, tissues or organs, or biochemical processes involved in body systems are not expected in state assessment.]

7.MS-LS1-4. Explain, based on evidence, how characteristic animal behaviors as well as how animals interact with specialized plant structures increase the probability of successful reproduction of animals and plants respectively. [Clarification Statement: Examples of animal behaviors that affect the probability of animal reproduction could include nest building to protect young from cold,

Comment [j14]: Standard was too broad as written; other standards include different time scales (e.g., MS-ESS1-4; 4-ESS2-1 + 2-2…) so this aspect was somewhat redundant. Focused this standard then on spatial scales.

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Comment [j15]: Removed groundwater to make the standard more focused and because there are other standards about the distribution of water on the Earth.

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Comment [j18]: Moved list of functions down to CS to ensure emphasis on key idea in standard.

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Comment [j19]: Added additional AB components to specify what is not expected.

herding of animals to protect young from predators, and vocalization of animals and colorful plumage to attract mates for breeding. Examples of animal behaviors that affect the probability of plant reproduction could include transferring pollen or seeds; and, creating conditions for seed germination and growth. Examples of plant structures that affect the probability of plant reproduction could include bright flowers attracting butterflies that transfer pollen, flower nectar, and odors that attract insects that transfer pollen, and hard shells on nuts that squirrels bury.] [State Assessment Boundary: Natural selection is not expected in state assessment.]

[Note: MS-LS1-1 and MS-LS1-2 are found in Grade 6. MS-LS1-5 and MS-LS1-7 are found in Grade 8. MS-LS1-6 and MS-LS1-8 from NGSS are not included.]

Grade 7 MS-LS2 Ecosystems: Interactions, Energy, and Dynamics
7.MS-LS2-1. Analyze and interpret data to provide evidence for the effects of periods of abundant and scarce resources on the growth of organisms and the number of organisms (size of populations) in an ecosystem.
7.MS-LS2-2. Describe how relationships among and between organisms in an ecosystem can be competitive, predatory, parasitic, and mutually beneficial and that these interactions are found across multiple ecosystems. [Clarification Statement: Emphasis is on describing consistent patterns of interactions in different ecosystems in terms of relationships among and between organisms.]
7.MS-LS2-3. Develop a model to describe the cycling of matter among living and nonliving parts of an ecosystem including the role of photosynthesis and decomposition. [Clarification Statement: Emphasis is on a general understanding of cycling of matter in an ecosystem.] [State Assessment Boundary: Cycling of specific atoms (such as carbon or oxygen), or the biochemical steps of photosynthesis and decomposition are not expected in state assessment.]
7.MS-LS2-4. Analyze data to provide evidence that disruptions (natural or human-made) to any physical or biological component of an ecosystem can lead to shifts in all its populations. [Clarification Statement: Focus should be on ecosystems characteristics varying over time, including disruptions such as hurricanes, floods, wildfires, oil spills, and construction.]
7.MS-LS2-5. Evaluate competing design solutions for protecting an ecosystem. Discuss benefits and limitations of each design.* [Clarification Statement: Examples of design solutions could include water, land, and species protection, and the prevention of soil erosion. Examples of design solution constraints could include scientific, economic, and social considerations.]
7.MS-LS2-6(MA). Explain how changes to the biodiversity of an ecosystem—the variety of species found in the ecosystem—may limit the availability of resources humans use. [Clarification Statement: Examples of resources can include food, energy, medicine, and clean water.]
7.MS-LS2-7(MA). Construct a model of a food web to explain that energy is transferred among producers, primary, secondary, and tertiary consumers, and decomposers as they interact within an ecosystem. [Clarification Statement: The food web should illustrate sunlight as a primary source of energy for the ecosystem.]

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Comment [j20]: CS added additional scope that is not necessary here, and is a better fit in High School (HS-LS2-4).

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Grade 7: Physical Science

Grade 7 MS-PS2 Motion and Stability: Forces and Interactions

7.MS-PS2-3. Analyze data to describe the effect of distance and magnitude of electric charge on the size of electric forces. [Clarification Statement: Includes both attractive and repulsive forces.] [State Assessment Boundary: State assessment will be limited to proportional reasoning.]

7.MS-PS2-5. Use scientific evidence to argue that fields exist between objects with mass, between magnetic objects, and between electrically charged objects that exert force on each other even though the objects are not in contact. [Clarification Statement: Emphasis is on evidence that demonstrates the existence of fields, limited to gravitational, electric, and magnetic fields.] [State Assessment Boundary: Calculations of force are not expected in state assessment.]

[Note: MS-PS2-4 is found in Grade 6. MS-PS2-1 and MS-PS2-2 are found in Grade 8.]

Grade 7 MS-PS3 Energy

7.MS-PS3-1. Construct and interpret data and graphs to describe the relationships among kinetic energy, mass, and speed of an object. [Clarification Statements: Examples could include riding a bicycle at different speeds and rolling different size rocks downhill. Consider relationships between kinetic energy vs. mass and kinetic energy vs. speed separate from each other.]

7.MS-PS3-2. Develop a model to describe the relationship between the relative position of objects interacting at a distance and their relative potential energy in the system. [Clarification Statement: Examples of objects within systems interacting at varying distances could include the Earth and either a roller coaster cart at varying positions on a hill or objects at varying heights on shelves; changing the direction/orientation of a magnet; and, a balloon with static electrical charge being brought closer to a stream of water. Examples of models could include representations, diagrams, pictures, and written descriptions of systems.] [State Assessment Boundary: State assessment will be limited to two objects and electric, magnetic, and gravitational interactions. Calculations of potential energy are not expected in state assessment.]

7.MS-PS3-3. Apply scientific principles of energy and heat transfer to design, construct, and test a device to minimize or maximize thermal energy transfer.* [Clarification Statement: Examples of devices could include an insulated box, a solar cooker, and a Styrofoam cup.] [State Assessment Boundary: Accounting for specific heat or calculations of the total amount of thermal energy transferred are not expected in state assessment.]

7.MS-PS3-4. Conduct an investigation to determine the relationships among the energy transferred, how well the type of matter retains or radiates heat, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample. [State Assessment Boundary: Calculations of specific heat or the total amount of thermal energy transferred are not expected in state assessment.]

7.MS-PS3-5. Present evidence to support the claim that when the motion energy of an object changes, energy is transferred to or from the object. [Clarification Statement: Examples of empirical evidence could include an inventory or other representation of the energy before and after the transfer in the form of temperature changes or motion of an object.] [State Assessment Boundary: Calculations of energy are not expected in state assessment.]

7.MS-PS3-6(MA). Use a model to explain how thermal energy is transferred out of hotter regions or objects and into colder ones by convection, conduction, and radiation.

7.MS-PS3-7(MA). Use informational text to describe the relationship between kinetic and potential energy and illustrate conversions from one form to another. [Clarification Statement: Types of kinetic energy include motion, sound, thermal and light; types of potential energy include gravitational, elastic, and chemical.]

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Grade 7: Technology/Engineering

Grade 7 MS-ETS1 Engineering Design
7.MS-ETS1-2. Evaluate competing solutions to a given design problem using a systematic process to determine how well each meets the criteria and constraints of the problem. Use a model of each solution to evaluate how variations in one or more design features, including size, shape, weight, or cost, may affect the function or effectiveness of the solution.*
7.MS-ETS1-4. Generate and analyze data from iterative testing and modification of a proposed object, tool, or process to optimize the object, tool, or process for its intended purpose.*
7.MS-ETS1-7(MA). Construct a prototype of a solution to a given design problem.*
[Note: MS-ETS1-1, MS-ETS1-5(MA), and MS-ETS1-6(MA) are found in Grade 6. MS-ETS1-3 from NGSS is not included.]

Grade 7 MS-ETS3 Technological Systems
7.MS-ETS3-1(MA). Explain the function of a communication system and the role of its components, including a source, encoder, transmitter, receiver, decoder, and storage.
7.MS-ETS3-2(MA). Compare the benefits and drawbacks of four different communication systems: radio, television, print, and internet. [Clarification Statement: Examples can include speed of communication, distance or range, number of people reached, audio only vs. audio and visual, and one-way vs. two-way communication.]
7.MS-ETS3-3(MA). Research and communicate information about how transportation systems are designed to move people and goods using a variety of vehicles and devices. Identify and describe subsystems of a transportation vehicle, including structural, propulsion, guidance, suspension, and control subsystems. [Clarification Statement: Examples of design elements include vehicle shape and cargo or passenger capacity, terminals, travel lanes, and communications/controls. Examples of vehicles can include a car, sailboat, and small airplane.]
7.MS-ETS3-4(MA). Show how the components of a structural system work together to serve a structural function or maintain an environment for a particular human use. Provide examples of physical structures and relate their design to their intended use. [Clarification Statement: Examples of uses include carrying loads and forces across a span (such as a bridge), providing livable space (such as a house or office building), and providing specific environmental conditions (such as a greenhouse or cold storage). Examples of components of a structural system could include foundation, decking, wall, roofing, inputs (such as heat or AC), and feedback mechanisms.]
7.MA-ETS3-5(MA). Use the concept of systems engineering to model inputs, processes, outputs, and feedback among components of a transportation, structural, or communication system.

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Grade 8

Grade 8: Earth and Space Sciences

Grade 8 MS-ESS1 Earth's Place in the Universe

8.**MS-ESS1-1b. Develop and use a model of the Earth-sun system to explain the cyclical pattern of seasons, which includes the Earth's tilt and differential intensity of sunlight on different areas of Earth across the year.** [Clarification Statement: Examples of models can be physical, graphical, or conceptual.]

8.**MS-ESS1-2. Explain the role of gravity in ocean tides, the orbital motions of planets, their moons, and asteroids in the solar system.** [State Assessment Boundary: Kepler's Laws of orbital motion or the apparent retrograde motion of the planets as viewed from Earth are not expected in state assessment.]

[Note: MS-ESS1-1a, MS-ESS1-4, and MS-ESS1-5 are found in Grade 6. MS-ESS1-3 and MS-ESS1-6 from NGSS are not included.]

Grade 8 MS-ESS2 Earth's Systems

8.**MS-ESS2-1. Use a model to illustrate that energy from the Earth's interior drives convection which cycles Earth's crust leading to melting, crystallization, weathering, and deformation of large rock formations, including generation of ocean sea floor at ridges, submergence of ocean sea floor at trenches, mountain building, and active volcanic chains.** [Clarification Statement: The emphasis is on large-scale cycling resulting from plate tectonics that includes changes in rock types through weathering, erosion, heat, and pressure.] [State Assessment Boundary: Specific mechanisms of plate tectonics, the identification and naming of minerals or rock types, or specifics of the "rock cycle" are not expected in state assessment.]

8.**MS-ESS2-5. Interpret basic weather data to identify patterns in air mass interactions and the relationship of those patterns to weather.** [Clarification Statement: Data includes temperature, pressure, humidity, precipitation, and wind. Examples of patterns can include air masses flow from regions of high pressure to low pressure, and how sudden changes in weather can result when different air masses collide. Data can be provided to students (such as weather maps, diagrams, and visualizations) or obtained through field observations or laboratory experiments.] [State Assessment Boundary: Specific names of cloud types, weather symbols used on weather maps, or the reported diagrams from weather stations are not expected in state assessment.]

8.**MS-ESS2-6. Describe how interactions involving the ocean affect weather and climate on a regional scale, including the influence of the ocean temperature as mediated by energy input from the sun and energy loss due to evaporation or redistribution via ocean currents.** [Clarification Statement: A regional scale includes a state or multi-state perspective.] [State Assessment Boundary: Koppen Climate Classification names are not expected in state assessment.]

[Note: MS-ESS2-3 is found in Grade 6. MS-ESS2-2 and MS-ESS2-4 are found in Grade 7.]

Grade 8 MS-ESS3 Earth and Human Activity

8.**MS-ESS3-5. Examine and interpret data to describe the role that human activities have played in causing the rise in global temperatures over the past century.** [Clarification Statements: Examples of human activities include fossil fuel combustion, cement production, and agricultural activity. Examples of evidence can include tables, graphs, and maps of global and regional temperatures; atmospheric levels of gases such as carbon dioxide and methane; and, the rates of human activities.]

[Note: MS-ESS3-1, MS-ESS3-2, and MS-ESS3-4 are found in Grade 7. MS-ESS3-3 from NGSS has been merged with MS-ESS3-4.]

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Comment [j22]: Removed emphasis statement as it had a global perspective, rather than a regional perspective as in the standard, so was misaligned and too broad.

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Grade 8: Life Science

Grade 8 MS-LS1 From Molecules to Organisms: Structures and Processes
8.MS-LS1-5. Construct an argument based on evidence for how environmental and genetic factors influence the growth of organisms. [Clarification Statement: Examples of local environmental conditions could include availability of food, light, space, and water. Examples of genetic factors could include the genes responsible for size differences in different breeds of dogs, such as Great Danes and Chihuahuas. Examples of environmental factors could include drought decreasing plant growth, fertilizer increasing plant growth, and fish growing larger in large ponds than they do in small ponds. Examples of both genetic and environmental factors could include different varieties of plants growing at different rates in different conditions.] [State Assessment Boundary: Methods of reproduction, genetic mechanisms, gene regulation, biochemical processes, or natural selection are not expected in state assessment.]
8.MS-LS1-7. Use informational text to describe that food molecules, including carbohydrates, proteins, and fats, are broken down and rearranged through chemical reactions forming new molecules that support cell growth and/or release of energy. [State Assessment Boundary: Details of the chemical reactions for respiration, biochemical steps of breaking down food, or the resulting molecules (e.g., carbohydrates are broken down into monosaccharides) are not expected in state assessment.]
[Note: MS-LS1-1 and MS-LS1-2 are found in Grade 6. MS-LS1-3 and MS-LS1-4 are found in Grade 7. MS-LS1-6 and MS-LS1-8 from NGSS are not included.]

Grade 8 MS-LS3 Heredity: Inheritance and Variation of Traits
8.MS-LS3-1. Develop and use a model to describe that structural changes to genes (mutations) may or may not result in changes to proteins, and if there are changes to proteins there may be harmful, beneficial, or neutral changes to traits. [Clarification Statement: An example of a beneficial change to the organism may be a strain of bacteria becoming resistant to an antibiotic. A harmful change could be the development of cancer; a neutral change may change the hair color of an organism with no direct consequence.] [State Assessment Boundary: Specific changes at the molecular level (e.g., amino acid sequence change), mechanisms for protein synthesis, or specific types of mutations are not expected in state assessment.]
8.MS-LS3-2. Construct an argument based on evidence for how asexual reproduction results in offspring with identical genetic information and sexual reproduction results in offspring with genetic variation. Compare and contrast advantages and disadvantages of asexual and sexual reproduction. [Clarification Statement: Examples of an advantage of sexual reproduction can include genetic variation when the environment changes or a disease is introduced, while examples of an advantage of asexual reproduction can include not using energy to find a mate and fast reproduction rates. Examples of a disadvantage of sexual reproduction can include using resources to find a mate, while a disadvantage in asexual reproduction can be the lack of genetic variation when the environment changes or a disease is introduced.]
8.MS-LS3-3(MA). Communicate through writing and in diagrams that chromosomes contain many distinct genes and that each gene holds the instructions for the production of specific proteins, which in turn affects the traits of an individual. [State Assessment Boundary: Specific changes at the molecular level or mechanisms for protein synthesis are not expected in state assessment.]
8.MS-LS3-4(MA). Develop and use a model to show that sexually reproducing organisms have two of each chromosome in their nucleus, and hence two variants (alleles) of each gene that can be the same or different from each other, with each chromosome acquired at random from both parents. [Clarification Statement: Examples of models can include Punnett squares, diagrams, and simulations. Focus should be on dominant-recessive pattern of inheritance.]

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Comment [j23]: Modeling fits better with 8.MS-LS3-4 below.

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Grade 8 MS-LS4 Biological Evolution: Unity and Diversity
8.MS-LS4-4. Use a model to describe the process of natural selection, in which genetic variations of some traits in a population increase some individuals' likelihood of surviving and reproducing in a changing environment. Provide evidence that natural selection occurs over many generations. [Clarification Statement: The model should include simple probability statements and proportional reasoning.] [State Assessment Boundary: Specific conditions that lead to natural selection are not expected in state assessment.] **8.MS-LS4-5. Synthesize and communicate information about artificial selection, or the ways in which humans have changed the inheritance of desired traits in organisms.** [Clarification Statement: Emphasis is on the influence of humans on genetic outcomes in artificial selection (such as genetic modification, animal husbandry, and gene therapy).] **[Note: MS-LS4-1 and MS-LS4-2 are found in Grade 6. MS-LS4-3 and MS-LS4-6 from NGSS are not included.]**

Grade 8: Physical Science

Grade 8 MS-PS1 Matter and Its Interactions
8.MS-PS1-1. Develop a model to describe that (a) atoms combine in a multitude of ways to produce pure substances which make up all of the living and nonliving things that we encounter, (b) atoms form molecules and compounds that range in size from two to thousands of atoms, and (c) mixtures are composed of different proportions of pure substances. [Clarification Statement: Examples of molecular-level models could include drawings, 3D ball and stick structures, and computer representations showing different molecules with different types of atoms.] [State Assessment Boundary: Valence electrons and bonding energy, the ionic nature of subunits of complex structures, complete depictions of all individual atoms in a complex molecule or extended structure, or calculations of proportions in mixtures are not expected in state assessment.] **8.MS-PS1-2. Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.** [Clarification Statements: Examples of reactions could include burning sugar or steel wool, fat reacting with sodium hydroxide, and mixing zinc with HCl. Properties of substances include density, melting point, boiling point, solubility, flammability, and odor.] **8.MS-PS1-4. Develop a model that describes and predicts changes in particle motion, relative spatial arrangement, temperature, and state of a pure substance when thermal energy is added or removed.** [Clarification Statement: Emphasis is on qualitative molecular-level models of solids, liquids, and gases to show that adding or removing thermal energy increases or decreases kinetic energy of the particles until a change of state occurs. Examples of models could include drawings and diagrams. Examples of pure substances could include water, carbon dioxide, and helium.] **8.MS-PS1-5. Use a model to explain that substances are rearranged during a chemical reaction to form new molecules with new properties. Explain that the atoms present in the reactants are all present in the products and thus the total number of atoms is conserved.** [Clarification Statement: Examples of models can include physical models or drawings, including digital forms, that represent atoms.] [State Assessment Boundary: Use of atomic masses, molecular weights, balancing symbolic equations, or intermolecular forces are not expected in state assessment.] **[Note: MS-PS1-6, MS-PS1-7(MA), and MS-PS1-8(MA) are found in Grade 6. MS-PS1-3 from NGSS is not included.]**

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Comment [j24]: Moved key idea of MS-PS1-9(MA) to MS-PS1-1; it was not necessary to have two standards on the same idea.

Moved up [2]: that: a. substances are composed of molecules, compounds or atoms; and b. atoms form molecules or compounds that range in size from two to thousands of atoms

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Grade 8 MS-PS2 Motion and Stability: Forces and Interactions
8.MS-PS2-1. Develop a model that demonstrates Newton's third law involving the motion of two colliding objects. [State Assessment Boundary: State assessment will be limited to vertical or horizontal interactions in one dimension.]
8.MS-PS2-2. Provide evidence that the change in an object's motion depends on the sum of the forces on the object (the net force) and the mass of the object. [Clarification Statement: Emphasis is on balanced (Newton's First Law) and unbalanced forces in a system, qualitative comparisons of forces, mass, and changes in motion (Newton's Second Law) in one dimension.] [State Assessment Boundary: State assessment will be limited to forces and changes in motion in one dimension in an inertial reference frame and to change in one variable at a time. The use of trigonometry is not expected in state assessment.]
[Note: MS-PS2-4 is found in Grade 6. MS-PS2-3 and MS-PS3-5 are found in Grade 6.]

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Grade 8: Technology/Engineering

Grade 8 MS-ETS2 Materials, Tools, and Manufacturing
8.MS-ETS2-4(MA). Use informational text to illustrate that materials maintain their composition under various kinds of physical processing; however, some material properties may change if a process changes the particulate structure of a material. [Clarification Statements: Examples of physical processing can include cutting, forming, extruding, and sanding. Examples of changes in material properties can include a non-magnetic iron material becoming magnetic after hammering and a plastic material becoming rigid (less elastic) after heat treatment.]
8.MS-ETS2-5(MA). Present information that illustrates how a product can be created using basic processes in manufacturing systems, including forming, separating, conditioning, assembling, finishing, quality control, and safety.
8.MS-ETS2-6(MA). Compare and contrast processes that transform materials into products that are controlled by humans and by computers. [Clarification Statement: Computer-aided processes can include use of robotic systems and automated manufacturing.]
[Note: MS-ETS2-1(MA), MS-ETS2-2(MA), and MS-ETS2-3(MA) are found in Grade 6.]

Grade 8 MS-ETS4 Energy and Power Technologies
8.MS-ETS4-1(MA). Explain how a machine converts energy, through mechanical means, to do work.

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High School (Grade 9 or 10)

Earth and Space Science

Earth and Space Science HS-PS1 Matter and Its Interactions
HS-PS1-8. Develop a model to illustrate the changes in the composition of the nucleus of the atom and the energy released or absorbed during the processes of fission, fusion, and radioactive decay. [Clarification Statement: Examples of models include simple qualitative models, such as pictures or diagrams. Types of radioactive decays include alpha, beta, and gamma.] [State Assessment Boundary: Quantitative calculations of energy released or absorbed are not expected in state assessment.] **[Note: HS-PS1-1, HS-PS1-2, HS-PS1-3, HS-PS1-4, HS-PS1-5, HS-PS1-6, and HS-PS1-7 are found in Chemistry.]**

Earth and Space Science HS-ESS1 Earth's Place in the Universe
HS-ESS1-1. Use informational text to explain that the life span of the sun over approximately 10 billion years is a function of nuclear fusion in its core. [State Assessment Boundary: Specific stages of the life of a star are not expected in state assessment.] **HS-ESS1-2. Describe the astronomical evidence for the Big Bang theory, including the red shift of light from the motion of distant galaxies as an indication that the universe is currently expanding, the cosmic microwave background as the remnant radiation from the Big Bang, and the observed composition of ordinary matter of the universe, primarily found in stars and interstellar gases, which matches that predicted by the Big Bang theory (3/4 hydrogen and 1/4 helium).** **HS-ESS1-3. Communicate that stars, through nuclear fusion over their life cycle, produce elements from helium to iron and release energy that eventually reaches Earth in the form of radiation.** [State Assessment Boundary: Details of the many different nucleosynthesis pathways for stars of differing masses are not expected in state assessment.] **HS-ESS1-4. Use Kepler's Laws to predict the motion of orbiting objects in the solar system. Describe how orbits may change due to the gravitational effects from, or collisions with, other objects in the solar system.** [Clarification Statement: Kepler's Laws apply to human-made satellites as well as planets, moons, and other objects. Calculations involving Kepler's Laws of orbital motions should not deal with more than two bodies, nor involve calculus.] **HS-ESS1-5. Evaluate evidence of the past and current movements of continental and oceanic crust, the theory of plate tectonics, and relative densities of oceanic and continental rocks to explain why continental rocks are generally much older than rocks of the ocean floor.** [Clarification Statement: Examples include the ages of oceanic crust (less than 200 million years old) increasing with distance from mid-ocean ridges (a result of plate spreading) and the ages of North American continental crust (which can be older than 4 billion years) increasing with distance away from a central ancient core (a result of past plate interactions).] **[Note: HS-ESS1-6 from NGSS is not included.]**

Earth and Space Science HS-ESS2 Earth's Systems
HS-ESS2-2. Analyze geoscience data to make the claim that one change to Earth's hydrosphere can create feedbacks that cause changes to other Earth systems. [Clarification Statement: Examples can include how decreasing the amount of glacial ice reduces the amount of sunlight reflected from Earth's surface, increasing surface temperatures and further reducing the amount of ice; how the loss of ground vegetation causes an increase in water runoff and soil erosion; how dammed rivers increase groundwater recharge, decrease sediment transport, and increase coastal erosion; and, how the loss of wetlands causes a decrease in local humidity that further reduces the wetland extent.] **HS-ESS2-3. Use a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection.** [Clarification Statement: Emphasis is on both a two-dimensional model of Earth, with radial layers determined by density, and a three-dimensional model, which is controlled by mantle convection and the resulting plate tectonics. Examples of evidence include maps of Earth's three-dimensional structure obtained from seismic waves, records of the rate of change of Earth's magnetic field (as constraints on convection in the outer core), and identification of the composition of Earth's

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Comment [j25]: Added to keep focus on the concept, not listing steps or stages.

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Comment [j26]: Moved 1-7 down to 2-4 as a second performance. They are directly related.

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Moved down [3]: Analyze and interpret data to explain that long-term changes in Earth's tilt and orbit result in cycles of climate change such as Ice Ages.

Comment [j27]: Changed to a focus on the hydrosphere to make the standard more focused and less broad.

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layers from high-pressure laboratory experiments.]

HS-ESS2-4. Use a model to describe how variations in the flow of energy into and out of Earth's systems over different time scales result in changes in climate. Analyze and interpret data to explain that long-term changes in Earth's tilt and orbit result in cycles of climate change such as Ice Ages. [Clarification Statement: Examples of the causes of climate change differ by timescale: large volcanic eruption and ocean circulation over 1-10 years; changes in human activity, ocean circulation, and solar output over 10-100s of years; changes to Earth's orbit and the orientation of its axis over 10-100s of thousands of years; long-term changes in atmospheric composition over and 10-100s of millions of years.] [State Assessment Boundary: Results of changes in climate will be limited to changes in surface temperatures, precipitation patterns, glacial ice volumes, sea levels, and biosphere distribution.]

HS-ESS2-5. Describe how the chemical and physical properties of water are important in mechanical and chemical mechanisms that affect Earth materials and surface processes. [Clarification Statement: Examples of mechanical mechanisms involving water include stream transportation and deposition, erosion using variations in soil moisture content, and frost wedging by the expansion of water as it freezes. Examples of chemical mechanisms involving water include chemical weathering and recrystallization (based on solubility of different materials) and melt generation (based on water lowering the melting temperature of most solids).]

HS-ESS2-6. Use a model to describe cycling of carbon through the ocean, atmosphere, soil, and biosphere and how increases in carbon dioxide concentrations due to human activity has resulted in gradual atmospheric and climate changes.

[Note: HS-ESS2-1 has been merged with MS-ESS2-1. HS-ESS2-7 from NGSS is not included.]

Earth and Space Science HS-ESS3 Earth and Human Activity

HS-ESS3-1. Construct an explanation based on evidence for how the availability of key natural resources and changes due to variations in climate have influenced human activity. [Clarification Statement: Examples of key natural resources include access to fresh water (such as rivers, lakes, and groundwater), regions of fertile soils (such as river deltas), high concentrations of minerals and fossil fuels, and biotic resources (such as fisheries and forests). Examples of changes due to variations in climate include changes to sea level and regional patterns of temperature and precipitation.]

HS-ESS3-2. Evaluate competing design solutions for minimizing impacts of developing and using energy and mineral resources, and conserving and recycling those resources, based on economic, social, and environmental cost-benefit ratios.* [Clarification Statement: Examples include developing best practices for agricultural soil use, mining (for metals, coal, tar sands, and oil shales), and pumping (for petroleum and natural gas).]

HS-ESS3-3. Illustrate relationships among management of natural resources, the sustainability of human populations, and biodiversity. [Clarification Statement: Examples of factors related to the management of natural resources include costs of resource extraction and waste management, per capita consumption, and the development of new technologies. Examples of factors related to human sustainability include agricultural efficiency, levels of conservation, and urban planning. Examples of factors related to biodiversity include habitat use and fragmentation, and land and resource conservation.]

HS-ESS3-5. Analyze results from global climate models to describe how forecasts are made of the current rate of global or regional climate change and associated future impacts to Earth systems. [Clarification Statement: Climate model outputs include both climate changes (such as precipitation and temperature) and associated impacts (such as on sea level, glacial ice volumes, and atmosphere and ocean composition).]

[Note: HS-ESS3-4 and HS-ESS3-6 from NGSS is not included.]

Comment [j28]: Moved this performance from 1-7 above as it directly relates to 2-4.

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Comment [j29]: Reworded for clarity.

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High School (Grade 9 or 10)

Biology

Biology HS-LS1 From Molecules to Organisms: Structures and Processes
HS-LS1-1. Use informational text to explain that genes are regions in the DNA that code for proteins that regulate and carry out essential functions of life. Construct a model of transcription and translation to explain the roles of DNA and RNA in coding for amino acids, which make up proteins. [Clarification Statement: Proteins that regulate and carry out the essential functions of life include enzymes (speed up chemical reactions), structural proteins (provide structure and enable movement), hormones and receptors (send and receive signals), and antibodies (help fight disease). The model should demonstrate that an individual's characteristics (phenotype) result, in part, from complex relationships among the various proteins (and RNAs) expressed by one or more genes (genotype).] [State Assessment Boundary: Specific names of proteins or specific steps of transcription and translation are not expected in state assessment.]
HS-LS1-2. Develop and use a model to illustrate the key functions of animal body systems, including nutrient uptake and transport through the body, exchange of oxygen and carbon dioxide, removal of waste, organism movement in response to neural stimuli, and coordination of body functions. [Clarification Statement: Emphasis is on the primary function of each animal body system, including circulatory, excretory, digestive, respiratory, muscular/skeletal, endocrine, and nervous systems. Major organs include the lungs, diaphragm, stomach, intestines, heart, arteries/veins, kidneys, liver, pancreas, brain, spinal cord, bones, and muscles.] [State Assessment Boundary: Interactions and functions at the molecular or chemical reaction level, or the identification of specific proteins in cells are not expected in state assessment.]
HS-LS1-3. Provide evidence that feedback mechanisms promote (through positive feedback) or inhibit (through negative feedback) activities within an organism to maintain homeostasis. [Clarification Statement: Examples could include heart rate response to exercise and recovery, insulin production and inhibition in response to blood sugar levels, stomate response to moisture and temperature, and root development in response to water levels.] [State Assessment Boundary: Sub-cellular processes involved in particular feedback mechanisms (for example, how stomata are stimulated to open or close) or interactions at the molecular level (for example, how insulin is produced) are not expected in state assessment.]
HS-LS1-4. Construct an explanation using evidence for why the cell cycle is necessary for the growth, maintenance, and repair of multicellular organisms. Model the major events of the cell cycle, including cell growth, DNA replication, preparation for division, separation of chromosomes, and separation of cell contents. [State Assessment Boundary: Specific gene control mechanisms or specific details of each event (e.g., steps of mitosis) are not expected in state assessment.]
HS-LS1-5. Use a model to illustrate how photosynthesis uses light energy to transform water and carbon dioxide into oxygen and chemical energy stored in the bonds of glucose and other carbohydrates. [Clarification Statement: Emphasis is on illustrating inputs and outputs of matter (including ATP) and the transfer and transformation of energy in photosynthesis by plants and other photosynthesizing organisms. Examples of models could include diagrams, chemical equations, and conceptual models.] [State Assessment Boundary: Specific biochemical steps of light reactions or the Calvin Cycle, or chemical structures of molecules are not expected in state assessment.]
HS-LS1-6. Construct an explanation based on evidence that organic molecules are primarily composed of six elements, where carbon, hydrogen, and oxygen atoms may combine with nitrogen, sulfur, and phosphorus to form monomers that can further combine to form large carbon-based macromolecules. [Clarification Statement: Monomers include amino acids, mono- and disaccharides, nucleotides, and fatty acids. Organic macromolecules include proteins, carbohydrates (polysaccharides), nucleic acids, and lipids.] [State Assessment Boundary: Details of the specific chemical reactions or identification of specific macromolecule structures are not expected in state assessment.]
HS-LS1-7. Use a model to illustrate that aerobic cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and new bonds form resulting in new compounds and a net transfer of energy. [Clarification Statement: Emphasis is on the conceptual understanding of the inputs and outputs of the process of aerobic cellular respiration. Examples of models could include diagrams, chemical equations, and conceptual models. The model should include the role of ATP for energy transfer in this process. Food molecules include sugars

Comment [JF30]: Edited first statement to consolidate with last statement, reducing the length while keeping the content.

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Comment [JF32]: Split this standard into two (other part moved to 7.MS-LS1-3) as it was trying to accomplish too much. This standard focuses on body systems (in alignment with NGSS) and 7.MS-LS1-3 focuses on the hierarchical components.

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(carbohydrates), fats (lipids), and proteins.] [State Assessment Boundary: Identification of the steps or specific processes involved in cellular respiration are not expected in state assessment.]

HS-LS1-8(MA). Research and communicate information about features of virus and bacteria reproduction and adaptation to explain their ability to survive in a wide variety of environments. [Clarification Statement: Key features include rate of mutations and the speed of reproduction which produces many generations in a short time, allowing for rapid adaptation.]

Biology HS-LS2 Ecosystems: Interactions, Energy, and Dynamics
HS-LS2-1. Analyze data sets to support explanations that biotic and abiotic factors affect ecosystem carrying capacity. [Clarification Statement: Examples of biotic factors could include relationships among individuals (e.g., feeding relationships, symbioses, competition) and disease. Examples of abiotic factors could include climate and weather conditions, natural disasters, and availability of resources. Example data sets can be derived from simulations or historical data.]
HS-LS2-2. Use mathematical representations to support explanations that biotic and abiotic factors affect biodiversity, including genetic diversity within a population and species diversity within an ecosystem. [Clarification Statement: Examples of biotic factors could include relationships among individuals (e.g., feeding relationships, symbioses, competition) and disease. Examples of abiotic factors could include climate and weather conditions, natural disasters, and availability of resources. Examples of mathematical representations include finding the average, determining trends, and using graphical comparisons of multiple sets of data.]
HS-LS2-3. Construct and revise an argument based on evidence that the processes of photosynthesis, aerobic respiration, and anaerobic respiration are responsible for the cycling of matter and flow of energy through an ecosystem. Explain that atoms, including elements of carbon, oxygen, hydrogen, and nitrogen, are conserved even as matter is broken down, recombined, and recycled by organisms in ecosystems. [State Assessment Boundary: The specific steps involved in photosynthesis, aerobic respiration, or anaerobic respiration are not expected in state assessment.]
HS-LS2-4. Use a mathematical model to describe the transfer of energy from one trophic level to another. Explain how the inefficiency of energy transfer between trophic levels affects the relative number of organisms that can be supported at each trophic level and necessitates a constant input of energy from sunlight or inorganic compounds from the environment. [Clarification Statement: The model should illustrate the "10% rule" of energy transfer and show approximate amounts of available energy at each trophic level in an ecosystem (up to five trophic levels.)]
HS-LS2-5. Use a model that illustrates the roles of photosynthesis, cellular respiration, decomposition, and combustion to explain the cycling of carbon in its various forms among the biosphere, atmosphere, hydrosphere, and geosphere. [Clarification Statement: The primary forms of carbon include carbon dioxide, hydrocarbons, waste (dead organic matter), and biomass (organic materials of living organisms). Examples of models could include simulations and mathematical models.] [State Assessment Boundary: The specific chemical steps of photosynthesis, respiration, decomposition, and combustion are not expected in state assessment.]
HS-LS2-6. Analyze data to show that in stable conditions the dynamic interactions within an ecosystem tend to maintain relatively consistent numbers and types of organisms even when small changes in conditions occur but that extreme fluctuations in conditions may result in a new ecosystem. Construct an argument with evidence that ecosystems with greater biodiversity tend to have greater resistance and resilience to change. [Clarification Statement: Examples of changes in ecosystem conditions could include modest biological or physical changes, such as moderate hunting or a seasonal flood; and, extreme changes, such as volcanic eruption, fires, climate changes, ocean acidification, or sea level rise.]
HS-LS2-7. Analyze direct and indirect effects of human activities on biodiversity and ecosystem health, specifically habitat fragmentation, introduction of non-native or invasive species, overharvesting, pollution, and climate change. Evaluate and refine a solution for reducing the impacts of human activities on biodiversity and ecosystem health.* [Clarification Statement: Examples of solutions can include captive breeding programs, habitat restoration, pollution mitigation, energy conservation, and ecotourism.]
[Note: HS-LS2-8 from NGSS is not included.]

Biology HS-LS3 Heredity: Inheritance and Variation of Traits
HS-LS3-1. Ask questions to clarify relationships about how DNA in the form of chromosomes is passed

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Comment [j33]: Cut standard on DNA shape as not critical for core idea and to reduce overall scope of course.

Deleted: Explain how the structure of DNA, including its spiral shape and paired nucleotides, is related to its function of storing and transmitting hereditary information. ¶ HS-LS1-9(MA).

Comment [j34]: Only included one feature in original version.

Deleted: [Assessment Boundary: Assessment is limited to provided data.]

Comment [JF35]: Changed to argument practice to be consistent across standards. Removed 2nd statement to make the standard more manageable; too big with additional expectation included.

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from parents to offspring through the processes of meiosis and fertilization in sexual reproduction. [State Assessment Boundary: Specific phases of meiosis or the biochemical mechanism of specific steps in the process are not expected in state assessment.]

HS-LS3-2. Make and defend a claim based on evidence that inheritable genetic variations may result from (a) new genetic combinations through meiosis, (b) mutations that occur during replication, and/or (c) mutations caused by environmental factors. Recognize that in general, only mutations that occur in gametes can be passed to offspring. [Clarification Statement: New genetic combinations through meiosis occur via the processes of crossing over and random segregation of chromosomes.] [State Assessment Boundary: Specific phases of meiosis or identification of specific types of mutations are not expected in state assessment.]

HS-LS3-3. Use scientific information to illustrate that genetic traits of individuals or genetic factors of a population interact with environmental factors to determine the variation and distribution of expressed traits in a population. [Clarification Statement: An example of the role of the environment in expressed traits in an individual can include the likelihood of developing inherited diseases (i.e., heart disease, cancer) in relation to exposure to environmental toxins and lifestyle; an example in populations can include the maintenance of the allele for sickle-cell anemia in high frequency in malaria-effected regions of the globe, such as Africa, because it confers partial resistance to malaria.] [State Assessment Boundary: Hardy-Weinberg calculations are not expected in state assessment.]

Biology HS-LS4 Biological Evolution: Unity and Diversity

HS-LS4-1. Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence, including molecular, anatomical, and developmental similarities inherited from a common ancestor (homologies), seen through fossils and documented laboratory and field observations.

HS-LS4-2. Construct an explanation based on evidence that the process of evolution by natural selection occurs in a population when the following conditions are met: (a) more offspring are produced than can be supported by the environment, (b) there is heritable variation among individuals, and (c) some of these variations lead to differential fitness among individuals as some individuals are better able to compete for limited resources than others. [Clarification Statement: Emphasis is on the overall result of an increase in the proportion of those individuals with advantageous heritable traits that are better able to survive and reproduce in the environment.]

HS-LS4-5. Evaluate the merits and limitations of a model that demonstrates how changes in environmental conditions may result in the emergence of new species over generations and/or the extinction of other species, and that these processes may occur at different rates depending on the conditions. [Clarification Statement: Examples of the processes occurring at different rates include gradualism versus punctuated equilibrium and background extinction versus mass extinction).]

[Note: HS-LS4-3 and HS-LS4-4 from NGSS are merged with HS-LS4-2. HS-LS4-6 from NGSS is not included.]

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Comment [JF38]: Part a removed as it is redundant with HS-LS1-1. Part b was moved to that standard as it was a better fit there. The focus of this standard is now clearer and in better alignment with NGSS.

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Comment [j40]: Standards about co-evolution and genetic drift-gene flow removed to reduce overall scope of course.

Deleted: HS-LS4-3. Explain based on evidence how coevolution and sexual selection can lead to individuals with behavioral, anatomical, and physiological adaptations in a population.¶ ...

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High School (Grade 9 or 10)

Chemistry

Chemistry HS-PS1 Matter and Its Interactions
HS-PS1-1. Use the periodic table as a model to predict the relative properties of main group elements, including ionization energy and relative sizes of atoms and ions, based on the patterns of electrons in the outermost energy level of each element. Use the patterns of valence electron configurations and Coulomb's law to explain and predict trends in ionization energies, relative sizes of atoms and ions, and reactivity of pure elements. [State Assessment Boundary: State assessment will be limited to main group (s and p block) elements.]
HS-PS1-2. Use the periodic table model to predict and design simple combination reactions that result in two main classes of binary compounds, ionic and molecular. Account for chemical changes in terms of charge redistribution. [Clarification Statements: Simple combination reactions include synthesis (combination), decomposition, single displacement, double displacement, and combustion. Emphasis should be on chemical reactions involving main group (s and p block) elements.]
HS-PS1-3. Cite evidence to relate physical properties of substances at the bulk scale to spatial arrangements, movement, and strength of electrostatic forces among ions, small molecules, or regions of large molecules in the substances. Make arguments to account for how intermolecular interactions are determined by atomic composition and molecular geometry, and for how ions or small molecules arrange into two major types of three-dimensional crystal structures: atom/ionic networks or molecular crystals. [Clarification Statement: Substances include both pure substances in solid, liquid, gas, and networked forms (such as graphite) as well as solutions. Examples of bulk properties of substances include melting point and boiling point, vapor pressure, and surface tension.] [State Assessment Boundary: Raoult's Law, calculations of vapor pressure, properties of heterogeneous mixtures, or names of specific intermolecular forces (such as dipole-dipole) are not expected in state assessment.]
HS-PS1-4. Develop a model to illustrate the energy transferred during an exothermic or endothermic chemical reaction based on the bond energy difference between bonds broken (absorption of energy) and bonds formed (release of energy). [Clarification Statement: Examples of models may include molecular-level drawings and diagrams of reactions, graphs showing the relative energies of reactants and products, and representations showing energy is conserved.]
HS-PS1-5. Construct an explanation based on collision theory for why varying conditions influence the rate of a chemical reaction or a dissolving process. Design and test ways to alter various conditions to influence (slow down or accelerate) rates of processes (chemical reactions or dissolving) as they occur.* [Clarification Statement: Explanations should be based on three variables in collision theory: (a) quantity of collisions per unit time, (b) molecular orientation on collision, and (c) energy input needed to induce atomic rearrangements. Conditions that affect these three variables include temperature, pressure, concentrations of reactants, mixing, particle size, surface area, and addition of a catalyst.] [State Assessment Boundary: State assessment will be limited to simple reactions in which there are only two reactants and to specifying the change in only one variable at a time.]
HS-PS1-6. Design ways to control the extent of a reaction at equilibrium (relative amount of products to reactants) by altering various conditions using Le Chatelier's principle. Make arguments based on collision theory to account for how altering conditions would affect the forward and reverse rates of the reaction until a new equilibrium is established.* [Clarification Statement: Conditions that can be altered include temperature, pressure, concentrations of reactants, mixing, particle size, surface area, and addition of a catalyst.] [State Assessment Boundary: Calculations of equilibrium constants or concentrations are not expected in state assessment. State assessment will be limited to simple reactions in which there are only two reactants and to specifying the change in only one variable at a time.]
HS-PS1-7. Use mathematical representations and provide experimental evidence to support the claim that atoms, and therefore mass, are conserved during a chemical reaction. Use the mole concept and proportional relationships to predict the quantities (masses or moles) of specific reactants or products. [Clarification Statement: Mathematical representations include balanced chemical equations that represent the laws of conservation of mass and constant composition (definite proportions), percent composition, empirical formulas, mass-to-mass stoichiometry, and calculations of percent yield. Calculations may involve mass-to-mass stoichiometry and atom economy comparisons, but only for single-step reactions that do not involve complexes.]
HS-PS1- 9(MA). Relate the strength of an aqueous acidic or basic solution to the hydronium ion

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concentration of the solution. Use the Arrhenius and Bronsted-Lowry acid-base reaction models and Le Chatelier's principle to predict whether the pH increases or decreases when conditions are modified. Make arguments about the relative strengths of two acids or bases with similar structure and/or composition. [Clarification Statement: Modification of conditions includes dilution of or addition or removal of reactants or products by physical or chemical means. Comparisons of relative strengths of aqueous acid or base solutions made from similar acid or base substances is limited to arguments based on periodic properties of elements, electronegativity model of electron distribution, empirical dipole moments, and molecular geometry. Reactions are limited to Arrhenius and Bronsted-Lowry acid-base reaction patterns with monoprotic acids. Acid or base strength comparisons are limited to homologous series.]

HS-PS1-10(MA). Use an oxidation-reduction reaction model to predict products of reactions given the reactants, and to communicate the reaction models using a representation that shows electron transfer (redox). Use periodic properties of elements, an electron distribution model and the periodic table model to design substances that could be used in devices that produce electricity via oxidation-reduction reactions.* [Clarification Statement: Devices may include batteries, fuel cells, electrolysis, and corrosion-protection. Reactions are limited to simple oxidation-reduction reactions that do not require hydronium or hydroxide ion to balance half-reactions. Electron distribution models are limited to oxidation numbers accounting.]

HS-PS1-11(MA). Construct an argument to show differences in the atomic composition and molecular geometry of substances that allow for identification, detection, and separation of substances in a mixture. [Clarification Statement: Atomic composition of the atom includes electrostatic attractions and repulsions between the electrons and nucleus and that neutral atoms can have different numbers of neutrons (isotopes).]

HS-PS1-12(MA). Combine period patterns and Coulomb's law with observational data about ionic substances versus molecular substances to develop a predictive model for ionic versus covalent bonding in binary structures. [Clarification Statement: Observational data include ionic substances (i.e., have ionic bonds), when pure, are crystalline salts at room temperature (common examples include NaCl, Na_2CO_3, Fe_2O_3); and, substances that are liquids and gasses at room temperature are usually made of molecules which have covalent bonds (common examples include CO_2, N_2, CH_4, H_2O, C_8H_{18}, $C_{12}H_{22}O_{11}$).]

HS-PS1-13(MA). Analyze data of the conductivity of pure water versus different solutions of water with another substance dissolved in it to make a claim about the nature of the molecules of the dissolved substances.

[Note: HS-PS1-8 is found in Earth and Space Science.]

Chemistry HS-PS2 Motion and Stability: Forces and Interactions

HS-PS2-6. Communicate scientific and technical information about the molecular-level structures of different materials to justify why particular classes of substances have specific properties that are useful in the functioning of designed materials.* [Clarification Statement: Examples could include comparing molecules with simple molecular geometries; why electrically conductive materials are often made of metal; foods and household products often contain ionic compounds; materials that need to be flexible but durable are made up of polymers; and, pharmaceuticals are designed to interact with specific receptors.] [State Assessment Boundary: State assessment will be limited to VESPR, polymers, ionic compounds, isomers, and metals.]

HS-PS2-7(MA). Construct a model to explain the process by which solutes dissolve in solvents, particularly water, and predict how intermolecular forces affect solubility. [Clarification Statement: Predictions include whether the substance will dissolve based on being polar or nonpolar and ionic or covalent.]

HS-PS2-8(MA). Communicate a qualitative explanation based on kinetic-molecular theory for why one variable in the combined gas law changes when another is varied. Using kinetic-molecular theory, explain the behavior of gases and the relationship between pressure and volume (Boyle's law), volume and temperature (Charles's law), and pressure and temperature (Gay-Lussac's law). Use the combined gas law to determine changes in pressure, volume, and temperature.

[Note: HS-PS2-1, HS-PS2-2, HS-PS2-3, HS-PS2-4, HS-PS2-5, HS-PS2-9(MA), and HS-PS2-10(MA) are found in Introductory Physics.]

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HS-PS3 Energy
HS-PS3-4b. Provide evidence from literature or available data to illustrate that the transfer of energy within a closed system involves heat (enthalpy change) and rearrangement of the system (entropy change) while the overall energy in the system is conserved. **[Note: HS-PS3-1, HS-PS3-2, HS-PS3-3, HS-PS3-4a, and HS-PS3-5 are found in Introductory Physics.]**

High School (Grade 9 or 10)

Introductory Physics

Introductory Physics HS-PS2 Motion and Stability: Forces and Interactions
HS-PS2-1. Analyze data to support the claim that Newton's second law of motion is a mathematical model describing change in motion (the acceleration) of objects when acted on by a net force. [Clarification Statement: Examples of data could include tables or graphs of position or velocity as a function of time for objects subject to a net unbalanced force, such as a falling object, an object rolling down a ramp, and a moving object being pulled by a constant force. Forces can include contact forces, including friction, and forces acting at a distance, such as gravity and magnetic forces.] [State Assessment Boundary: Variable forces are not expected in state assessment.]
HS-PS2-2. Use mathematical representations to show that the total momentum of a system of interacting objects is conserved when there is no net force on the system. [Clarification Statement: Emphasis is on the qualitative meaning of the conservation of momentum and the quantitative understanding of the conservation of linear momentum in interactions involving elastic and inelastic collisions between two objects in one dimension.]
HS-PS2-3. Apply scientific principles of motion and momentum to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.* [Clarification Statement: Both qualitative evaluations and algebraic manipulations may be used.]
HS-PS2-4. Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to both qualitatively and quantitatively describe and predict the effects of gravitational and electrostatic forces between objects. [Clarification Statement: Emphasis is on the relative changes when distance, mass or charge, or both are changed; as well as the relative strength comparison between the two forces.] [State Assessment Boundary: State assessment will be limited to systems with two objects. Permittivity of free space is not expected in state assessment.]
HS-PS2-5. Provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current. [Clarification Statement: Examples of evidence can include movement of a magnetic compass when placed in the vicinity of a current-carrying wire, and a magnet passing through a coil that turns on the light of a Faraday flashlight.] [State Assessment Boundary: Explanations of motors or generators are not expected in state assessment.]
HS-PS2-9(MA). Evaluate simple series and parallel circuits to predict changes to voltage, current, or resistance when simple changes are made to a circuit. [Clarification Statements: Predictions of changes can be represented numerically, graphically, or algebraically using Ohm's Law. Simple changes to a circuit may include adding a component, changing the resistance of a load of a component, and adding a parallel path in a circuit using circuits with batteries and common loads or resistors.] [State Assessment Boundary: Use of schematic diagrams, use of measurement devices, and predictions of changes in power are not expected in state assessment.]
HS-PS2-10(MA). Use free-body force diagrams, algebraic expressions, and Newton's laws of motion to predict changes to position and acceleration for an object moving in one dimension in various situations. [Clarification Statement: Predictions of changes in motion can be made numerically, graphically, and algebraically using basic equations for velocity, constant acceleration, and Newton's first and second laws. Forces can include contact forces, including friction, and forces acting at a distance, such as gravity and magnetic forces.]
[Note: HS-PS2-6, HS-PS2-7(MA), and HS-PS2-8(MA) are found in Chemistry.]

Introductory Physics HS-PS3 Energy
HS-PS3-1. Use algebraic expressions and the principle of energy conservation to calculate the change in energy of one component of a system when the change in energy of the other component(s) of the system, as well as the total energy of the system including any energy entering or leaving the system, is known. Identify any transformations from one form of energy to another, including thermal, kinetic, gravitational, magnetic, or electrical energy, in the system. [Clarification Statement: Systems should be limited to two or three components; and to thermal energy, kinetic energy, or the energies in gravitational, magnetic, or electric fields.]
HS-PS3-2. Develop and use a model to illustrate that energy at the macroscopic scale can be accounted for as either motions of particles and objects or energy stored in fields. [Clarification Statement: Examples of phenomena at the macroscopic scale could include the conversion of kinetic energy to thermal energy, the gravitational potential energy stored due to position of an object

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Comment [JF42]: Removed part of this standard to a new standard HS-PS1-10 below. Added to CS and AB to add specificity and clarity.

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Comment [JF43]: Added CS and AB to help define this standard.

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Comment [JF44]: Rewritten to put it in more of an application context.

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above the Earth, and the energy stored (electrical potential) of a charged object's position within an electrical field. Examples of models could include diagrams, drawings, descriptions, and computer simulations.]

HS-PS3-3. Design and evaluate a device that works within given constraints to convert one form of energy into another form of energy.* [Clarification Statement: Emphasis is on both qualitative and quantitative evaluations of devices. Examples of devices could include Rube Goldberg devices, wind turbines, solar cells, solar ovens, and generators. Examples of constraints could include use of renewable energy forms and efficiency.] [State Assessment Boundary: Quantitative evaluations will be limited to total output for a given input in state assessment.]

HS-PS3-4a. Provide evidence that when two objects of different temperature are in thermal contact within a closed system, the transfer of thermal energy from higher temperature objects to lower temperature objects results in thermal equilibrium, or a more uniform energy distribution among the objects and that temperature changes necessary to achieve thermal equilibrium depend on the specific heat values of the two substances. [Clarification Statement: Energy changes should be described both quantitatively in a single phase ($Q = mc\Delta T$) and conceptually in either a single phase or during a phase change.]

HS-PS3-5. Develop and use a model of magnetic or electric fields to illustrate the forces and changes in energy between two magnetically or electrically charged objects changing relative position in a magnetic or electric field, respectively. [Clarification Statements: Emphasis is on change in force and energy as objects move relative to each other. Examples of models could include drawings, diagrams, and texts, such as drawings of what happens when two charges of opposite polarity are near each other.]

[Note: HS-PS3-4b is found in Chemistry.]

Introductory Physics HS-PS4	Waves and Their Applications in Technologies for Information Transfer

HS-PS4-1. Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling within various media. Recognize that electromagnetic waves can travel through empty space (without a medium). [Clarification Statement: Emphasis is on relationships when waves travel within a medium, and comparisons when a wave travels in different media. Examples of situations to consider could include electromagnetic radiation traveling in a vacuum and glass, sound waves traveling through air and water, and seismic waves traveling through the Earth. Relationships include $v = \lambda f$, $T = 1/f$, and the qualitative comparison of the speed of a transverse (including electromagnetic) or longitudinal mechanical wave in a solid, liquid, gas, or vacuum.] [State Assessment Boundary: Transitions between two media are not expected in state assessment.]

HS-PS4-3. 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 involving resonance, interference, diffraction, or the photoelectric effect, one model is more useful than the other. [State Assessment Boundary: Use of quantum theory is not expected in state assessment.]

HS-PS4-5. Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.* [Clarification Statement: Examples of technological devices could include solar cells capturing light and converting it to electricity; medical imaging; and, communications technology. Examples of principles of wave behavior include resonance, photoelectric effect, and constructive and destructive interference.] [State Assessment Boundary: State assessment will be limited to qualitative information. Band theory is not expected in state assessment.]

[Note: HS-PS4-2 and HS-PS4-4 from NGSS are not included.]

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Comment [JF47]: Change made to reflect a focus on explaining phenomena or situations, not just the concept. Removed CS as the standard is only about EM, not longitudinal mechanical waves.

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High School (Grade 9 or 10)

Technology/Engineering

Technology/Engineering HS-ETS1 Engineering Design
HS-ETS1-1. Analyze a major global challenge to specify a design problem that can be improved. Determine necessary qualitative and quantitative criteria and constraints for solutions, including any requirements set by society.* [Clarification Statement: Examples of societal requirements can include risk mitigation, aesthetics, ethical considerations, and long-term maintenance costs.]
HS-ETS1-2. Break a complex real-world problem into smaller, more manageable problems that each can be solved using scientific and engineering principles.*
HS-ETS1-3. Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, aesthetics, and maintenance, as well as social, cultural, and environmental impacts.*
HS-ETS1-4. Use a computer simulation to model the impact of a proposed solution to a complex real-world problem that has numerous criteria and constraints on the interactions within and between systems relevant to the problem.*
HS-ETS1-5(MA). Plan a prototype or design solution using orthographic projections and isometric drawings, using proper scales and proportions.*
HS-ETS1-6(MA). Document and present solutions that include specifications, performance results, successes and remaining issues, and limitations.*

Technology/Engineering HS-ETS2 Materials, Tools, and Manufacturing
HS-ETS2-1(MA). Determine the best application of manufacturing processes to create parts of desired shape, size, and finish based on available resources and safety. [Clarification Statement: Examples of processes can include forming (molding of plastics, casting of metals, shaping, rolling, forging, and stamping), machining (cutting and milling), conditioning (thermal, mechanical, and chemical processes), and finishing.] [State Assessment Boundary: Specific manufacturing machines are not expected in state assessment.]
HS-ETS2-2(MA). Explain how computers and robots can be used at different stages of a manufacturing system, typically for jobs that are repetitive, very small, or very dangerous. [Clarification Statement: Examples of stages include design, testing, production, and quality control.]
HS-ETS2-3(MA). Compare the costs and benefits of custom versus mass production based on qualities of the desired product, the cost of each unit to produce, and the number of units needed.
HS-ETS2-4(MA). Explain how manufacturing processes transform material properties to meet a specified purpose or function. Recognize that new materials can be synthesized through chemical and physical processes that are designed to manipulate material properties to meet a desired performance condition. [Clarification Statement: Examples of material properties can include resistance to force, density, hardness, and elasticity.]

Technology/Engineering HS-ETS3 Technological Systems
HS-ETS3-1(MA). Model a technological system in which the output of one subsystem becomes the input to other subsystems.
HS-ETS3-2(MA). Use a model to explain how information transmitted via digital and analog signals travels through the following media: electrical wire, optical fiber, air, and space. Analyze a communication problem and determine the best mode of delivery for the communication(s).
HS-ETS3-3(MA). Explain the importance of considering both live loads and dead loads when constructing structures. Calculate the resultant force(s) for a combination of live loads and dead loads for various situations. [Clarification Statement: Examples of structures can include buildings, decks, and bridges. Examples of loads and forces include live load, dead load, total load, tension, sheer, compression, and torsion.]
HS-ETS3-4(MA). Use a model to illustrate how the forces of tension, compression, torsion, and shear affect the performance of a structure. Analyze situations that involve these forces and justify the selection of materials for the given situation based on their properties. [Clarification Statement: Examples of structures include bridges, houses, and

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Comment [j48]: Removed graphs of material properties to reduce scope of standard.

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	skyscrapers. Examples of material properties can include elasticity, plasticity, thermal conductivity, density, and resistance to force.]
HS-ETS3-5(MA).	**Analyze how the design of a building is influenced by thermal conditions such as wind, solar angle, and temperature. Give examples of how conduction, convection, and radiation are considered in the selection of materials for buildings and in the design of a heating system.**
HS-ETS3-6(MA).	**Use informational text to illustrate how a vehicle or device can be modified to produce a change in lift, drag, friction, thrust, and weight.** [Clarification Statement: Examples of vehicles can include cars, boats, airplanes, and rockets. Considerations of lift require consideration of Bernoulli's principle.]

Technology/Engineering HS-ETS4 Energy and Power Technologies	
HS-ETS4-1(MA).	**Research and describe various ways that humans use energy and power systems to harness resources to accomplish tasks effectively and efficiently.** [Clarification Statement: Examples of energy and power systems can include fluid systems such as hydraulics and pneumatics, thermal systems such as heating and cooling, and electrical systems such as electronic devices and residential wiring.]
HS-ETS4-2(MA).	**Use a model to explain differences between open fluid systems and closed fluid systems. Determine when it is more or less appropriate to use one type of system instead of the other.** [Clarification Statements: Examples of open systems can include irrigation, forced hot air system, and air compressors. Examples of closed systems can include forced hot water system and hydraulic brakes.]
HS-ETS4-3(MA).	**Calculate and describe the ability of a hydraulic system to multiply distance, multiply force, and effect directional change.** [Clarification Statement: Emphasis is on the ratio of piston sizes (cross-sectional area) as represented in Pascal's Law.]

Comment [JF50]: Changed properties to be consistent across the standards.

Deleted: resistance

Deleted: strength

Deleted: **Describe**

Comment [j51]: CS added to clarify expectation of the standard.