



**DRAFT REVISED**

**Massachusetts  
Science and Technology/Engineering  
Standards**

**Pre-K to Grade 8 by grade and Introductory High School Courses**

*Based on the Next Generation Science Standards*

**December, 2013**

**This set of draft revised STE standards will remain in draft form until they are moved forward for adoption in the 2015-2016 school year. Please direct all input on these standards, including comments, suggested edits, and questions, to:**

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# *Introduction to the Standards*

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## **Key shifts in the draft revised Science and Technology/Engineering (STE) standards**

The STE standards are intended to drive coherent, rigorous instruction that results in student mastery and application of scientific, technological and engineering knowledge, reasoning, and skills. The draft revised standards reflect several key shifts from prior Massachusetts standards, a number of which reflect similar shifts in recent mathematics and ELA standards:

- 1. Integration of disciplinary core ideas and practices reflect the interconnected nature of science and engineering.*  
The standards integrate disciplinary core ideas (concepts) with scientific and engineering practices (skills). Currently, Massachusetts science and technology/engineering standards focus primarily on content. The integration of rigorous concepts and practices reflects how science and engineering is applied and practiced every day and is shown to enhance student learning of both.
- 2. Preparation for post-secondary success in college and careers.*  
The standards articulate key knowledge and skills students need to succeed in entry-level, credit-bearing science, engineering or technical courses in college or university; certificate or workplace training programs requiring an equivalent level of science; or comparable entry-level science or technical courses, as well as jobs and postsecondary opportunities that require scientific and technical proficiency to earn a living wage.
- 3. Science and technology/engineering concepts and practices progress coherently from Pre-K to high school.*  
The standards emphasize a focused and coherent progression of knowledge and skills from grade band to grade band, allowing for a dynamic process of knowledge and skill building throughout a student's scientific education. The progression gives students the opportunity to learn more sophisticated material and re-conceptualize their understanding of how the natural and designed world works, leading to the scientific and technical understanding needed for post-secondary success.
- 4. Focus on deeper understanding and application of concepts.*  
The standards are focused on a small set of disciplinary core ideas that build across grades and lead to deeper understanding and application of concepts. The standards are written to both articulate the broad concepts *and* key components that specify expected learning.
- 5. Each discipline is integrated in grade-by-grade standards Pre-K to grade 8.*  
To achieve consistency across schools and districts and to facilitate collaborative work, resource sharing, and effective education for transient populations, the PreK to grade 8 standards are presented by grade level. All four disciplines, including earth and space science, life science, physical science, and technology/engineering are included in each grade to encourage integration across the year and through curriculum, including the use of crosscutting concepts and nature of science themes.
- 6. The STE standards are coordinated with the Commonwealth's English Language Arts and Mathematics standards.*

The STE standards require the use and application of key English Language Arts and Mathematics standards needed to support science and technology/engineering learning. The three sets of standards overlap in meaningful and substantive ways, particularly in regards to practices (skills) that are common across all three, and offer an opportunity for all students to better apply and learn science and technology/engineering.

### **The Standards are Outcomes**

State standards are outcomes, or goals, that reflect what a student should know and be able to do. They do not dictate the manner or methods by which the standards are taught. The standards are written in a way that expresses the concept and skills to be achieved and demonstrated by students but leaves curricular and instructional decisions to districts, school and teachers. The standards are not a set of instructional activities or assessment tasks. They are statements of what students should be able to do *as a result of* instruction.

In particular, it is important to note that the scientific and engineering practices are not teaching strategies – they are important learning goals in their own right; they are skills to be learned as a result of instruction. Coupling practice with content gives the context for performance, whereas practices alone are activities and content alone is memorization. The scientific and engineering practices are represented across the standards. Curriculum and assessment must be developed in a way that builds students’ knowledge and ability toward the standards. As the standards are performances meant to be accomplished at the conclusion of instruction, quality instruction will have students engage in several practices throughout instruction. Teachers have the flexibility to arrange the standards in any order within a grade level to suit the needs of students and science programs. The use of various applications of science, such as biotechnology, clean energy, medicine, forensics, agriculture, or robotic, would nicely facilitate student interest and demonstrate how the standards are applied in real world contexts.

The term “practices” is used in the standards instead of a term such as “inquiry” or “skills” to emphasize that the practices are outcomes to be learned, not the method of instruction. The term “inquiry” in particular has so often been used to refer to an instructional approach as well as the skills to be learned that most readers cannot separate the two uses. So the term practices denotes the skills to be learned as a result of instruction, whether that instruction is inquiry-based or not. Students cannot comprehend scientific practices, nor fully appreciate the nature of scientific knowledge itself, without learning the science and engineering practices.

It is also important to note that the standards identify the most essential material for students to know and do. The standards are not intended to represent an exhaustive list of all that could be included in a student’s science education nor should they prevent students from going beyond the standards where appropriate.

### **Structural features of the standards**

The coding system used for the standards is the coding system used for the Next Generation Science Standards (NGSS). As with the titles, the first digit indicates a grade (Pre-K to grade 5), or specifies middle school (MS) or high school (HS). The next alpha-numeric code specifies the discipline, core idea and sub-idea. Finally, the number at the end of each code indicates the particular standards which integrate a disciplinary core idea and a practice. For those standards that are not aligned to NGSS (additional standards) an “(MA)” has been added to the code. The intent is to keep consistent coding to allow Massachusetts educators access to any resources developed nationally that are aligned to NGSS. While this does occasionally result in standards that appear to not be in sequence or skip a number, the benefits of maintaining consistency with NGSS outweighed the value of renumbering the standards. Additionally, the order in which the standard in each discipline is listed does not imply the order of teaching or the instructional sequence.

Also consistent with NGSS, many standards include *clarification statements*, which supply examples or additional clarification to the performance expectations, and *assessment boundary* statements which are meant to specify limits to large-scale assessment. These are not intended to limit or constrain curriculum or classroom instruction; they are meant to clarify the expectations for student performance.

The use of an “\*” at the end of some standards designates those standards that have an engineering design application. This is also consistent with NGSS.

Finally, unlike NGSS, some standards presented here may have multiple performances or multiple parts. There are some standards that need additional statements or components to convey the richness of expected student outcomes.

[This section draws from and is an adaptation of NGSS Appendix A.]

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## Pre-K: Overview

### *The World Around Me*

Pre-K students focus on experiencing and making observations of the world around them. They are beginning to learn about their own environment as they observe plants and animals, the moon and the sun, and the daily weather. They experience their world through their senses and body parts and begin to recognize that animals also use their senses and body parts to meet their basic needs. They are given opportunities in their play to investigate pitch and volume, shadow and light, liquids and solids, and how things move. They sort materials by simple observable properties such as texture and color. They share their understanding of these concepts through discussion as they develop their language and quantitative skills. Pre-K students build awareness of the wide variety of natural phenomena and processes in the world around them.

## Pre-K: Earth and Space Sciences

<b>PreK-ESS1. Earth's Place in the Universe</b>
<b>PreK-ESS1-1(MA).</b> 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. [Assessment Boundary: Assessment does not include names for moon phases or sequencing moon phases.]
<b>PreK-ESS1-2(MA).</b> Observe and use evidence to describe that the sun is in different places in the sky during the day.
<b>PreK-ESS2. Earth's Systems</b>
<b>PreK-ESS2-1(MA).</b> Raise questions and engage in discussions about how different types of local environments (including water) provide homes for different kinds of living things.
<b>PreK-ESS2-2(MA).</b> Observe and classify non-living materials, natural and human made, in their local environment.
<b>PreK-ESS2-3(MA).</b> Explore and describe different places water is found in the local environment.
<b>PreK-ESS2-4(MA).</b> 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.
<b>PreK-ESS2-5(MA).</b> 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.]
<b>PreK-ESS2-6(MA).</b> Understand 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.]
<b>PreK-ESS3. Earth and Human Activity</b>
<b>PreK-ESS3-1(MA).</b> Engage in discussion and raise questions using examples about local resources (including soil and water) humans use to meet their needs.
<b>PreK-ESS3-2(MA).</b> Observe and discuss the impact of people's activities on the local environment.

## PreK: Life Science

<b>PreK-LS1 From Molecules to Organisms: Structures and Processes</b>
<b>PreK-LS1-1(MA).</b> 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.]
<b>PreK-LS1-2(MA).</b> Recognize that all plants and animals grow and change over time.
<b>PreK-LS1-3(MA).</b> Explain that most animals have 5 senses they use to gather information about the world around them.
<b>PreK-LS1-4(MA).</b> Use their five senses in their exploration and play to gather information.

<b>PreK-LS2</b>	<b>Ecosystems: Interactions, Energy, and Dynamics</b>
<p>PreK-LS2-1(MA). Use evidence from animals and plants to define several characteristics of living things that distinguish them from non-living things.</p> <p>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.]</p> <p>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.</p>	

<b>PreK-LS3</b>	<b>Variation of Traits</b>
<p>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 similar but not exactly the same as their parents.]</p> <p>PreK-LS3-2(MA). Use observations to recognize differences and similarities among themselves and their friends.</p>	

## PreK: Physical Sciences

<b>PreK-PS1.</b>	<b>Matter and Its Interactions</b>
<p>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.</p> <p>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.</p> <p>PreK-PS1-3(MA). Differentiate between the properties of an object and those of the material of which it is made.</p> <p>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, or changing state.]</p>	

<b>PreK-PS2.</b>	<b>Motion and Stability: Forces and Interactions</b>
<p>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.</p> <p>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.]</p>	

<b>PreK-PS4.</b>	<b>Waves and Their Applications in Technologies for Information Transfer</b>
<p>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.</p> <p>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.</p>	

## Kindergarten: Overview

### *Reasons for Change*

In kindergarten, students build on early experiences observing the world around them as they continue to make observations that are more quantitative in nature and help them identify why some changes occur. Students begin to learn to use these observations as evidence to support a claim through growing language skills. They learn that all animals and plants need food, water, and air to grow and thrive and that the fundamental difference between plants and animals is a plants ability to make its own food. Students build their quantitative knowledge of temperature in relationship to the weather and its effect on different kinds of materials. They observe that the amount of sunlight shining on a surface causes a temperature change and they design a structure to reduce the warming effects of sunlight. They investigate motions of objects by changing the strength and direction of pushes and pulls. They provide examples of plants and animals that can change their environment through their interactions with it. In kindergarten science students begin to identify reasons for changes in some common phenomena.

## Kindergarten: Earth and Space Sciences

<b>K-ESS2 Earth's Systems</b>
<b>K-ESS2-1. Use and share quantitative observations of local weather conditions to describe patterns over time.</b> [Clarification Statement: Examples of quantitative observations could include numbers of sunny, windy and rainy days in a month, and relative temperature.] [Assessment Boundary: Assessment of quantitative observations limited to whole numbers.]
<b>K-ESS2-2. Construct an argument supported by evidence for how plants and animals (including humans) can change the environment.</b> [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.]

  

<b>K-ESS3 Earth and Human Activity</b>
<b>K-ESS3-2. Obtain information about the purpose of weather forecasting to prepare for, and respond to, different types of local weather.</b>
<b>K-ESS3-3. Communicate solutions to reduce the amount of natural resources an individual uses.*</b> [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

<b>K-LS1 From Molecules to Organisms: Structures and Processes</b>
<b>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.</b>
<b>K-LS1-2(MA). Recognize that all plants and animals have a life cycle: 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.</b>

## Kindergarten: Physical Science

<b>K-PS1 Matter and its Interactions</b>
<b>K-PS1-1(MA). Design and conduct an experiment to test the idea that different kinds of materials can be a solid or liquid depending on temperature.</b> [Clarification Statement: 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.] [Assessment Boundary: 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.] [Assessment Boundary: Assessment is limited to different relative strengths or different directions, but not both at the same time. Assessment does not include non-contact pushes or pulls such as those produced by magnets.]

[Note: K-PS2-2 from NGSS is not included.]

**K-PS3 Energy**

**K-PS3-1. Make observations to determine that sunlight warms materials on Earth's surface.** [Clarification Statement: Examples of materials on Earth's surface could include sand, soil, rocks, and water] [Assessment Boundary: Assessment of temperature is 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.\***

## Grade 1: Overview

### *Describing Patterns*

In grade 1, students have more fluency with language, number sense and inquiry skills. This allows students to describe patterns of motion between the sun, moon, and stars in relation to the Earth. From this understanding they can identify seasonal patterns from sunrise and sunset data that will allow them to predict future patterns. Building from their experiences in Pre-K and kindergarten observing and describing daily weather, they can now examine seasonal data of temperature and rainfall to describe patterns over time. Grade 1 students investigate sound and light through various materials. They describe patterns in how light passes through and sounds differ from different types of materials. Based on this they design and build a device to send a signal. Students compare the ways different animals and plants use their body parts and senses to do the things they need to do to grow and survive including typical ways parents keep the young safe so they will survive to adulthood. They notice that though there are differences between plants or animals of the same type, the similarities of behavior and appearance are what allow us to identify them as belonging to a group. Grade 1 students begin to understand the power of patterns to predict future events in the natural and designed world.

## Grade 1: Earth and Space Sciences

<b>1-ESS1 Earth's Place in the Universe</b>
<b>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.</b>
<b>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.]</b>

## Grade 1: Life Science

<b>1-LS1 From Molecules to Organisms: Structures and Processes</b>
<b>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. [Assessment Boundary: Descriptions are not expected to include mechanisms.]</b>
<b>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).]</b>
<b>1-LS3 Heredity: Inheritance and Variation of Traits</b>
<b>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 Statement: Examples of observations could include leaves from the same kind of plant are the same shape but can differ in size.] [Assessment Boundary: Assessment does not include inheritance or animals that undergo metamorphosis or hybrids.]</b>

## Grade 1: Physical Science

1-PS4 Waves and their Applications in Technologies for Information Transfer
<p><b>1-PS4-1. Demonstrate that vibrating materials can make sound and that sound can make materials vibrate.</b> [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 matter vibrate could include holding a piece of paper near a speaker making sound and holding an object near a vibrating tuning fork.]</p>
<p><b>1-PS4-3. 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.</b> [Clarification Statement: Effects can include some or all light passing through, creation of a shadow, or redirecting light.] [Assessment Boundary: Assessment does not include quantitative measures.]</p>
<p><b>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.*</b> [Clarification Statement: Examples of devices could include a light source to send signals, paper cup and string “telephones,” and a pattern of drum beats.] [Assessment Boundary: Assessment does not include technological details for how communication devices work.]</p>
<p>[Note: 1-PS4-2 from NGSS is not included.]</p>

## Grade 1: Technology/Engineering

Grade 1 K-2-ETS1 Engineering Design
<p><b>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.*</b></p>
<p><b>K-2-ETS1-2. Generate multiple solutions to a design problem and make a drawing (plan) to represent one or more of the solutions.*</b></p>
<p>[NOTE: K-2-ETS1-3 is found in Grade 2]</p>

## Grade 2: Overview

### *Wholes and Parts*

As students grow in their ability to speak, read, write and reason mathematically, they also grow in their ability to grapple with larger systems and the parts that make them up. In grade 2, students start to look beyond the structures of individual plants and animals to looking at the environment in which the plants and animals live as a provider of the food, water, and shelter that the organisms need. They learn that water is found everywhere on Earth and takes different forms and shapes. They map landforms and bodies of water and observe that flowing water and wind shapes these landforms. Grade 2 students use their observation skills gained in earlier grades to classify materials based on similar properties and functions. They gain experience testing different materials to collect and then analyze data for the purpose of determining which materials are the best for a specific function. They construct large objects from smaller pieces and, conversely, learn that when materials are cut into the smallest possible pieces, they still exist as the same material that has weight. These investigations of how parts relate to the whole provide a key basis for understanding systems in later grades.

## Grade 2: Earth and Space Sciences

<b>2-ESS1 Earth's Place in the Universe</b>
[Note: 2-ESS1-1 from NGSS is not included]
<b>2-ESS2 Earth's Systems</b>
<b>2-ESS2-1. Compare the effectiveness of multiple solutions designed to slow or prevent wind or water from changing the shape of the land.*</b> [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.]
<b>2-ESS2-2. Map the shapes and types of landforms and bodies of water in an area.</b> [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.] [Assessment Boundary: Assessment does not include quantitative scaling in models.]
<b>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.</b>
<b>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.</b> [Clarification Statement: Examples of types of landforms can include hills, valleys, river banks, and dunes.]

## Grade 2: Life Science

<b>2-LS2 Ecosystems: Interactions, Energy, and Dynamics</b>
<b>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.</b> [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 are not included.]
<b>2-LS4 Biological Evolution: Unity and Diversity</b>
<b>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.</b> [Clarification Statement: Examples of areas to compare might include temperate forest, desert, tropical rain forest, grassland, arctic, and aquatic.] [Assessment Boundary: Assessment does not include specific animal and plant names in specific areas.]

## Grade 2: Physical Science

2-PS1 Matter and its Interactions
<b>2-PS1-1. Describe and classify different kinds of materials by observable properties of color, strength, flexibility, hardness, texture, and absorbency.</b>
<b>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.*</b> [Clarification Statement: Examples of properties could include, color, strength, flexibility, hardness, texture, and absorbency.] [Assessment Boundary: Assessment is limited to qualitative and relative observations.]
<b>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.</b> [Clarification Statement: Materials should be pure substances or microscopic mixtures that appear contiguous at observable scales. Examples of pieces could include blocks, building bricks, or other assorted small objects.]
<b>2-PS1-4. Construct an argument with evidence that some changes to materials caused by heating or cooling can be reversed and some cannot.</b> [Clarification Statement: Examples of reversible changes could include materials such as water and butter at different temperatures. Examples of irreversible changes could include cooking an egg, freezing a plant leaf, and burning paper.]

2-PS3 Energy
<b>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.</b> [Clarification Statement: Examples could include an object sliding on rough vs. smooth surfaces.] [Assessment Boundary: Observations of temperature and speed are qualitative.]

## Grade 2: Technology/Engineering

Grade 2 K-2-ETS1 Engineering Design
<b>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.*</b>
[Note: K-2-ETS1-1 and K-2-ETS1-2 are found in Grade 1]

## Grade 3: Overview

### *Human Interactions*

In grade 3, students develop and sharpen their skills at obtaining, recording and charting, and analyzing data in order to study their environment. They use these practices to study the interactions between humans and earth systems, humans and the environment, and humans and the designed world. They learn that these entities not only interact but influence behaviors, reactions, and traits of organisms. Grade 3 students analyze weather patterns and consider humans' influence and opportunity to impact weather-related events. In life science they study the interactions between and influence of the environment and human traits and characteristics. They use the engineering design process to identify a problem and design solutions that enhance human's interactions with their surroundings and to meet their needs. Students consider the interactions and consequent reactions between objects and forces, including forces that are balanced or not. Students reason and provide evidence to support arguments for the influence of humans on nature and nature on human experience.

## Grade 3: Earth and Space Sciences

<b>3-ESS2 Earth's Systems</b>
<b>3-ESS2-1. Use graphs and tables of local weather data to describe and predict typical weather during a particular season in an area.</b> [Clarification Statement: Examples of data could include average temperature, precipitation, wind direction and wind speed.] [Assessment Boundary: Graphical displays are limited to pictographs and bar graphs. Assessment does not include climate change.]
<b>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.</b>
<b>3-ESS3 Earth and Human Activity</b>
<b>3-ESS3-1. Evaluate the merit of a design solution that reduces the impacts of a weather-related hazard.*</b> [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

<b>3-LS1 From Molecules to Organisms: Structures and Processes</b>
<b>3-LS1-1. Use simple graphical representations to show that species 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.</b> [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).] [Assessment Boundary: Assessment of plant life cycles is limited to those of flowering plants. Assessment of animal life cycles is focused on a comparison of the stages, not on a detailed description of any one organism's cycle, nor the differences of "complete metamorphosis" and "incomplete metamorphosis". Assessment does not include details of human reproduction.]
<b>3-LS2 Ecosystems: Interactions, Energy, and Dynamics</b>
[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.] [Assessment Boundary: Assessment does not include genetic mechanisms of inheritance nor prediction of traits. Assessment is limited to non-human examples.]
- 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.]

### 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.** [Assessment Boundary: Assessment does not include identification of specific fossils or present plants and animals. Comparisons are limited to physical or observable features; not to include dynamic processes or genetics.]
- 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 might 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 the environment in an area and describe how the changes may affect the ability of organisms that live in that area to survive and reproduce.** [Clarification Statement: Environmental changes should include changes to landforms, distribution of water, climate, and availability of resources. Changes in the environment could range in time from a season to decades. Data should be provided.] [Assessment Boundary: Assessment is limited to a single environmental change, however, it is understood that environmental changes are complex.]
- 3-LS4-5(MA). Provide evidence to support a claim that the survival of a population is dependent upon reproduction.** [Assessment Boundary: Assessment does not address details of reproduction.]

## 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.** [Assessment Boundary: Assessment is limited to one variable at a time: number, size, or direction of forces. Assessment does not include quantitative force magnitude, only qualitative and relative. All descriptions of gravity are limited to a force that pulls objects down.]
- 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.** [Assessment Boundary: Assessment is limited to forces produced by magnetic objects that can be manipulated by students.]
- 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

Grade 3 3-5-ETS1 Engineering Design
<p>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.*</p> <p>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.*</p> <p>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.]</p>
[Note: 3-5-ETS1-3 and 3-5-ETS1-5(MA) are found in Grade 4.]



## Grade 4: Overview

### *Matter and Energy*

In grade 4, students observe and interpret patterns related to the transfer of matter and energy on earth, in physical interactions, and in organisms. Students learn about energy—its motion, transfer, and conversion—in different physical contexts. Grade 4 students interpret patterns of changes over time as it relates to the deposition and erosion in landscape formation. They study today’s landscapes to provide evidence for past processes. Students learn about a broader set of animal internal and external structures that support life, growth, behavior, and reproduction. They work through the engineering design process, focusing on developing solutions by building, testing, and redesigning prototypes to fit a specific purpose. Each domain relates to the use of matter and energy over time and for specific purposes.

## Grade 4: Earth and Space Sciences

<b>4-ESS1 Earth’s Place in the Universe</b>
<b>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.</b> [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.] [Assessment Boundary: Assessment does not include specific knowledge of the mechanisms of rock formation or memorization of specific rock formations and layers. Assessment is limited to relative time.]
<b>4-ESS2 Earth’s Systems</b>
<b>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.</b> [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.] [Assessment Boundary: Assessment does not include chemical processes.]
<b>4-ESS2-2. Analyze and interpret maps of Earth’s mountain ranges, deep ocean trenches, and the placement of volcanoes and earthquakes to describe patterns of these features and their locations relative to boundaries between continents and oceans.</b>
<b>4-ESS3 Earth and Human Activity</b>
<b>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.</b> [Clarification Statement: Examples of renewable energy resources could include wind energy, water behind dams, and sunlight; non-renewable energy resources are fossil fuels and fissile materials.]
<b>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.*</b> [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-LS1 From 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 might include legs, wings, feathers, trunks, claws, horns and antennae. Animal organs might include eyes, ears, nose, heart, stomach, lung, brain, and skin. Plant structures might include leaves, roots, stems, bark, branches, and flowers.] [Assessment Boundary: Assessment is 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.** [Assessment Boundary: Assessment does not include quantitative measures of changes in the speed of an object or on any precise or quantitative definition of energy, nor account for mass.]

**4-PS3-2. Make observations to show that energy can be transferred from place to place by sound, light, heat, and electric currents.** [Assessment Boundary: Assessment does not include quantitative measurements of energy.]

**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.] [Assessment Boundary: Assessment does not include analysis of forces or quantitative measurements of energy.]

**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.\***

### 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.] [Assessment Boundary: Assessment is limited to mechanical waves (including sound) and does not include interference effects, electromagnetic waves, non-periodic waves, or quantitative models of amplitude and wavelength.]

**4-PS4-2. Develop a model to describe that light must bounce off an object and enter the eye for the object to be seen.** [Assessment Boundary: Assessment does not include knowledge of specific colors reflected and seen, the cellular mechanisms of vision, or how the retina works.]

**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 1's and 0's 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

**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.\***

**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-ETS2 Technological Systems**

**3-5-ETS2-1(MA). Recognize that technology is any modification of the natural or designed world done to fulfill human needs or wants. These modifications can be improvements to existing technologies or the development of new technologies.\***

**3-5-ETS2-2(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.\***

## Grade 5: Overview

### *Connections and Relationships in Systems*

In grade 5, students model, provide evidence to support arguments, and obtain and display data about relationships and interactions among observable components of different systems. By studying systems grade 5 students learn that objects and organisms do not exist in isolation and that animals, plants and their environments are connected to, interact with, and are influenced by each other. They study the relationships between Earth and other nearby objects in the solar system and the impact of those relationships on patterns of events as seen from Earth. They learn about the relationship among elements of Earth's systems through the cycling of water and human practices and processes with Earth's resources. They also learn that matter and energy cycle through plants and animals, and the ecosystems within which they live. An ability to describe, analyze and model observable components of different systems is key to understanding the natural and designed world.

## Grade 5: Earth and Space Sciences

<b>5-ESS1</b>	<b>Earth's Place in the Universe</b>
<b>5-ESS1-1.</b>	<b>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.</b> [Assessment Boundary: Assessment does not include other factors that affect apparent brightness (such as stellar masses, age, stage).]
<b>5-ESS1-2.</b>	<b>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 position of the sun, moon and constellations at different times during a day, over a month, and over a year.</b> [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 Earth's rotation about its axis.] [Assessment Boundary: Assessment does not include causes of seasons nor expect use of Earth's tilt.]
<b>5-ESS2</b>	<b>Earth's Systems</b>
<b>5-ESS2-1.</b>	<b>Use a model to describe the cycling of water on Earth between the geosphere, biosphere, hydrosphere, and atmosphere through evaporation, precipitation, surface runoff, condensation, transpiration, and runoff.</b> [Assessment Boundary: Assessment does not include explanations of mechanisms that drive the cycle.]
<b>5-ESS2-2.</b>	<b>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.</b> [Clarification Statement: Nearly all of Earth's available water is in the ocean; most fresh water is in glaciers or underground.] [Assessment Boundary: Assessment does not include the atmosphere.]
<b>5-ESS3</b>	<b>Earth and Human Activity</b>
<b>5-ESS3-1.</b>	<b>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.</b> [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.] [Assessment Boundary: Assessment does not include social science aspects of practices such as regulation or policy.]
<b>5-ESS3-2(MA).</b>	<b>Test a simple system designed to filter an impurity out of water and propose one change to the design to improve it.*</b> [Clarification Statement: Examples of impurities could include particulates or bacteria.]

## Grade 5: Life Science

### 5-LS1 From Molecules to Organisms: Structures and Processes

**5-LS1-1. Support an argument with evidence that plants get the materials they need for growth and reproduction chiefly through a process in which they use air, water, and energy from the sun to produce sugars and plant materials .** [Assessment Boundary: The chemical formula or details about the process of photosynthesis is not expected.]

### 5-LS2 Ecosystems: Interactions, Energy, and Dynamics

**5-LS2-1. Develop a model of a food web to describe the movement of matter among producers, primary and secondary consumers, decomposers, and the air and soil in the environment: a. show that plants produce sugars and plant materials; b. show that some animals eat plants for food and other animals eat the animals that eat plants; 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. Waste includes matter in the form of gasses (such as air), liquids (such as water), or solids (such as minerals or nutrients).] [Assessment Boundary: Assessment does not include molecular explanations.]

**5-LS2-2(MA). Compare at least two designs for a composter to determine which is most likely to encourage decomposition of materials.\*** [Assessment Boundary: Assessment is limited to qualitative descriptions or comparisons of decomposition.]

## 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, phase changes between gas and liquid, and dissolving.** [Clarification Statement: Examples of common phenomena the model should be able to describe include adding air to expand a basketball, compressing air in a syringe, dissolving sugar in water, and evaporating salt water.] [Assessment Boundary: Assessment does not include the atomic-scale mechanism of evaporation and condensation or defining the unseen particles.]

**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.] [Assessment Boundary: Assessment does not include distinguishing mass and weight.]

**5-PS1-3. Make observations and measurements to identify substances based on their unique properties, including color, hardness, reflectivity, electrical conductivity, thermal conductivity, response to magnetic forces, and solubility.** [Clarification Statement: Examples of substances to be identified could include baking soda and other powders, metals, minerals, and liquids.] [Assessment Boundary: Assessment does not include density or distinguishing mass and weight.]

**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.** [Assessment Boundary: Assessment does not include mathematical representation of gravitational force.]

### 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.] [Assessment Boundary: Details of photosynthesis or respiration are not expected.]

## Grade 6: Overview

### *Structure and Function*

In Grade 6 students inquire about the structure and function of the world around them. The integration of earth, life, and physical sciences with technology/engineering gives students relevant and engaging opportunities with natural phenomena and design problems that provide the foundation for more abstract and complex topics through grade 7 and 8. Grade 6 students start with a framework that relates structure and function of the macro and microscopic world and introduces scale and time in all science and technology/engineering domains. Students use models and provide evidence to make claims and explanations about structure-function relationships in different science and technology/engineering domains.

## Grade 6: Earth and Space Sciences

Grade 6 MS-ESS1 Earth's Place in the Universe
<b>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.</b> [Clarification Statement: Examples of models can be physical, graphical, or conceptual and should emphasize relative positions and distances.]
<b>MS-ESS1-4. Analyze and interpret rock layers and index fossils to determine the relative ages of rock formations. Explain that these sources of evidence, along with radiometric dating, are used to construct the geologic time scale of Earth's history.</b> [Clarification Statement: Analysis includes Laws of Superposition and Crosscutting Relationships. Not all organisms are fossilized.] [Assessment Boundary: Assessment is limited to minor displacement faults that offset layers and does not include strata sequences that have been reordered or overturned. Assessment does not include recalling the names of specific periods or epochs and events within them, nor specifics of radiometric dating.]
<b>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.</b> [Clarification Statement: Graphical displays can include maps, charts, graphs, or data tables.]
[Note: MS-ESS1-1b and MS-ESS1-2 are found in Grade 8. MS-ESS1-3 from NGSS is not included.]

Grade 6 MS-ESS2 Earth's Systems
<b>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.</b> [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).] [Assessment Boundary: Paleomagnetic anomalies in oceanic and continental crust are not assessed. Does not include mechanisms for plate motion.]
[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
<p><b>MS-LS1-1.</b> 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.]</p> <p><b>MS-LS1-2.</b> Develop and use a model to describe the ways parts of cells contribute to key cellular functions of obtaining nutrients and water from its environment, disposing of waste, and producing energy: a. the nucleus contains genetic information (DNA) which regulates a cell's activities; b. chloroplasts are the site of photosynthesis which produces necessary glucose and oxygen; c. mitochondria facilitate cellular respiration (energy production); d. vacuoles store materials, including water, nutrients and waste; e. the cell membrane is a protective 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. [Clarification Statement: Functions should focus on basic survival needs.] [Assessment Boundary: Assessment does not include specific biochemical steps or chemical processes, ATP, or active transport through the cell membrane.]</p> <p>[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.]</p>

Grade 6 MS-LS4 Biological Evolution: Unity and Diversity
<p><b>MS-LS4-1.</b> 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 an environment, anatomical structures that indicate the function of an organism in the environment, and fossilized tracks that indicate behavior of organisms.] [Assessment Boundary: Assessment does not include the names of individual species, geological eras in the fossil record, nor mechanisms for extinction or speciation.]</p> <p><b>MS-LS4-2.</b> Construct an argument using anatomical structures to support evolutionary relationships among and between fossil organisms and modern organisms. Include evidence showing that: 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 over time, their environments have changed.</p> <p>[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.]</p>

## Grade 6: Physical Science

Grade 6 MS-PS1 Matter and Its Interactions
<p><b>MS-PS1-6.</b> Plan and conduct an experiment using exothermic and endothermic reactions to explain that the type and concentration of the reacting substances affects the amount of thermal energy released or absorbed. [Clarification Statement: Examples of chemical reactions could include dissolving ammonium chloride or calcium chloride.] [Assessment Boundary: Assessment is limited to factors of concentration, time, and change in thermal energy (measured by temperature).]</p> <p><b>MS-PS1-7(MA).</b> Use a particulate model of matter to explain that density is the amount of matter (mass) in a given volume. Measure the mass and volume of regular and irregular shaped objects and calculate their density.</p> <p><b>MS-PS1-8(MA).</b> Conduct an experiment to show that many materials are mixtures of pure substances that can be separated into the component pure substances. [Clarification Statement: Examples of common mixtures include salt water, oil and vinegar, milk, concrete, and air.]</p> <p>[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.]</p>



**Grade 6 MS-PS2 Motion and Stability: Forces and Interactions**

**MS-PS2-4.** Use evidence to support the claim that gravitational interactions 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.] [Assessment Boundary: Assessment does not include Newton's Law of Gravitation or Kepler's Laws.]

[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.]

**Grade 6 MS-PS4 Waves and Their Applications in Technologies for Information Transfer**

**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. [Assessment Boundary: Assessment does not include electromagnetic waves and is limited to standard repeating waves.]

**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.] [Assessment Boundary: Assessment is limited to qualitative applications.]

**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. [Assessment Boundary: Assessment does not include binary counting nor the specific mechanism of any given device.]

## Grade 6: Technology/Engineering

**Grade 6 MS-ETS1 Engineering Design**

**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.\*

**MS-ETS1-5(MA).** Create visual representations of solutions to a design problem. Accurately interpret and apply scale and proportion to visual representations.\* [Clarification Statement: Examples of visual representations can include sketches, scaled drawings, and orthographic projections. Examples of scale can include  $\frac{1}{4}'' = 1'0''$ ,  $1\text{ cm} = 1\text{ m}$ .]

**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.]

**Grade 6 MS-ETS2 Materials, Tools and Manufacturing**

**MS-ETS2-1(MA).** Analyze and compare properties of metals, plastics, wood and ceramics, including stiffness, strength, ductility, hardness, thermal conductivity, electrical conductivity, and melting point.

**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.]

**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.]

**MS-ETS2-4(MA).** Analyze the shape, form, size and materials of a designed object to infer the function for which it was designed.

[Note: MS-ETS2-5(MA), MS-ETS2-6(MA), and MS-ETS2-7(MA) are found in Grade 8.]



## Grade 7: Overview

### *Systems and Cycles*

Students in grade 7 focus on systems and cycles to build a systems perspective using their understanding of structures and elements developed in earlier grades. A focus on systems requires students to interpret information and apply concepts and skills in the broad context of the discipline, and thus make connections between different domains of knowledge. Standards in grade 7 highlight interdisciplinary connections within and across domains since most natural and designed systems and cycles are complex and interactive. Students begin a process of building expert knowledge, moving from a more concrete to an abstract perspective and creating a foundation for exploring cause and effect relationships in more depth in grade 8. They have experience in observing structure of cells, body systems, matter, the Earth, measuring changes in energy, and applying these ideas to systems and cycles that span domains.

## Grade 7: Earth and Space Sciences

Grade 7 MS-ESS2 Earth's Systems
<p><b>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 and operate at times ranging from fractions of a second to billions of years.</b> [Clarification Statement: Examples of processes occurring over large spatial and time scales include plate motion and ice ages. Examples of changes occurring over small spatial and time scales include earthquakes and seasonal weathering and erosion.]</p> <p><b>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.</b> [Clarification Statement: Examples of models can be conceptual or physical.] [Assessment Boundary: A quantitative understanding of the latent heats of vaporization and fusion is not assessed.]</p> <p>[Note: MS-ESS2-3 is found in Grade 6. MS-ESS2-1, MS-ESS2-5 and MS-ESS2-6 are found in Grade 8.]</p>

Grade 7 MS-ESS3 Earth and Human Activity
<p><b>MS-ESS3-1. Interpret data to explain that the Earth's mineral, fossil fuel, and groundwater resources are unevenly distributed as a result of geologic processes.</b> [Clarification Statement: Examples of uneven distributions of resources can include petroleum (locations of the burial of organic marine sediments and subsequent geologic traps), metal ores (locations of past volcanic and hydrothermal activity associated with subduction zones), and soil (locations of active weathering and/or deposition of rock).]</p> <p><b>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.</b> [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.] [Assessment Boundary: Assessment does not include analysis of data nor forecasting.]</p> <p><b>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.</b> [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.]</p> <p>[Note: MS-ESS3-5 is found in Grade 8. MS-ESS3-3 from NGSS has been merged with MS-ESS3-4.]</p>

## Grade 7: Life Science

Grade 7 MS-LS1 From Molecules to Organisms: Structures and Processes
<p><b>MS-LS1-3. Develop an argument supported by evidence that the body systems interact to carry out key body functions, including providing nutrients and oxygen to cells, removing carbon dioxide and waste from cells and the body, controlling body motion/activity and coordination, and protecting the body.</b> [Clarification Statement: Body systems to be included are the circulatory, excretory, digestive, respiratory, muscular/skeletal and nervous systems. Emphasis is on the function and interactions of the body systems, not specific body parts or organs.] [Assessment Boundary: Assessment does not include the mechanism of one body system independent of others.]</p> <p><b>MS-LS1-4. Explain, based on evidence, how characteristic animal behaviors as well as specialized plant structures increase the probability of successful reproduction of animals and plants respectively.</b> [Clarification Statement: Examples of animal behaviors that affect the probability of animal reproduction could include nest building to protect young from cold, 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.] [Assessment Boundary: Assessment does not include natural selection.]</p> <p>[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.]</p>

Grade 7 MS-LS2 Ecosystems: Interactions, Energy, and Dynamics
<p><b>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.</b></p> <p><b>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.</b> [Clarification Statement: Emphasis is on describing consistent patterns of interactions in different ecosystems in terms of relationships among and between organisms.]</p> <p><b>MS-LS2-3. Develop a model to describe the cycling of matter among living and nonliving parts of an ecosystem including through the process of photosynthesis and cellular respiration.</b> [Clarification Statement: Emphasis is on a general understanding of cycling of matter in an ecosystem.] [Assessment Boundary: Assessment does not include cycling of specific atoms (such as carbon or oxygen), nor the biochemical steps of photosynthesis or cellular respiration.]</p> <p><b>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.</b> [Clarification Statement: Focus should be on ecosystems characteristics varying over time, including disruptions such as hurricanes, floods, wildfires, oil spills, and construction.]</p> <p><b>MS-LS2-5. Evaluate competing design solutions for protecting an ecosystem. Discuss benefits and limitations of each design.*</b> [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.]</p> <p><b>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.</b> [Clarification Statement: Examples of resources can include food, energy, medicine, and clean water.]</p> <p><b>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.</b> [Clarification Statement: Student should be able to predict changes in relative sizes of populations based on food webs.]</p>

## Grade 7: Physical Science

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

- MS-PS2-3.** Describe the effect of distance and magnitude of electric charge and current on the size of electromagnetic forces. [Clarification Statement: Includes both attractive and repulsive forces.] [Assessment Boundary: Assessment is limited to proportional reasoning and algebraic thinking.]
- 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. [Assessment Boundary: Assessment is limited to electric and magnetic fields, and limited to qualitative evidence for the existence of fields.]

[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

- MS-PS3-1.** Construct and interpret data and graphs to describe the relationships among kinetic energy, mass, and speed of an object. [Clarification Statement: Examples could include riding a bicycle at different speeds and rolling different size rocks downhill.] [Assessment Boundary: Assessment is limited to relationships between kinetic energy vs. mass and kinetic energy vs. Speed separate from each other.]
- 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.] [Assessment Boundary: Assessment is limited to two objects and electric, magnetic, and gravitational interactions, and does not include calculations of potential energy.]
- 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.] [Assessment Boundary: Assessment does not include calculating the total amount of thermal energy transferred, nor account for specific heat.]
- MS-PS3-4.** 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. [Assessment Boundary: Assessment does not include calculating the total amount of thermal energy transferred nor calculations of specific heat.]
- 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.] [Assessment Boundary: Assessment does not include calculations of energy.]
- MS-PS3-6(MA).** Explain how thermal energy is transferred out of hotter regions or objects and into colder ones by convection, conduction and radiation.
- MS-PS3-7(MA).** Describe the relationship between kinetic and potential energy and describe conversions from one form to another. [Clarification Statement: Types of kinetic energy include motion, sound, and radiation; types of potential energy include gravitational, elastic, and chemical.]

## Grade 7: Technology/Engineering

### Grade 7 MS-ETS1 Engineering Design

**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.\*

**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.\*

**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

**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.

**MS-ETS3-2(MA).** Compare the benefits and drawbacks of four different communication systems: radio, television, print, and internet.

**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.]

**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), or 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.]

**MA-ETS3-5(MA).** Use the concept of systems engineering to: a. analyze how components of a transportation, structural or communication system work together or affect each other, and b. model the inputs, processes, outputs, and feedback of a technological system.

## Grade 8: Overview

### *Cause and Effect*

Grade 8 students use more robust abstract thinking skills to explain causes of the more complex phenomena and systems. Many causes are not immediately or physically visible to students. Students wrestle with the “why” of science, to deal with unseen mechanisms at work, to make predictions about future events, and to explain patterns. In grade 8 these include, for example, causes of seasons and tides, causes of plate tectonics and weather or climate, the role of genetics in heredity and natural selection, and understanding interactions of atoms and molecules (from a more general particulate model in prior grades). Being able to analyze phenomena for evidence of causes and processes that often cannot be seen, and being able to conceptualize and describe those, is a significant cognitive transition for students in grade 8.

## Grade 8: Earth and Space Sciences

Grade 8 MS-ESS1 Earth's Place in the Universe
<p><b>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.</b> [Clarification Statement: Examples of models can be physical, graphical, or conceptual.]</p> <p><b>MS-ESS1-2. Explain the role of gravity in ocean tides, the orbital motions of planets, their moons, and asteroids in the solar system.</b> [Assessment Boundary: Assessment does not include Kepler's Laws of orbital motion or the apparent retrograde motion of the planets as viewed from Earth.]</p> <p>[Note: MS-ESS1-1a, MS-ESS1-4, MS-ESS1-5 and MS-ESS1-6 are found in Grade 6. MS-ESS1-3 from NGSS is not included.]</p>

Grade 8 MS-ESS2 Earth's Systems
<p><b>MS-ESS2-1. Develop and 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.</b> [Clarification Statement: The emphasis is on large-scale cycling resulting from plate tectonics that includes changes in rock types through erosion, heat and pressure.] [Assessment Boundary: Assessment does not include specific mechanisms of plate tectonics, the identification and naming of minerals or rock types, nor rote memorization of the “rock cycle”.]</p> <p><b>MS-ESS2-5. Interpret basic weather data to identify patterns in air mass interactions and the relationship of those patterns to weather.</b> [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, 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.] [Assessment Boundary: Assessment does not include recalling the names of cloud types or weather symbols used on weather maps or the reported diagrams from weather stations.]</p> <p><b>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.</b> [Clarification Statement: Emphasis of ocean circulation is on the transfer of heat by the global ocean convection cycle, which is constrained by the Coriolis effect and the outlines of continents. A regional scale includes a state or multi-state perspective.] [Assessment Boundary: Assessment does not include Koppen Climate Classification names.]</p> <p>[Note: MS-ESS2-3 is found in Grade 6. MS-ESS2-2 and MS-ESS2-4 are found in Grade 7.]</p>

### Grade 8 MS-ESS3 Earth and Human Activity

**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 Statement: 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.]

## Grade 8: Life Science

### Grade 8 MS-LS1 From Molecules to Organisms: Structures and Processes

**MS-LS1-5. Construct a scientific explanation 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.] [Assessment Boundary: Assessment does not include methods of reproduction, genetic mechanisms, gene regulation, biochemical processes, or natural selection.]

**MS-LS1-7. Describe that food molecules, including carbohydrates, proteins and fats, are broken down and rearranged through chemical reactions forming new molecules that support growth and/or release of energy.** [Clarification Statement: Emphasis is on describing that molecules are broken apart and rearranged and that in these processes result in cell growth and energy release.] [Assessment Boundary: Assessment does not include 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).]

[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

**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.] [Assessment Boundary: Assessment does not include specific changes at the molecular level (e.g., amino acid sequence change), mechanisms for protein synthesis, or specific types of mutations.]

**MS-LS3-2. Develop and use a model to describe 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 models can include Punnett squares, diagrams, and simulations. 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.]

**MS-LS3-3(MA). Communicate through writing and in diagrams that chromosomes contain many distinct genes, and that each chromosome pair contains two alleles that can be the same or different from each other. Illustrate that each gene holds the instructions for the production of specific proteins, which in turn affects the traits of an individual.** [Assessment



Boundary: Assessment does not include specific changes at the molecular level or mechanisms for protein synthesis.]

**MS-LS3-4(MA).** Develop and use a model to show that in sexually reproducing organisms individuals have two of each chromosome, and hence two alleles of each gene, one acquired (randomly) from each parent. [Clarification Statement: Examples of models can include Punnett squares, diagrams, and simulations.] [Assessment Boundary: Assessment should only include dominant-recessive pattern of inheritance.]

#### Grade 8 MS-LS4 Biological Evolution: Unity and Diversity

**MS-LS4-4.** Explain the mechanism 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: Explanations should include simple probability statements and proportional reasoning.]

**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

**MS-PS1-1.** Develop a model to describe that combine in a multitude of ways to produce substances which make up all of the living and nonliving things that we encounter. [Clarification Statement: Examples of molecular-level models could include drawings, 3D ball and stick structures, or computer representations showing different molecules with different types of atoms.] [Assessment Boundary: Assessment does not include valence electrons and bonding energy, discussing the ionic nature of subunits of complex structures, or a complete depiction of all individual atoms in a complex molecule or extended structure.]

**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 Statement: 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.]

**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.]

**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.] [Assessment Boundary: Assessment does not include the use of atomic masses, balancing symbolic equations, or intermolecular forces.]

**MS-PS1-9(MA).** Present evidence to support the claims 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.

[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.]

**Grade 8 MS-PS2 Motion and Stability: Forces and Interactions**

**MS-PS2-1. Develop a model that demonstrates Newton's third law involving the motion of two colliding objects.** [Assessment Boundary: Assessment is limited to vertical or horizontal interactions in one dimension.]

**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.] [Assessment Boundary: Assessment is limited to forces and changes in motion in one dimension in an inertial reference frame and to change in one variable at a time. Assessment does not include the use of trigonometry.]

[Note: MS-PS2-4 is found in Grade 6. MS-PS2-3 and MS-PS3-5 are found in Grade 6.]

## Grade 8: Technology/Engineering

**Grade 8 MS-ETS2 Materials, Tools and Manufacturing**

**MS-ETS2-5(MA). Recognize 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 Statement: 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 or a plastic material becoming rigid (less elastic) after heat treatment, or.]

**MS-ETS2-6(MA). Describe how a product can be created using basic processes in manufacturing systems, including forming, separating, conditioning, assembling, finishing, quality control, and safety.**

**MS-ETS2-7(MA). Recognize that processes that transform materials into products can be controlled by humans or by computers.** [Clarification Statement: Computer-aided processes are robotic or automated manufacturing.]

[Note: MS-ETS2-1(MA), MS-ETS2-2(MA), MS-ETS2-3(MA), and MS-ETS2-4(MA) are found in Grade 6.]

**Grade 8 MS-ETS4 Energy and Power Technologies**

**MS-ETS4-1(MA). Explain how a machine converts energy, through mechanical means, to do work.**



## Earth and Space Science (Grade 9 or 10)

Earth and Space Science HS-PS1 Matter and Its Interactions
<p><b>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.</b> [Clarification Statement: Examples of models include simple qualitative models, such as pictures or diagrams.] [Assessment Boundary: Assessment does not include quantitative calculation of energy released or absorbed. Assessment is limited to alpha, beta, and gamma radioactive decays.]</p> <p>[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.]</p>

Earth and Space Science HS-ESS1 Earth's Place in the Universe
<p><b>HS-ESS1-1. Explain that the life span of the sun over approximately 10 billion years is a function of nuclear fusion in its core.</b></p> <p><b>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).</b></p> <p><b>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.</b> [Assessment Boundary: Details of the many different nucleosynthesis pathways for stars of differing masses are not assessed.]</p> <p><b>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.</b> [Clarification Statement: Kepler's Laws apply to human-made satellites as well as planets, moons, and other objects.] [Assessment Boundary: Calculations involving Kepler's Laws of orbital motions should not deal with more than two bodies, nor involve calculus.]</p> <p><b>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.</b> [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).]</p> <p><b>HS-ESS1-7(MA). 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.</b></p> <p>[Note: HS-ESS1-6 from NGSS is not included.]</p>

Earth and Space Science HS-ESS2 Earth's Systems
<p><b>HS-ESS2-2. Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth's systems.</b> [Clarification Statement: Examples should include climate feedbacks, such as how an increase in greenhouse gases causes a rise in global temperatures that melts glacial ice, which reduces the amount of sunlight reflected from Earth's surface, increasing surface temperatures and further reducing the amount of ice. Examples could also be taken from other system interactions, such as 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; or how the loss of wetlands causes a decrease in local humidity that further reduces the wetland extent.]</p> <p><b>HS-ESS2-3. Use a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection.</b> [Clarification Statement: Emphasis is on both a one-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</p>

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 result in changes in climate.** [Clarification Statement: Examples of the causes of climate change differ by timescale, over 1-10 years: large volcanic eruption, ocean circulation; 10-100s of years: changes in human activity, ocean circulation, solar output; 10-100s of thousands of years: changes to Earth's orbit and the orientation of its axis; and 10-100s of millions of years: long-term changes in atmospheric composition.] [Assessment Boundary: Assessment of the results of changes in climate is 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, or 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) or melt generation (based on water lowering the melting temperature of most solids).]

**HS-ESS2-6. Use a model to describe the gradual atmospheric and climatic changes due to carbon capture and oxygen release by plants and due to increased carbon dioxide generation through human activity.**

[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, or atmosphere and ocean composition).] [Assessment Boundary: Assessment is limited to one example of a climate change and its associated impacts.]

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

## Biology (Grade 9 or 10)

Biology HS-LS1 From Molecules to Organisms: Structures and Processes	
HS-LS1-1.	<b>Explain that genes are regions in the DNA that code for proteins, which carry out the essential functions of life. Construct a model of transcription and translation to explain the roles of DNA and RNA in coding the instructions for polypeptides, which make up proteins. Explain that different classes of proteins regulate and carry out the essential functions of life.</b> [Clarification Statement: Four classes of proteins that regulate and carry out the essential functions of life include: enzymes (speeding up chemical reactions), structural proteins (providing structure and enabling movement), hormones (sending signals between cells), and antibodies (fighting disease).] [Assessment Boundary: Assessment does not include specific names of proteins or rote memorization of steps of transcription and translation.]
HS-LS1-2.	<b>Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within animals. Use the model to illustrate that: a. different types of cells contain different sets of proteins which enables the cells to perform specific functions; b. specialized cells work together to form specialized tissues, which in turn join to form specialized organs; and c. specialized organs work together to form the body systems that coordinate to carry out the essential functions of life.</b> [Clarification Statement: Emphasis is on functions at the organism system level such as nutrient uptake, water delivery, and organism movement in response to neural stimuli. Animal body systems include circulatory, excretory, digestive, respiratory, muscular/skeletal, endocrine and nervous systems. Examples of interacting systems could include an artery depending on the proper function of elastic tissue and smooth muscle to regulate and deliver the proper amount of blood within the circulatory system.] [Assessment Boundary: Assessment does not include interactions and functions at the molecular or chemical reaction level. Assessment does not include the identification of specific proteins in cells. Assessment is limited to include major organs, such a lungs, stomach, small intestine, liver, heart and kidneys.]
HS-LS1-3.	<b>Provide evidence that feedback mechanisms promote (through positive feedback) or inhibit (through negative feedback) activities within an organism to maintain homeostasis.</b> [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.] [Assessment Boundary: Assessment does not include sub-cellular processes involved in the feedback mechanism nor interactions at the molecular level.]
HS-LS1-4.	<b>Explain 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.</b> [Assessment Boundary: Assessment does not include specific gene control mechanisms or rote memorization of steps of mitosis.]
HS-LS1-5.	<b>Use a model to illustrate how photosynthesis uses light energy to transform carbon dioxide and water into oxygen and chemical energy stored in the bonds of glucose and other carbohydrates.</b> [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.] [Assessment Boundary: Assessment does not include specific biochemical steps of light reactions or the Calvin Cycle, or chemical structures of molecules.]
HS-LS1-6.	<b>Construct and revise an explanation based on evidence that macromolecules are primarily composed of six elements, where carbon, hydrogen, and oxygen atoms from carbohydrates may combine with nitrogen, sulfur, and phosphorus to form large carbon-based molecules.</b> [Clarification Statement: Large carbon-based molecules included are proteins, carbohydrates, amino acids, nucleic acids, and lipids.] [Assessment Boundary: Assessment does not include the details of the specific chemical reactions or identification of specific macromolecules.]
HS-LS1-7.	<b>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. Contrast this process to anaerobic cellular respiration and compare the amount of energy released in each process.</b> [Clarification Statement: Emphasis is on the conceptual understanding of the inputs and outputs of the process of cellular respiration, lactic acid fermentation and alcoholic fermentation. Students should understand that molecules other than glucose can be broken down to release energy in the form of ATP. Examples of models could include diagrams, chemical equations, and conceptual models.] [Assessment Boundary:

Assessment should not include identification of the steps or specific processes involved in either aerobic or anaerobic cellular respiration.]

**HS-LS1-8(MA).** 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).** 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 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.] [Assessment Boundary: Assessment is limited to provided data.]

**HS-LS2-3.** Construct and revise an explanation based on evidence that the processes of photosynthesis, chemosynthesis, and aerobic and anaerobic respiration are responsible for the cycling of matter and flow of energy through ecosystems. Explain that environmental conditions restrict which reactions can occur. [Clarification Statement: Examples of environmental conditions can include the availability of sunlight or oxygen.] [Assessment Boundary: Assessment does not include the specific chemical processes of photosynthesis, chemosynthesis, of either aerobic respiration or anaerobic respiration.]

**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. 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. [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, and biomass. Examples of models could include simulations and mathematical models.] [Assessment Boundary: Assessment does not include the specific chemical steps of photosynthesis, respiration, decomposition, and combustion.]

**HS-LS2-6.** Evaluate the claims, evidence, and reasoning 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. Analyze data to provide 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 from parents to offspring through the processes of meiosis and fertilization in sexual reproduction. [Assessment Boundary: Assessment does not include rote memorization of the phases of meiosis or the biochemical mechanism of specific steps in the process.]

**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.] [Assessment Boundary: Assessment does not include rote memorization of the phases of meiosis nor identification of specific types of mutations.]

**HS-LS3-3.** Explain that: a. genes have variations (alleles) that code for specific variants of a protein (or RNA), and therefore specific traits of an individual; b. an individual's characteristics (phenotype) result, in part, from complex relationships among the various proteins (and RNAs) expressed by one or more genes; and c. the environment can affect 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-affected regions of the globe, such as Africa, because it confers partial resistance to malaria.] [Assessment Boundary: Assessment does not include Hardy-Weinberg calculations.]

**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: (1) more offspring are produced than can be supported by the environment, (2) there is heritable variation among individuals, and (3) some of these variations lead to differential fitness among individuals as some individuals are better able to compete for limited resources than others. The result is the proliferation of those individuals with advantageous heritable traits that are better able to survive and reproduce in the environment.

**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.

**HS-LS4-4.** Construct an explanation based on evidence for how genetic drift and gene flow together with natural selection lead to populations that have more individuals with behavioral, anatomical, and physiological adaptations.

**HS-LS4-5.** Evaluate evidence 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-LS4-6 from NGSS is not included.]



## Chemistry (Grade 10)

Chemistry HS-PS1 Matter and Its Interactions
<p><b>HS-PS1-1.</b> 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. [Assessment Boundary: Assessment is limited to main group (s and p block) elements.]</p>
<p><b>HS-PS1-2.</b> 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 Statement: Simple combination reactions include synthesis (combination), decomposition, single displacement, double displacement, or combustion.] [Assessment Boundary: Assessment is limited to chemical reactions involving main group (s and p block) elements and combustion reactions.]</p>
<p><b>HS-PS1-3.</b> 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 composition, melting point and boiling point, vapor pressure, and surface tension.] [Assessment Boundary: Assessment does not include Raoult's law calculations of vapor pressure. Properties of heterogeneous mixtures are not assessed. Names of specific intermolecular forces (such as dipole-dipole) are not assessed.]</p>
<p><b>HS-PS1-4.</b> 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.]</p>
<p><b>HS-PS1-5.</b> 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: quantity of collisions per unit time, molecular orientation on collision, and 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.] [Assessment Boundary: Assessment is limited to simple reactions in which there are only two reactants and to specifying the change in only one variable at a time.]</p>
<p><b>HS-PS1-6.</b> 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.] [Assessment Boundary: Assessment does not include calculating equilibrium constants or concentrations. Assessment is limited to simple reactions in which there are only two reactants and to specifying the change in only one variable at a time.]</p>
<p><b>HS-PS1-7.</b> 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.] [Assessment Boundary: Calculations may involve mass-to-mass stoichiometry and atom economy comparisons, but only for single-step reactions that do not involve complexes.]</p>
<p><b>HS-PS1-9(MA).</b> Recognize that the strength of an aqueous acidic or basic solution is determined by the hydronium ion concentration. Use the Arrhenius and Bronsted-Lowry acid-base reaction</p>

<p>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.] [Assessment Boundary: 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.]</p> <p><b>HS-PS1-10(MA).</b> 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.] [Assessment Boundary: 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.]</p> <p><b>HS-PS1-11(MA).</b> 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).]</p> <p><b>HS-PS1-12(MA).</b> 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<sub>2</sub>CO<sub>3</sub>, Fe<sub>2</sub>O<sub>3</sub>); and substances that are liquids and gasses at room temperature are usually made of molecules which have covalent bonds (common examples include CO<sub>2</sub>, N<sub>2</sub>, CH<sub>4</sub>, H<sub>2</sub>O, C<sub>8</sub>H<sub>18</sub>, C<sub>12</sub>H<sub>22</sub>O<sub>11</sub>).]</p> <p><b>HS-PS1-13(MA).</b> 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.</p> <p>[Note: HS-PS1-8 is found in Earth and Space Science.]</p>
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<p><b>Chemistry HS-PS2 Motion and Stability: Forces and Interactions</b></p> <p><b>HS-PS2-6.</b> 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.] [Assessment Boundary: Assessment is limited to VESPR, polymers, ionic compounds, isomers, and metals.]</p> <p><b>HS-PS2-7(MA).</b> 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.]</p> <p><b>HS-PS2-8(MA).</b> 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.</p> <p>[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.]</p>
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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.]**



## Introductory Physics (Grade 9 or 10)

Introductory Physics HS-PS2 Motion and Stability: Forces and Interactions
<p><b>HS-PS2-1.</b> Analyze data to support the claim that Newton’s second law of motion is a mathematical model describing motion and change in motion (acceleration) of objects with mass when acted on by a net force. Use free-body force diagrams and algebraic expressions representing Newton’s laws of motion to predict changes to velocity and acceleration for an object moving in one dimension in various situations. [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, or a moving object being pulled by a constant force. Predictions of changes in motion can be made numerically, graphically, and algebraically using basic equations for velocity, average speed and constant acceleration.]</p>
<p><b>HS-PS2-2.</b> Use mathematical representations to show that the total momentum of a system of interacting objects moving in one dimension 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.]</p>
<p><b>HS-PS2-3.</b> 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.]</p>
<p><b>HS-PS2-4.</b> 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.] [Assessment Boundary: Assessment is limited to systems with two objects and does not include permittivity of free space.]</p>
<p><b>HS-PS2-5.</b> Provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current.</p>
<p><b>HS-PS2-9(MA).</b> Analyze simple arrangements of electrical components in both series and parallel circuits. Use appropriate instruments to measure the voltage across and current through a resistor. Use Ohm’s Law to determine the resistance in a circuit when given the voltage and current.</p>
<p>[Note: HS-PS2-6, HS-PS2-7(MA), and HS-PS2-8(MA) are found in Chemistry.]</p>

Introductory Physics HS-PS3 Energy
<p><b>HS-PS3-1.</b> 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. [Assessment Boundary: Assessment is limited to systems of two or three components; and to thermal energy, kinetic energy, and/or the energies in gravitational, magnetic, or electric fields.]</p>
<p><b>HS-PS3-2.</b> 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 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.]</p>
<p><b>HS-PS3-3.</b> 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.] [Assessment Boundary: Assessment for quantitative evaluations is limited to total output for a given input.]</p>
<p><b>HS-PS3-4a.</b> Provide evidence that when two objects of different temperature are in thermal contact within a closed system, the transfer of thermal energy results in thermal equilibrium, or a</p>

more uniform energy distribution among the objects (second law of thermodynamics) and that temperature changes at 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 electric or magnetic fields to illustrate the forces and changes in energy between two magnetically or electrically charged objects changing relative position in a field.** [Clarification Statement: 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 in various media. Recognize that electromagnetic waves can travel through empty space (without a medium).** [Clarification Statement: 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 (if applicable).] [Assessment Boundary: Assessment is limited to algebraic relationships and not to include Snell's Law.]

**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 explaining reflection, refraction, resonance, interference, diffraction, and the photoelectric effect, one model is more useful than the other.** [Clarification Statement: Includes both transverse (including electromagnetic) and longitudinal mechanical waves.]

**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 interference.] [Assessment Boundary: Assessments are limited to qualitative information. Assessments do not include band theory.]

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

## Technology/Engineering (Grade 9 or 10)

Technology/Engineering HS-ETS1 Engineering Design
<p><b>HS-ETS1-1.</b> 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.]</p> <p><b>HS-ETS1-2.</b> Break a complex real-world problem into smaller, more manageable problems that each can be solved using scientific and engineering principles.*</p> <p><b>HS-ETS1-3.</b> 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.*</p> <p><b>HS-ETS1-4.</b> 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.*</p> <p><b>HS-ETS1-5(MA).</b> Plan a prototype or design solution using orthographic projections and isometric drawings, using proper scales and proportions.*</p> <p><b>HS-ETS1-6(MA).</b> Document and present solutions that include specifications, performance results, successes and remaining issues, and limitations.*</p>
Technology/Engineering HS-ETS2 Materials, Tools and Manufacturing
<p><b>HS-ETS2-1(MA).</b> 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.] [Assessment Boundary: Assessment does not include specific manufacturing machines.]</p> <p><b>HS-ETS2-2(MA).</b> Explain that 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.]</p> <p><b>HS-ETS2-3(MA).</b> Compare the costs and benefits of custom versus mass production based on qualities of the desired product, the cost of each unit to produce, the number of units needed.</p> <p><b>HS-ETS2-4(MA).</b> 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. Create and interpret graphs that relate material properties to a desired performance condition a designed object must meet. [Clarification Statement: Examples of material properties can include strength, durability, hardness, and elasticity. Examples of graphs can include graphs of extension vs. load-as for an elastic material, or stiffness vs. temperature-as for metals.]</p>
Technology/Engineering HS-ETS3 Technological Systems
<p><b>HS-ETS3-1(MA).</b> Model a technological system in which the output of one subsystem becomes the input to other subsystems.</p> <p><b>HS-ETS3-2(MA).</b> 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).</p> <p><b>HS-ETS3-3(MA).</b> 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.]</p> <p><b>HS-ETS3-4(MA).</b> 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</p>

<p><b>properties.</b> [Clarification Statement: Examples of structures include bridges, houses, and skyscrapers. Examples of material properties can include elasticity, plasticity, thermal resistance, density, and strength.]</p> <p><b>HS-ETS3-5(MA).</b> 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.</p> <p><b>HS-ETS3-6(MA).</b> Describe 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.]</p>
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Technology/Engineering HS-ETS4 Energy and Power Technologies
<p><b>HS-ETS4-1(MA).</b> 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.]</p> <p><b>HS-ETS4-2(MA).</b> 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 Statement: 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.]</p> <p><b>HS-ETS4-3(MA).</b> Calculate and describe the ability of a hydraulic system to multiply distance, multiply force, and effect directional change.</p>