**Science & Technology/Engineering Standards: Connections to the Mathematics and English Language Arts/Literacy standaRds**

**Grades Pre-Kindergarten to 12**

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Science and Technology/Engineering Curriculum Framework Overview

The Massachusetts [2016 Science and Technology/Engineering (STE) Curriculum Framework](http://www.doe.mass.edu/stem/ste/) provides guidance on teaching and learning for pre-K–12 science and engineering educators, administrators, professional development providers and curriculum developers. The Framework sets forth a vision that by end of grade 12, *all* students have an appreciation for the wonder of science, possess sufficient knowledge of science and engineering to engage in public discussions on related issues, and are careful consumers of scientific and technological information and products in their everyday lives.

Teaching and learning are at the heart of quality science and engineering education. The Framework presents standards as outcomes, or goals, that reflect what a student should know and be able to do. While each standard presents a discrete learning expectation, authentic and effective teaching often engages students with multiple standards at once, helping them make connections within and across content areas.

The Framework’s Guiding Principles provide an overview of qualities of an effective STE program. Guiding principle VI, “An effective science and technology/engineering program integrates STE learning with mathematics and disciplinary literacy,” supports the ideas presented in this document.

Purpose and Structure

Students experience and navigate the world as an integrated whole. Language, literacy, mathematics, science, technology, and engineering are seamlessly interwoven in our everyday lives. Within the set of [Massachusetts Curriculum Frameworks](http://www.doe.mass.edu/frameworks/current.html) there are many connections between standards across frameworks. Explicit cross-subject connections appear in the curriculum frameworks for ELA/literacy (see p. 74, 121, 151) and history/social science (see literacy standards for each grade). The ELA/literacy framework in particular acknowledges that “reading texts in history/social studies, science, mathematics builds a foundation of knowledge to give students the background to be better readers in all content areas. Students can gain this foundation only when the curriculum is intentionally and coherently structured to develop rich content knowledge within and across grades.”

This Connections document aims to provide a resource for educators and curriculum planners to draw from as they look for intersections between the 2016 Science and Technology/Engineering Curriculum Framework, the 2017 Mathematics Curriculum Framework, and the 2017 ELA/Literacy Curriculum Framework. Educators are encouraged to use this tool to purposefully plan, align, and recognize relationships across content to strengthen learning for all students. The document is not intended to be prescriptive or a curriculum guide, but rather a bank of ideas to which educators and curriculum planners can refer within the context of their own curriculum and teaching practices.

#### Criteria for Relevant Connections

All science and technology/engineering (STE) standards are listed in this document with a connection box that identifies standards at or before grade level from the 2017 Mathematics or English Language Arts and Literacy Curriculum Framework. A math or ELA/literacy standard connection is listed in a connection box associated with a set of STE standards if one of the following applies:

* The ELA/literacy and math connection standards listed are intended to be helpful to students to effectively master the grade level STE standard.
* The content of a math or ELA/literacy standard is stated or strongly alluded to in the STE standard in question. For example, if the word “probability” is stated in a STE standard, then the connection box will list a math standard for which students will know what the word probability means or how it applies to a specific context. These connections could be interpreted as grade level pre-requisite knowledge *or* as potential opportunities to create an interdisciplinary lesson/unit that addresses multiple standards.

The document is not an exhaustive list of connections as educators may find additional connections for their own purposes. This document may be updated as necessary. To add connections to the document, please email the STEM office at stem@doe.mass.edu.

Features and Design

The Connections document design is adapted from the [Next Generation Science Standards](http://www.nextgenscience.org/) and [*Framework for K-12 Science Education*](https://www.nap.edu/catalog/13165/a-framework-for-k-12-science-education-practices-crosscutting-concepts). The document is set up into multiple boxes that are designed to support a coherent vision of the standards by showing how the performance expectations in each standard connect to other standards.

#### Organization and Key

The STE standards are presented by grade level pre-K–8 with each grade focused on a grade-level theme (introductory paragraph at the beginning of each grade level) that links the standards and all four STE disciplines (Life, Physical, Earth and Space, and Technology/Engineering). High school standards are provided for five common introductory-level courses (Biology, Physics, Chemistry, Earth and Space, and Technology/Engineering). Standards are organized by disciplinary core ideas, consistently referenced throughout the grades.

A math or ELA/literacy standard in a connection box will include the code and language by which it is located in its respective framework and the STE standard with which the standard connects. In some instances, there are multiple STE standards that connect to a given math or ELA/literacy standard.

**Symbol:** Math and ELA/literacy standards that are listed with a **◊** (diamond) next to their code mean they are listed on the [STE strand map](http://www.doe.mass.edu/stem/standards/StrandMaps.html). The diamond emphasizes that these standards are pre-requisites to the associated STE standard.

**Labeling/Coding of the Standards**

The Massachusetts STE standards are labeled using the NGSS system, as shown in Figure 1:



The first component of each label indicates the grade (pre-K to grade 8) and/or span (middle or high school). The next component specifies the discipline and core idea. Finally, the number at the end of each label indicates the standard within the related set.

An example from the Connections document is shown in Figure 2:



**Connection Box Components**

The Connections document is composed of a series of smaller boxes. Refer to figure 2 on previous page for key. The top box is the STE standard(s) and underneath the standards (middle row) is a blue box with the science and engineering practices and an orange box with the disciplinary core ideas. Underneath those boxes (bottom row) are the connected mathematics and ELA/literacy standards. Description of the boxes:

**Science and Engineering Practices.** The blue box includes science and engineering practices that could be used with the standard above. The STE Curriculum Framework identifies eight essential science and engineering practices:

1. Asking questions (for science) and defining problems (for engineering).

2. Developing and using models.

3. Planning and carrying out investigations.

4. Analyzing and interpreting data.

5. Using mathematics and computational thinking.

6. Constructing explanations (for science) and designing solutions (for engineering).

7. Engaging in argument from evidence.

8. Obtaining, evaluating, and communicating information.

The science and engineering practices include the skills necessary to engage in scientific inquiry and engineering design. It is necessary to teach these in tandem with science and engineering content, so students develop an understanding and facility with the practices in appropriate contexts.

Most sets of standards emphasize only a few of the practices; however, all practices are emphasized within a grade band. Teachers should utilize several practices in any STE topic and need not be limited by the practice listed in the standard, which is only intended to guide instruction. The practices are considered *interchangeable* so that multiple practices (such as data analysis, modeling, and reasoning) can be used to learn the content of a particular standard, even if that practice is not listed in the standard. For the purposes of this document, the practices listed in the blue box match the practices listed in the STE standard. See Appendix II of the STE Curriculum Framework for more information.

**Disciplinary Core Ideas (DCI).** The orange box includes statements (Disciplinary Core Ideas) that list out some of the most essential ideas in the major science disciplines that all students should understand during their pre-K-12 education. Each disciplinary core idea (DCI) spans pre-K to high school, with each grade span representing a reconceptualization or more sophisticated understanding of how students think about the core idea.

The orange box contains the names of DCIs that briefly describe the content addressed at each grade band for each disciplinary core idea. See Appendix III of the STE Curriculum Framework for more information. DCIs that are listed as *secondary* to standards are a foundational idea building towards the content of the standard

**Connections to the Massachusetts ELA/Literacy and Mathematics Standards.** The bottom white box contains the coding and names of pre-requisite or connected English language arts and literacy and/or mathematics standards. For example, STE standards that require student use of exponential notation will align to the corresponding MA mathematics standards. An effort has been made to ensure that the mathematical skills that students need for science were taught in a previous year where possible.

Pre-K

***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. (STE Curriculum Framework, p.25)

**Pre-K: Earth and Space Sciences**

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| **ESS1. Earth’s Place in the Universe** |
| **PreK-ESS1-1(MA). Demonstrate awareness that the moon can be seen in the daytime and at night, and of the different apparent shapes of the moon over a month.** **Clarification statement:** * **The names of moon phase or sequencing of moon phases is not expected.**

**PreK-ESS1-2(MA). Observe and use evidence to describe that the sun is in different places in the sky during the day.**  |
| The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*: |
| **Science and Engineering Practices****Asking Questions and Defining Problems*** Ask questions based on observations to find more information about the natural and/or designed worlds. (PreK-ESS1-1(MA)), (PreK-ESS1-2(MA))

**Constructing Explanations and Designing Solutions*** Use information from observations (first-hand and from media) to construct an evidence-based account for natural phenomena. (PreK-ESS1-2(MA))
 | **Disciplinary Core Ideas****ESS1.A: The Universe and Its Stars** * Patterns of the motion of the sun, moon, and stars in the sky can be observed, described, and predicted. (PreK-ESS1-1(MA)), (PreK-ESS1-2(MA))
 |
| *ELA/Literacy* **◊RI.PK.7** With prompting and support, describe important details from an illustration or photograph. **(◊PreK-ESS1-2(MA))****◊W.PK.3** Use a combination of dictating and drawing to tell a story. **(PreK-ESS1-1(MA)), (◊ PreK-ESS1-2(MA))***Mathematics* **PK.G.A.1** Identify relative positions of objects in space, and use appropriate language (e.g.., beside, inside, next to, close to, above, below, apart). **(PreK-ESS1-2(MA))****PK.G.A.2** Identify various two-dimensional shapes using appropriate language. **(PreK-ESS1-1(MA))****PK.G.B.3** Create and represent three-dimensional shapes (ball/sphere, square box/cube, tube/cylinder) using various manipulative materials (such as popsicle sticks, blocks, pipe cleaners, pattern blocks). **(PreK-ESS1-2(MA))** |

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

**PreK-ESS2-6(MA). Provide examples of the impact of weather on living things.****Clarification statement:*** **Make connections between the weather and what they wear and can do and the weather and the needs of plants and animals for water and shelter.**
 |
| The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*: |
| **Science and Engineering Practices****Asking Questions and Defining Problems*** Ask questions based on observations to find more information about the natural and/or designed worlds. (PreK-ESS2-1(MA))

**Planning and Carrying Out Investigations** * Make observations (first hand or from media) and/or measurements to collect data that can be used to make comparisons. (PreK-ESS2-2(MA)), (PreK-ESS2-3(MA)), (PreK-ESS2-4(MA)), (PreK-ESS2-6(MA))

**Constructing Explanations and Designing Solutions*** Use information from observations (first-hand and from media) to construct an evidence-based account for natural phenomena. (PreK-ESS2-5(MA))

**Analyzing and Interpreting Data*** Record information (observations, thoughts, and ideas). (PreK-ESS2-4(MA))
 | **Disciplinary Core Ideas****ESS2.A: Earth Materials and Systems** * The materials on the land provide homes for living things. (PreK-ESS2-1(MA))

**ESS2.B: Plate Tectonics and Large-Scale System Interactions*** Rocks, soils, and sand are present in most areas where plants and animals live. There may also be rivers, streams, lakes, and ponds. (PreK-ESS2-2(MA))

**ESS2.C: The Roles of Water in Earth’s Surface Processes*** Water is found in the ocean, rivers, lakes, and ponds. (PreK-ESS2-3(MA))

**ESS2.D: Weather and Climate*** Weather is the combination of sunlight, wind, snow or rain, and temperature in a particular region at a particular time. People measure these conditions to describe and record the weather and to notice patterns over time. (PreK-ESS2-4(MA)), (PreK-ESS2-5(MA)), *(secondary to PreK-ESS2-6(MA))*
* Living things react to the weather, such as plants dying in a drought or animals seeking shelter in the cold. (PreK-ESS2-6(MA))
 |
| *ELA/Literacy –***◊SL.PK.3**  Ask and answer questions in order to seek help, get information, or clarify something that is not understood. **(◊PreK-ESS2-1(MA))****◊SL.PK.6**  Speak audibly and express thoughts, feelings, and ideas.  **(◊PreK-ESS2-1(MA))***Mathematics –***◊PK.CC.C.5 Use** comparative language, such as more/less than, equal to, to compare and describe collections of objects*.* **(◊PreK-ESS2-4(MA)), (PreK-ESS2-5(MA))****◊PK.G.A.1** Identify relative positions of objects in space, and use appropriate language (e.g., beside, inside, next to, close to, above, below, apart). **(◊PreK-ESS2-4(MA))****PK.MD.B.3** Sort, categorize, and classify objects by more than one attribute.**(PreK-ESS2-2(MA))** |

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| **ESS3. Earth and Human Activity** |
| **PreK-ESS3-1(MA). Engage in discussion and raise questions using examples about local resources (including soil and water) humans use to meet their needs.****PreK-ESS3-2(MA). Observe and discuss the impact of people’s activities on the local environment.** |
| The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*: |
| **Science and Engineering Practices****Asking Questions and Defining Problems*** Ask questions based on observations to find more information about the natural and/or designed worlds (PreK-ESS3-1(MA))

**Engaging in Argument from Evidence*** Construct an argument with evidence to support claim. (PreK-ESS3-1(MA)), (PreK-ESS3-2(MA))
 | **Disciplinary Core Ideas****ESS3.A: Natural Resources*** Living things need water, air, and resources from the land, and they try to live in places that have the things they need. Humans use natural resources for everything they do: for example, they use soil and water to grow food, wood to burn to provide heat and clay and wood to build shelters. (PreK-ESS3-1)

**ESS3.C: Human Impacts on Earth Systems*** Things that people do to live comfortably can affect the world around them. But they can make choices that reduce their impacts on the land, water, air, and other living things—for example, by reducing trash through reuse and recycling. (PreK-ESS3-2), (Note: This Disciplinary Core Idea is also addressed by K-ESS2-2 and K-ESS3-3)
 |
| *ELA/Literacy –***◊SL.PK.1**  Participate in collaborative conversations with diverse partners during daily routines and play. **(◊PreK-ESS3-1), (◊PreK-ESS3-2)****◊SL.PK.2** Recall information for short periods of time and retell, act out, or represent information from a text read aloud, a recording, or a video (e.g., watch a video about birds and their habitats and make drawings or constructions of birds and their nests). **(◊PreK-ESS3-2)****◊SL.PK.3**  Ask and answer questions in order to seek help, get information, or clarify something that is not understood. **(◊PreK-ESS3-1), (◊PreK-ESS3-2)****◊SL.PK.4**  Describe personal experiences; tell stories. **(◊PreK-ESS3-2)****◊SL.PK.5**  Create representations of experiences or stories (e.g., drawings, constructions with blocks or other materials, clay models) and explain them to others. **(◊PreK-ESS3-2)****◊SL.PK.6**  Speak audibly and express thoughts, feelings, and ideas. **(◊PreK-ESS3-2)***Mathematics –***PK.MD.A.1.** Recognize the attributes of length, area, weight, and capacity of everyday objects using appropriate vocabulary (e.g., long, short, tall, heavy, light, big, small, wide, narrow). **(◊PreK- ESS3-1)** **PK.MD.A.2.** Compare the attributes of length and weight for two objects, including longer/shorter, same length; heavier/lighter, same weight; holds more/less, holds the same amount. **(◊PreK- ESS3-1)** |

**Pre-K: Life Science**

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| **LS1. From Molecules to Organisms: Structures and Processes** |
| **PreK-LS1-1(MA). Compare, using descriptions and drawings, the external body parts of animals (including humans) and plants and explain functions of some of the observable body parts.****Clarification Statement:*** **Examples can include comparison of humans and horses: humans have two legs and horses four, but both use legs to move.**

**PreK-LS1-2(MA). Explain that most animals have five senses they use to gather information about the world around them.** **PreK-LS1-3(MA). Use their five senses in their exploration and play to gather information.** |
| The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*: |
| **Science and Engineering Practices****Developing and Using Models*** Develop and/or use a model to represent amounts, relationships, relative scales (bigger, smaller), and/or patterns in the natural or designed worlds. (PreK-LS1-1(MA))

**Constructing Explanations and Designing Solutions*** Use information from observations (first-hand and from media) to construct an evidence-based account for natural phenomena. (PreK-LS1-2(MA))

**Obtaining, Evaluating, and Communicating Information*** Obtain information using various texts, text features (e.g. headings, tables of contents, glossaries, electronic menus, icons), and other media that will be useful in answering a scientific question and/or supporting a scientific claim. (PreK-LS1-3(MA))

**Planning and Carrying Out Investigations** * Evaluate different ways of observing and/or measuring a phenomenon to determine which way to answer a question. (PreK-LS1-3(MA))
* Make observations (first hand or from media) and/or measurements to collect data that can be used to make comparisons. (PreK-LS1-1(MA))
 | **Disciplinary Core Ideas****LS1.A: Structure and Function** * All organisms have external parts. Different animals use their body parts 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. Plants also have different parts (roots, stems, leaves, flowers, fruits) that help them survive, grow, and produce more plants. (PreK-LS1-1(MA)), (Note: This Disciplinary Core Idea is also addressed by PreK-LS2-1(MA))

**LS1.B: Growth and Development of Organisms*** Plants and animals have predictable characteristics at different stages of development. Plants and animals grow and change. (PreK-LS1-1(MA)), (PreK-LS1-3(MA)). (Note: This Disciplinary Core Idea is also addressed by PreK-LS2-1(MA))

**LS1.D: Information Processing** * Animals have body parts that capture and convey different kinds of information needed for growth and survival-for example, eyes for light, ears for sounds, and skin for temperature or touch. (PreK-LS1-2(MA)), (PreK-LS1-3(MA))
 |
| *ELA/Literacy –* **RI.PK.7**  With prompting and support, describe important details from an illustration or photograph. **(◊ PreK-LS1-1(MA)), PreK-LS1-2(MA)), PreK-LS1-3(MA))***Mathematics –* **PK.CC.C.4** Count many kinds of concrete objects and actions up to ten, using one-to-one correspondence, and accurately count as many as seven things in a scattered configuration.**(PreK-LS1-1(MA))****PK.CC.C.5** Use comparative language, such as more/less than, equal to, to compare and describe collections of objects.**(PreK-LS1-1(MA))****PK.MD.A.1** Recognize the attributes of length, area, weight, and capacity of everyday objects using appropriate vocabulary (e.g. long, short, tall, heavy, light, big, small, wide, narrow).**(PreK-LS1-1(MA)), (PreK-LS1-3(MA))****PK.MD.A.2** Compare attributes of length and weight for two objects, including longer/shorter, same length; heavier/lighter, same weight; holds more/less, holds the same amount. **(PreK-LS1-1(MA)), (PreK-LS1-3(MA))****PK.OA.A.1** Use concrete objects to model real-world addition (putting together) and subtraction (taking away) problems up through five.**(PreK-LS1-1(MA)), (PreK-LS1-3(MA))** |

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

**PreK-LS2-3(MA). Give examples from the local environment of how animals and plants are dependent on one another to meet their basic needs.**  |
| The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*: |
| **Science and Engineering Practices****Engaging in Argument from Evidence*** Construct an argument with evidence to support a claim. (PreK-LS2-1(MA))

**Constructing Explanations and Designing Solutions*** Use information from observations (first-hand and from media) to construct an evidence-based account for natural phenomena. (PreK-LS2-2(MA)), (PreK-LS2-3(MA))
 | **Disciplinary Core Ideas****LS1.A: Structure and Function** * All organisms have external parts. Different animals use their body parts 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. Plants also have different parts (roots, stems, leaves, flowers, fruits) that help them survive, grow, and produce more plants. (PreK-LS2-1(MA)), (Note: This Disciplinary Core Idea is also addressed by PreK-LS1-1(MA))

**LS1.B: Growth and Development of Organisms*** Plants and animals have predictable characteristics at different stages of development. Plants and animals grow and change. (PreK-LS2-1(MA)) (Note: This Disciplinary Core Idea is also addressed by PreK-LS1-1(MA) and PreK-LS1-3(MA))

**LS2.A: Interdependent Relationships in Ecosystems** * Animals depend on their surroundings to get what they need, including food, water, shelter, and a favorable temperature. (PreK-LS2-2(MA)), (PreK-LS2-3(MA)), (Note: This Disciplinary Core Idea is also addressed by 2-LS2-3(MA))
* Animals depend on plants or other animals for food. (PreK-LS2-2(MA)), (PreK-LS2-3(MA)), (Note: This Disciplinary Core Idea is also addressed by 2-LS2-3(MA))
* Plants depend on air, water, minerals (in the soil), and light to grow. (PreK-LS2-2(MA)), (PreK-LS2-3(MA)), (Note: This Disciplinary Core Idea is also addressed by 2-LS2-3(MA))
* Animals can move around, but plants cannot, and they often depend on animals for pollination or to move their seeds around. Different plants survive better in different settings because they have varied needs for water, minerals, and sunlight. (PreK-LS2-2(MA)), (PreK-LS2-3(MA)), (Note: This Disciplinary Core Idea is also addressed by 2-LS2-3(MA))

**LS2.B: Cycles of Matter and Energy Transfer in Ecosystems*** Organisms obtain the materials they need to grow and survive from the environment. (PreK-LS2-2), (PreK-LS2-3)
 |
| *ELA/Literacy –***◊SL.PK.MA.1** Participate in collaborative conversations with diverse partners during daily routines and play. **(PreK-LS2-1(MA))****W.PK.2** Use a combination of dictating and drawing to supply information about a topic. **(PreK-LS2-3(MA)), (PreK-LS2-2(MA))***Mathematics –* **PK.MD.B.3** Sort, categorize, and classify objects by more than one attribute.**(PreK-LS2-1(MA))** |

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

**PreK-LS3-2(MA). Use observations to recognize differences and similarities among themselves and their friends.** |
| The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*: |
| **Science and Engineering Practices****Engaging in Argument from Evidence*** Construct an argument with evidence to support a claim. (PreK-LS3-1(MA))

**Planning and Carrying Out Investigations*** Make observations (first-hand or from media) and/or measurements to collect data that can be used to make comparisons. (PreK-LS3-1(MA)), (PreK-LS3-2(MA))
 | **Disciplinary Core Ideas****LS3.A: Inheritance of Traits*** Young animals are very much, but not exactly, like their parents and also resemble other animals of the same kind. (PreK-LS3-1(MA)), (PreK-LS3-2(MA))
 |
| *ELA/Literacy –***W.PK.2** Use a combination of dictating and drawing to supply information about a topic. **(PreK-LS3-1(MA)), (PreK-LS3-2(MA))****L.PK.5.a** Demonstrate understanding of concepts by sorting common objects into categories (e.g., sort objects by color, shape, texture). **(PreK-LS3-1(MA)), (PreK-LS3-2(MA))***Mathematics –***PK.MD.A.1** Recognize the attributes of length, area, weight, and capacity of everyday objects using appropriate vocabulary (e.g. long, short, tall, heavy, light, big, small, wide, narrow).**(PreK-LS3-1(MA)), (PreK-LS3-2(MA))****PK.MD.A.2** Compare attributes of length and weight for two objects, including longer/shorter, same length; heavier/lighter, same weight; holds more/less, holds the same amount. **(PreK-LS3-1(MA)), (PreK-LS3-2(MA))** |

**Pre-K: Physical Sciences**

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| **PS1. Matter and Its Interactions** |
| **PreK-PS1-1(MA). Raise questions and investigate the differences between liquids and solids and develop awareness that a liquid can become a solid and vice versa.****PreK-PS1-2(MA). Investigate natural and human-made objects to describe, compare, sort and classify objects based on observable physical characteristics, uses, and whether something is manufactured or occurs in nature.****PreK-PS1-3(MA). Differentiate between the properties of an object and those of the material of which it is made.****PreK-PS1-4(MA). Recognize through investigation that physical objects and materials can change under different circumstances.****Clarification Statement:*** **Changes include building up or breaking apart, mixing, dissolving, or changing state.**
 |
| The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*: |
| **Science and Engineering Practices****Asking Questions and Defining Problems*** Ask questions based on observations to find more information about the natural and/or designed worlds. (PreK-PS1-1(MA))

**Planning and Carrying Out Investigations*** Make observations (first-hand or from media) and/or measurements to collect data that can be used to make comparisons. (PreK-PS1-2(MA)), (PreK-PS1-3(MA))

**Constructing Explanations and Designing Solutions*** Use information from observations (first-hand and from media) to construct an evidence-based account for natural phenomena. (PreK-PS1-1(MA)), (PreK-PS1-4(MA))

**Analyzing and Interpreting Data*** Record information (observations, thoughts, and ideas). (PreK-PS1-2), (PreK-PS1-3(MA))
 | **Disciplinary Core Ideas****PS1.A: Structure and Properties of Matter** * Different kinds of matter exist (e.g., wood, metal, water), and many of them can be either solid or liquid, depending on temperature. (PreK-PS1-1(MA))
* Objects and materials can be described and classified by their observable properties (e.g., visual, aural, textural), by their uses, and by whether they occur naturally or are manufactured. Different properties are suited to different purposes. A great variety of objects can be built up from a small set of pieces (e.g., blocks, construction sets). Objects or samples of a substance can be weighed, and their size can be described and measured. (Boundary: volume is introduced only for liquid measure.) (PreK-PS1-2(MA)), (PreK-PS1-3(MA))

**PS1.B: Chemical Reactions*** Materials and objects can change under different circumstances. Sometimes these changes are reversible (e.g., melting and freezing, taking something apart and putting it back together), and sometimes they are not (e.g., baking a cake, burning fuel, mixing certain substances.) (PreK-PS1-4(MA))
 |
| *ELA/Literacy –***◊SL.PK.3**  Ask and answer questions in order to seek help, get information, or clarify something that is not understood. **(◊PreK-PS1-1(MA))***Mathematics –***PK.MD.A.2** Compare the attributes of length and weight for two objects, including longer/shorter, same length; heavier/lighter, same weight; holds more/less, holds the same amount. **(PreK-PS1-1(MA)),(◊PreK-PS1-2(MA)), (PreK-PS1-4(MA))****PK.MD.B.3** Sort, categorize, and classify objects by more than one attribute*.* **(◊PreK-PS1-1(MA)), (◊PreK-PS1-2(MA))****PK.CC.C.5** Use comparative language, such as more/less than, equal to, to compare and describe collections of objects*.***(PreK-PS1-4(MA))** |

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| **PS2. Motion and Stability: Forces and Interactions** |
| **PreK-PS2-1(MA). Using evidence, discuss ideas about what is making something move the way it does and how some movements can be controlled.** **PreK-PS2-2(MA). Through experience, develop awareness of factors that influence whether things stand or fall.****Clarification Statement:*** **Examples of factors in children’s construction play include using a broad foundation when building, considering the strength of materials, and using balanced weight distribution in a block building.**
 |
| The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*: |
| **Science and Engineering Practices****Engaging in Argument from Evidence*** Construct an argument with evidence to support a claim. (PreK-PS2-1(MA))

**Planning and Carrying Out Investigations** * Make observations (first-hand or from media) and/or measurements to collect data that can be used to make comparisons. (PreK-PS2-1(MA)), (PreK-PS2-2(MA))

**Analyzing and Interpreting Data*** Use observations (first-hand or from media) to describe patterns and/or relationships in the natural and designed worlds in order to answer scientific questions and solve problems. (PreK-PS2-2(MA))
 | **Disciplinary Core Ideas****PS2.A: Forces and Motion** * Objects pull or push each other when they collide or are connected. Pushes and pulls can have different strengths and directions. Pushing or pulling on an object can change the speed or direction of its motion and can start or stop it. (PreK-PS2-1(MA)), (PreK-PS2-2(MA))

**PS2.B: Types of Interactions*** When objects touch or collide, they push on one another and can change motion or shape. (PreK-PS2-2(MA))
 |
| *ELA/Literacy –***◊SL.PK.5**  Create representations of experiences or stories (e.g., drawings, constructions with blocks or other materials, clay models) and explain them to others. **(◊PreK-PS2-2(MA))** **◊SL.PK.6**  Speak audibly and express thoughts, feelings, and ideas. **(◊PreK-PS2-1(MA))***Mathematics –***PK.MD.A.1** Recognize the attributes of length, area, weight, and capacity of everyday objects using appropriate vocabulary (e.g. long, short, tall, heavy, light, big, small, wide, narrow).**(PreK-PS2-1(MA)), (PreK-PS2-2(MA))** |

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| **PS4. Waves and Their Applications in Technologies for Information Transfer** |
| **PreK-PS4-1(MA). Investigate sounds made by different objects and materials and discuss explanations about what is causing the sounds. Through play and investigations, identify ways to manipulate different objects and materials that make sound to change volume and pitch.****PreK-PS4-2(MA). Connect daily experience and investigations to demonstrate the relationships between the size and shape of shadows, the objects creating the shadow, and the light source.**  |
| The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*: |
| **Science and Engineering Practices****Planning and Carrying Out Investigations** * Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence to answer a question. (PreK-PS4-1(MA))

**Analyzing and Interpreting Data*** Record information (observations, thoughts, and ideas). (PreK-PS4-1(MA)), (PreK-PS4-2(MA))

**Constructing Explanations and Designing Solutions*** Use information from observations (first-hand or from media) to construct an evidence-based account for natural phenomena (PreK-PS4-2(MA))
 | **Disciplinary Core Ideas****PS4.A: Wave Properties** * Sound can make matter vibrate, and vibrating matter can make sound. Different objects and materials make different sounds. The pitch and volume of sound can be changed. (PreK-PS4-1(MA))

**PS2.B: Electromagnetic Radiation*** Some materials allow light to pass through them, others allow only some light through, and others block all the light and create a dark shadow on any surface beyond them (i.e., on the other side from the light source), where the light cannot reach. The size and shape of a shadow depend on several factors (i.e. the orientation of the object, the location of the light source, and the distances between light source, object, and shadow. (PreK-PS4-2(MA))
 |
| *ELA/Literacy –***SL.PK.5**Create representations of experiences or stories (e.g., drawings, constructions with blocks or other materials, clay models) and explain them to others **(PreK-PS4-1(MA)), (PreK-PS4-2(MA))****SL.PK.1**Participate in collaborative conversations with diverse partners during daily routines and play. **(PreK-PS4-1(MA)), (PreK-PS4-2(MA))***Mathematics –***PK.CC.C.5** Use comparative language, such as more/less than, equal to, to compare and describe collections of objects*.* **(PreK-PS4-2(MA))****PK.MD.A.2** Compare the attributes of length and weight for two objects, including longer/shorter, same length; heavier/lighter, same weight; holds more/less, holds the same amount. **(PreK-PS4-1(MA)), (PreK-PS4-2(MA))****PK.G.A.1** Identify relative positions of objects in space, and use appropriate language (e.g. beside, inside, next to, close to, above, below, apart). **(PreK-PS4-2(MA))****PK.G.A.2** Identify various two-dimensional shapes using appropriate language. **(PreK-PS4-2(MA))****PK.G.B.3** Create and represent three-dimensional shapes (ball/sphere, square box/cube, tube/cylinder,) using various manipulative materials (such as popsicle sticks, blocks, pipe cleaners, pattern blocks). **(PreK-PS4-2(MA))** |

Kindergarten

***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 plant’s ability to make its own food. Students build their quantitative knowledge of temperature in relation 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. (STE Curriculum Framework, p.28)

**Kindergarten: Earth and Space Sciences**

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| **ESS2. Earth’s Systems** |
| **K-ESS2-1. Use and share quantitative observations of local weather conditions to describe patterns over time.****Clarification Statements:** * **Examples of quantitative observations could include numbers of sunny, windy and rainy days in a month, and relative temperature.**
* **Quantitative observations should be limited to whole numbers.**

**K-ESS2-2. Construct an argument supported by evidence for how plants and animals (including humans) can change the environment.****Clarification Statement:*** **Examples of plants and animals changing their environment could include a squirrel digging holes in the ground and tree roots that break concrete.**
 |
| The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*: |
| **Science and Engineering Practices****Analyzing and Interpreting Data** * Use observations (firsthand or from media) to describe patterns and/or relationships in the natural and designed worlds in order to answer scientific questions and solve problems. (K-ESS2-1)

**Engaging in Argument from Evidence*** Construct an argument with evidence to support a claim. (K-ESS2-2)
 | **Disciplinary Core Ideas****ESS2.D: Weather and Climate*** Weather is the combination of sunlight, wind, snow or rain, and temperature in a particular region at a particular time. People measure these conditions to describe and record the weather and to notice patterns over time. (K-ESS2-1)

**ESS2.E: Bio-geology*** Plants and animals can change their environment. (K-ESS2-2)

**ESS3.C: Human Impacts on Earth Systems*** Things that people do to live comfortably can affect the world around them. But they can make choices that reduce their impacts on the land, water, air, and other living things, for example, by reducing trash through reuse and recycling. (K-ESS2-2), (Note: This Disciplinary Core Idea is also addressed by PreK-ESS3-2 and K-ESS3-3)
 |
| *ELA/Literacy –***◊W.K.2** Use a combination of drawing, dictating, and writing to compose informative/explanatory texts in which they name what they are writing about and supply some information about the topic. **(◊K-ESS2-2)****SL.K.5** Add drawings or other visual displays to descriptions as desired to provide additional detail. **(K-ESS2-2)***Mathematics –***PK.MD.A.2** Compare the attributes of length and weight for two objects, including longer/shorter, same length; heavier/lighter, same weight; holds more/less, holds the same amount.**(K-ESS2-1)****◊K.CC.C.6** Identify whether the number of objects in one group is greater than, less than, or equal to the number of objects in another group, e.g., by using matching and counting strategies. **(◊K-ESS2-1)****◊K.MD.A.2** Directly compare two objects with a measurable attribute in common, see which object has “more of”/”less of” the attribute, and describe the difference. **(◊K-ESS2-1)****◊K.MD.B.3** Classify objects into given categories; count the number of objects in each category and sort the categories by count. **(◊K-ESS2-1)** |

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| **ESS3. Earth and Human Activity** |
| **K-ESS3-2. Obtain information about the purpose of weather forecasting to prepare for, and respond to, different types of local weather.** **K-ESS3-3. Communicate solutions to reduce the amount of natural resources an individual uses.\*****Clarification Statement:** * **Examples of solutions could include reusing paper to reduce the number of trees cut down and recycling cans and bottles to reduce the amount of plastic or metal used.**

**[Note: K-ESS3-1 from NGSS is not included.]** |
| The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*: |
| **Science and Engineering Practices****Obtaining, Evaluating, and Communicating Information*** Obtain information using various texts, text features (e.g. headings, table of contents, glossaries, electronic menus, icons), and other media that will be useful in answering a scientific question and/or supporting a scientific claim. (K-ESS3-2)
* Communicate information or design ideas and/or solutions with others in oral and/or written forms using models, drawings, writing, or numbers that provide detail about scientific ideas, practices, and/or design ideas. (K-ESS3-3)
 | **Disciplinary Core Ideas****ESS3.B: Natural Hazards*** Weather scientists forecast severe weather so that the communities can prepare for and respond to these events. (K-ESS3-2)

**ESS3.C: Human Impacts on Earth Systems*** Things that people do to live comfortably can affect the world around them. But they can make choices that reduce their impacts on the land, water, air, and other living things, for example, by reducing trash through reuse and recycling. (K-ESS3-3), (Note: This Disciplinary Core Idea is also addressed by K-ESS2-2)

**ETS1.B: Developing Possible Solutions*** Designs can be conveyed through sketches, drawings, or physical models. These representations are useful in communicating ideas for a problem’s solutions to other people. *(secondary to K-ESS3-3),* (Note: This Disciplinary Core Idea is also addressed by 1.K-2-ETS1-2),
 |
| *ELA/Literacy –***◊RI.K.3** With prompting and support, describe the connection between two individuals, events, ideas, or pieces of information in a text. **(◊K-ESS3-2)****RI.K.2** With prompting and support, identify the main topic and retell key details of a text. **(K-ESS3-2)****SL.K.5**  Add drawings or other visual displays to descriptions as desired to provide additional detail. **(K-ESS3-3)****SL.K.6**  Speak audibly and express thoughts, feelings, and ideas clearly. **(K-ESS3-3)***Mathematics –***K.MD.A** Directly compare two objects with a measurable attribute in common, to see which object has “more of”/“less of” the attribute, and describe the difference. For example, directly compare the heights of two children and describe one child as taller/shorter (**K-ESS3-2)** |

**Kindergarten: Life Science**

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| **LS1. From Molecules to Organisms: Structures and Processes** |
| **K-LS1-1. Observe and communicate that animals (including humans) and plants need food, water, and air to survive. Animals get food from plants or other animals. Plants make their own food and need light to live and grow.****K-LS1-2(MA). Recognize that all plants and animals grow and change over time.** |
| The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*: |
| **Science and Engineering Practices****Analyzing and Interpreting Data*** Use observations (firsthand or from media) to describe patterns in the natural world in order to answer scientific questions. (K-LS1-1)

**Obtaining, Evaluating, and Communicating Information*** Communicate information or design ideas and/or solutions with others in oral and/or written forms using models, drawings, writing, or numbers that provide detail about scientific ideas, practices, and/or design ideas. (K-LS1-1)
 | **Disciplinary Core Ideas****LS1.B: Growth and Development of Organisms*** All plants and animals grow and develop into adulthood through observable changes. (K-LS1-2(MA))

**LS1.C: Organization for Matter and Energy Flow in Organisms*** All animals need food in order to live and grow. They obtain their food from plants or from other animals. Plants need water and light to live and grow. (K-LS1-1), (K-LS1-2(MA))

**LS2.A: Interdependent Relationships in Ecosystems*** Plants depend on air, water, minerals (in the soil), and light to grow (K-LS1-1), (Note: This Disciplinary Core Idea is also addressed by 2-LS2-3(MA))
 |
| *ELA/Literacy –***◊SL.K.5** Add drawings or other visual displays to descriptions as desired to provide additional detail. **(◊K-LS1-1)**RI.K.7 With prompting and support, describe the relationship between illustrations and the text in which they appear (e.g., what person, place, thing, or idea in the text an illustration depicts). **(K-LS1-2(MA))***Mathematics –***K.MD.A.1** Describe measurable attributes of objects, such as length or weight. Describe several measurable attributes of a single object. **(K-LS1-2(MA))****K.MD.A.2** Directly compare two objects with a measurable attribute in common, see which object has “more of”/”less of” the attribute, and describe the difference. **(K-LS1-2(MA))** |

**Kindergarten: Physical Science**

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| **PS1. Matter and its Interactions** |
| **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.****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.**
* **Only a qualitative description of temperature, such as hot, warm, and cool, is expected.**
 |
| The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*: |
| **Science and Engineering Practices****Planning and Carrying Out Investigations*** With guidance, plan and conduct an investigation in collaboration with peers (for K). (K-PS1-1(MA))
 | **Disciplinary Core Ideas****PS1.A: Structure and Properties of Matter** * Different kinds of matter exist (e.g., wood, metal, water), and many of them can be either solid or liquid, depending on temperature. Matter can be described and classified by its observable properties. (K-PS1-1(MA))
 |
| *ELA/Literacy –***SL.K.5** Add drawings or other visual displays to descriptions as desired to provide additional detail. **(K-PS1-1(MA))****L.K.5.c** Identify real-life connections between words and their use (e.g., note places at school that are colorful). **(K-PS1-1(MA))***Mathematics –***K.MD.B.3** Classify objects into given categories; count the number of objects in each category and sort the categories by count. **(K-PS1-1(MA))** |

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| **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 Statements:** * **Examples of pushes or pulls could include a string attached to an object being pulled, a person pushing an object, a person stopping a rolling ball, and two objects colliding and pushing on each other.**
* **Comparisons should be on different relative strengths or different directions, not both at the same time.**
* **Non-contact pushes or pulls such as those produced by magnets are not expected.**

**[Note: K-PS2-2 from NGSS is not included.]** |
| The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*: |
| **Science and Engineering Practices****Planning and Carrying Out Investigations*** Make observations (firsthand or from media) and/or measurements to collect data that can be used to make comparisons. (K-PS2-1)
 | **Disciplinary Core Ideas****PS2.A: Forces and Motion*** Pushes and pulls can have different strengths and directions. (K-PS2-1)
* Pushing or pulling on an object can change the speed or direction of its motion and can start or stop it. (K-PS2-1)

**PS2.B: Types of Interactions*** When objects touch or collide, they push on one another and can change motion. (K-PS2-1)

**PS3.C: Relationship Between Energy and Forces*** A bigger push or pull makes things speed up or slow down more quickly. (K-PS2-1)
 |
| *ELA/Literacy –***W.K.3**With guidance and support from adults, respond to questions and suggestions from peers and add details to strengthen writing as needed. **(K-PS2-1)****SL.K.5** Add drawings or other visual displays to descriptions as desired to provide additional detail. **(K-PS2-1)***Mathematics –***◊K.MD.A.2** Directly compare two objects with a measurable attribute in common, to see which object has “more of”/”less of” the attribute, and describe the difference. **(◊K-PS2-1)** |

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| **PS3. Energy** |
| **K-PS3-1. Make observations to determine that sunlight warms materials on Earth’s surface.** **Clarification Statements:** * **Examples of materials on Earth’s surface could include sand, soil, rocks, and water.**
* **Measures of temperature should be limited to relative measures such as warmer/cooler.**

**K-PS3-2. Use tools and materials to design and build a prototype of a structure that will reduce the warming effect of sunlight on an area.\*** |
| The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*: |
| **Science and Engineering Practices****Planning and Carrying Out Investigations*** Make observations (firsthand or from media) to collect data that can be used to make comparisons. (K-PS3-1)

**Constructing Explanations and Designing Solutions*** Use tools and/or materials to design and build a device that solves a specific problem. (K-PS3-2)
 | **Disciplinary Core Ideas****PS3.B: Conservation of Energy and Energy Transfer*** Sunlight warms Earth’s surface. (K-PS3-1),(K-PS3-2)
 |
| *ELA/Literacy –***SL.K.5**Add drawings or other visual displays to descriptions as desired to provide additional detail. **(K-PS3-1), (K-PS3-2)****RI.K.3**Describe the connection between two individuals, events, ideas, or pieces of information in a text. **(K-PS3-1), (K-PS3-2)***Mathematics –***K.MD.A.2** Directly compare two objects with a measurable attribute in common, to see which object has “more of”/”less of” the attribute, and describe the difference. **(K-PS3-1), (K-PS3-2)****K.G.A.1** Describe objects in the environment using names of shapes, and describe the relative positions of these objects using terms such as above, below, beside, in front of, behind, and next to.**(K-PS3-2)** |

Grade 1

***Describing Patterns***

In grade 1, students have more fluency with language, number sense, and inquiry skills. This allows them 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 on 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 and use this to 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 their 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.

(STE Curriculum Framework, p.30)

**Grade 1: Earth and Space Sciences**

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| **ESS1. Earth’s Place in the Universe** |
| **1-ESS1-1. Use observations of the Sun, Moon, and stars to describe that each appears to rise in one part of the sky, appears to move across the sky, and appears to set.** **1-ESS1-2. Analyze provided data to identify relationships among seasonal patterns of change, including relative 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.**
 |
| The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*: |
| **Science and Engineering Practices****Analyzing and Interpreting Data** * Use observations (firsthand or from media) to describe patterns in the natural world in order to answer scientific questions. (1-ESS1-1), (1-ESS1-2)
 | **Disciplinary Core Ideas****ESS1.A: The Universe and its Stars*** Patterns of the motion of the sun, moon, and stars in the sky can be observed, described, and predicted. (1-ESS1-1)

**ESS1.B: Earth and the Solar System*** Seasonal patterns of sunrise and sunset can be observed, described, and predicted. (1-ESS1-2)

**ESS2.D: Weather and Climate*** Temperature, rainfall and snowfall, and environmental changes follow a pattern throughout the seasons, depending on where you are in the world. (1-ESS1-2)
 |
| *ELA/Literacy –***RI.1.7** Use the illustrations and details in a text to describe its key ideas. **(1-ESS1-1),** **(1-ESS1-2)****W.1.7**Participate in shared research and writing projects (e.g., explore a number of how-to books on a given topic and use them to write a sequence of instructions). **(1-ESS1-1),** **(1-ESS1-2)***Mathematics –***K.G.A.1** Describe objects in the environment using names of shapes, and describe the relative positions of these objects using terms such as above, below, beside, in front of, behind, and next to. **(1-ESS1-1)****◊1.MD.B.3** Tell and write time in hours and half hours using analog and digital clocks.**(◊1-ESS1-1),** **(◊1-ESS1-2)****◊1.MD.C.4** Organize, represent, and interpret data with up to three categories; ask and answer questions about the total number of data points, how many in each category, and how many more or less are in one category than in another.**(◊1-ESS1-1), (◊1-ESS1-2)****1.NBT.B.3** Compare two two-digit numbers based on meanings of the tens and ones digits, recording the results of comparisons with the symbols >, =, <.**(1-ESS1-2)** |

**Grade 1: Life Science**

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| **LS1. From Molecules to Organisms: Structures and Processes** |
| **1-LS1-1. Use evidence to explain that (a) different animals use their body parts and senses in different ways to see, hear, grasp objects, protect themselves, move from place to place, and seek, find, and take in food, water, and air, and (b) plants have roots, stems, leaves, flowers, and fruits that are used to take in water, air, and other nutrients, and produce food for the plant.** **Clarification Statement:*** **Descriptions are not expected to include mechanisms such as the process of photosynthesis.**

**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).**
 |
| The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*: |
| **Science and Engineering Practices****Constructing Explanations and Designing Solutions*** Use information from observations (first-hand and from media) to construct an evidence-based account for natural phenomena. (1-LS1-1)

**Obtaining, Evaluating, and Communicating Information*** Read grade-appropriate texts and use media to obtain scientific information to determine patterns in and evidence about the natural world. (1-LS1-2)
 | **Disciplinary Core Ideas****LS1.A: Structure and Function** * All organisms have body parts. Different animals use their body parts 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. Plants also have different parts (roots, stems, leaves, flowers, fruits) that help them survive and grow. (1-LS1-1)

**LS1.B: Growth and Development of Organisms** * In many kinds of animals, parents and the offspring themselves engage in behaviors that help the offspring to survive. (1-LS1-2)

**LS1.D: Information Processing*** Animals have body parts that capture and convey different kinds of information needed for growth and survival. Animals respond to these inputs with behaviors that help them survive. Plants also respond to some external inputs.
 |
| *ELA/Literacy –***◊RI.1.5** Know and use various text features (e.g., headings, tables of contents, glossaries, electronic menus, icons) to locate key facts or information in a text. **(◊1-LS1-2)****◊RI.1.6** Distinguish between information provided by pictures or other illustrations and information provided by the words in a text. **(◊1-LS1-2)***Mathematics –***1.MD.C.4** Organize, represent, and interpret data with up to three categories; ask and answer questions about the total number of data points, how many in each category, and how many more or less are in one category than in another.**(1-LS1-1)** |

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| **LS3. Heredity: Inheritance and Variation of Traits** |
| **1-LS3-1. Use information from observations (first-hand and from media) to identify similarities and differences among individual plants or animals of the same kind.** **Clarification Statements:** * **Examples of observations could include that leaves from the same kind of plant are the same shape but can differ in size.**
* **Inheritance, animals that undergo metamorphosis, or hybrids are not expected.**
 |
| The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*: |
| **Science and Engineering Practices****Constructing Explanations and Designing Solutions*** Use information from observations (firsthand and from media) to construct an evidence-based account for natural phenomena. (1-LS3-1)
 | **Disciplinary Core Ideas****LS3.B: Variation of Traits** * Individuals of the same kind of plant or animal are recognizable as similar but can also vary in many ways. (1-LS3-1)
 |
| *ELA/Literacy –***◊RI.1.6** Distinguish between information provided by pictures or other illustrations and information provided by the words in a text. **(◊1-LS3-1)***Mathematics –***K.MD.A.2** Directly compare two objects with a measurable attribute in common, to see which object has “more of”/”less of” the attribute, and describe the difference. **(1-PS3-1)****K.CC.B.5** Count to answer “how many?” questions about as many as 20 things arranged in a line, a rectangular array, or a circle, or as many as 10 things in a scattered configuration; given a number from 1-20, count out that many objects. **(1-PS3-1)****1.NBT.B.3** Compare two two-digit numbers based on meanings of the tens and ones digits, recording the results of comparisons with the symbols >, =, <. **(1-PS3-1)****1.MD.A.1** Order three objects by length; compare the lengths of two objects indirectly by using a third object. **(1-PS3-1)****1.MD.C.4** Organize, represent, and interpret data with up to three categories; ask and answer questions about the total number of data points, how many in each category, and how many more or less are in one category than in another. **(1-PS3-1)** |

**Grade 1: Physical Science**

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| **PS4. Waves and their Applications in Technologies for Information Transfer** |
| **1-PS4-1. Demonstrate that vibrating materials can make sound and that sound can make materials vibrate.** **Clarification Statements:** * **Examples of vibrating materials that make sound could include tuning forks, a stretched string or rubber band, and a drum head.**
* **Examples of how sound can make materials vibrate could include holding a piece of paper near a speaker making sound and holding an object near a vibrating tuning fork.**

**1-PS4-3. Conduct an investigation to determine the effect of placing materials that allow light to pass through them, allow only some light through them, block all the light, or redirect light when put in the path of a beam of light.** **Clarification Statements:*** **Effects can include some or all light passing through, creation of a shadow, and redirecting light.**
* **Quantitative measures are not expected.**

**1-PS4-4. Use tools and materials to design and build a device that uses light or sound to send a signal over a distance.\*** **Clarification Statements:** * **Examples of devices could include a light source to send signals, paper cup and string “telephones,” and a pattern of drum beats.**
* **Technological details for how communication devices work are not expected.**

**[1-PS4-2 from NGSS is not included.]** |
| The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*: |
| **Science and Engineering Practices****Planning and Carrying Out Investigations*** Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence to answer a question.

(1-PS4-1), (1-PS4-3)**Constructing Explanations and Designing Solutions*** Use tools and materials to design and build a device that solves a specific problem. (1-PS4-4)
 | **Disciplinary Core Ideas****PS4.A: Wave Properties*** Sound can make matter vibrate, and vibrating matter can make sound. The volume and pitch of sound depends on the characteristics of the material that is vibrating. (1-PS4-1)

**PS4.B: Electromagnetic Radiation*** Some materials allow light to pass through them, others allow only some light through and others block all the light and create a dark shadow on any surface beyond them, where the light cannot reach. Mirrors can be used to redirect a light beam. (Boundary: The idea that light travels from place to place is developed through experiences with light sources, mirrors, and shadows, but no attempt is made to discuss the speed of light.) (1-PS4-3)

**PS4.C: Information Technologies and Instrumentation*** People also use a variety of devices to communicate (send and receive information) over long distances. (1-PS4-4)
 |
| *ELA/Literacy –***W.1.2**Write informative/explanatory texts that name a topic, supply some facts about the topic, and provide some sense of closure. **(1-PS4-1), (1-PS4-3), (1-PS4-4)****SL.1.5**Add drawings or other visual displays to descriptions when appropriate to clarify ideas, thoughts, and feelings. **(1-PS4-1), (1-PS4-3), (1-PS4-4)****SL.1.6** Produce complete sentences when appropriate to task and situation. **(1-PS4-1), (1-PS4-3)***Mathematics –***◊PK.MD.B.3** Sort, categorize, and classify objects by more than one attribute.**(◊1-PS4-3), (1-PS4-1)****K.G.A.1** Describe objects in the environment using names of shapes, and describe the relative positions of these objects using terms such as above, below, beside, in front of, behind, and next to. **(1-PS4-1), (1-PS4-3), (1-PS4-4)****1.MD.C.4** Organize, represent, and interpret data with up to three categories; ask and answer questions about the total number of data points, how many in each category, and how many more or less are in one category than in another. **(1-PS4-3), (1-PS4-4)****1.NBT.B.3** Compare two two-digit numbers based on meanings of the tens and ones digits, recording the results of comparisons with the symbols >, =, <.**(1-PS4-3), (1-PS4-4)** |

**Grade 1: Technology/Engineering**

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| **ETS1. Engineering Design** |
| **1.K-2-ETS1-1. Ask questions, make observations, and gather information about a situation people want to change that can be solved by developing or improving an object or tool.\*****1.K-2-ETS1-2. Generate multiple solutions to a design problem and make a drawing (plan) to represent one or more of the solutions.\*****[K-2-ETS1-3 is found in grade 2.]** |
| The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*: |
| **Science and Engineering Practices****Asking Questions and Defining Problems** * Define a simple problem that can be solved through the development of a new or improved object or tool. (1.K-2-ETS1-1)

**Constructing Explanations and Designing Solutions*** Generate and/or compare multiple solutions to a problem. (1.K-2-ETS1-2)

**Developing and Using Models*** Develop a simple model based on evidence to represent a proposed object or tool. (1.K-2-ETS1-2)
 | **Disciplinary Core Ideas****ETS1.A: Defining and Delimiting Engineering Problems*** A situation that people want to change or create can be approached as a problem to be solved through engineering. (1.K-2-ETS1-1)
* Asking questions, making observations, and gathering information are helpful in thinking about problems. (1.K-2-ETS1-1)
* Before beginning to design a solution, it is important to clearly understand the problem. (1.K-2-ETS1-1)

**ETS1.B: Developing Possible Solutions*** Designs can be conveyed through sketches, drawings, or physical models. These representations are useful in communicating ideas for a problem’s solutions to other people. (1.K-2-ETS1-2), *(Note: This Disciplinary Core Idea is also secondary to K-ESS3-3)*
 |
| *ELA/Literacy –***SL.1.4** Describe people, places, things and events with relevant details, expressing ideas and feelings clearly and using appropriate vocabulary. **(1.K-2-ETS1-1)***Mathematics –***◊1.MD.C.4** Organize, represent, and interpret data with up to three categories; ask and answer questions about the total number of data points, how many in each category, and how many more or less are in one category than in another. **(◊1.K-2-ETS1-1)****1.NBT.B.3** Compare two two-digit numbers based on meanings of the tens and ones digits, recording the results of comparisons with the symbols >, =, <.**(1.K-2-ETS1-1), (1.K-2-ETS1-2)** |

Grade 2

***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. (STE Curriculum Framework, p.32)

**Grade 2: Earth and Space Sciences**

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| **ESS2. Earth’s Systems** |
| **2-ESS2-1. Investigate and compare the effectiveness of multiple solutions designed to slow or prevent wind or water from changing the shape of the land.\*** **Clarification Statements:** * **Solutions to be compared could include different designs of dikes and windbreaks to hold back wind and water, and different designs for using shrubs, grass, and trees to hold back the land.**
* **Solutions can be generated or provided.**

**2-ESS2-2. Map the shapes and types of landforms and bodies of water in an area.** **Clarification Statements:*** **Examples of types of landforms can include hills, valleys, river banks, and dunes.**
* **Examples of water bodies can include streams, ponds, bays, and rivers.**
* **Quantitative scaling in models or contour mapping is not expected.**

**2-ESS2-3. Use examples obtained from informational sources to explain that water is found in the ocean, rivers and streams, lakes and ponds, and may be solid or liquid.** **2-ESS2-4(MA). Observe how blowing wind and flowing water can move Earth materials from one place to another and change the shape of a landform.** **Clarification Statement:** * **Examples of types of landforms can include hills, valleys, river banks, and dunes.**
 |
| The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*: |
| **Science and Engineering Practices****Developing and Using Models*** Develop a model to represent amounts, relationships, relative scales (bigger, smaller), and/or patterns in the natural or designed world. (2-ESS2-2)

**Constructing Explanations and Designing Solutions*** Compare multiple solutions to a problem. (2-ESS2-1)

**Obtaining, Evaluating, and Communicating Information*** Obtain information using various texts, text features (e.g., headings, tables of contents, glossaries, electronic menus, icons), and other media that will be useful in answering a scientific question. (2-ESS2-3)

**Planning and Carrying Out Investigations*** Make observations (firsthand or from media) and/or measurements to collect data that can be used to make comparisons. (2-ESS2-4(MA))
 | **Disciplinary Core Ideas****ESS2.A: Earth Materials and Systems*** Wind and water can change the shape of the land. (2-ESS2-1) (2-ESS2-4(MA))

**ESS2.B: Plate Tectonics and Large-Scale System Interactions*** Maps show where things are located. One can map the shapes and kinds of land and water in any area. (2-ESS2-2)

**ESS2.C: The Roles of Water in Earth’s Surface Processes*** Water is found in the ocean, rivers, lakes, and ponds. Water exists as solid ice and in liquid form. It carries soil and rocks from one place to another. (2-ESS2-3) (2-ESS2-4(MA))

**ETS1.C: Optimizing the Design Solution*** Because there is always more than one possible solution to a problem, it is useful to compare and test designs. *(secondary to 2-ESS2-1)***,** (Note: This Disciplinary Core Idea is also addressed by 2.K-2-ETS1-3)
 |
| *ELA/Literacy –***RI.2.9** Compare and contrast the most important points presented by two texts on the same topic. **(◊2-ESS2-3)****RI.2.7** Explain how specific images (e.g., a diagram showing how a machine works) contribute to and clarify a text. **(2-ESS2-1), (2-ESS2-3), (2-ESS2-4)***Mathematics –***K.MD.A.1** Describe measurable attributes of objects, such as length or weight. Describe several measurable attributes of a single object.**(2-ESS2-1)****K.MD.A.2** Directly compare two objects with a measurable attribute in common, to see which object has “more of”/”less of” the attributes, and describe the difference. **(2-ESS2-1), (2-ESS2-2), (2-ESS2-3)****2.MD.A.4** Measure to determine how much longer one object is than another, expressing the length difference in terms of a standard length unit.**(2-ESS2-1), (2-ESS2-2)** |

**Grade 2: Life Science**

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| **LS2. Ecosystems: Interactions, Energy, and Dynamics** |
| **2-LS2-3(MA). Develop and use models to compare how plants and animals depend on their surroundings and other living things to meet their needs in the places they live.** **Clarification Statement:** * **Animals need food, water, air, shelter, and favorable temperature; plants need sufficient light, water, minerals, favorable temperature, and animals or other mechanisms to disperse seeds.**

**[2-LS2-1 is included in other standards, including K-LS1-1 and 2-LS2-3(MA). 2-LS2-2 from NGSS is not included.]** |
| The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*: |
| **Science and Engineering Practices****Developing and Using Models*** + Develop and use a model to represent relationships and patterns in the natural world. (2-LS2-3(MA))
 | **Disciplinary Core Ideas****LS2.A: Interdependent Relationships in Ecosystems*** + Animals depend on their surroundings to get what they need, including food, water, shelter, and a favorable temperature. (2-LS2-3(MA)), (Note: This Disciplinary Core Idea is also addressed by PreK-LS2-2(MA), and PreK-LS2-3(MA))
	+ Animals depend on plants or other animals for food. They use their senses to find food and water, and they use their body parts to gather, catch, eat, and chew the food. (2-LS2-3(MA)), (Note: This Disciplinary Core Idea is also addressed by PreK-LS2-2(MA), and PreK-LS2-3(MA))
	+ Plants depend on air, water, minerals (in the soil), and light to grow. (2-LS2-3(MA)), (Note: This Disciplinary Core Idea is also addressed by PreK-LS2-2(MA), and PreK-LS2-3(MA))
	+ Animals can move around, but plants cannot, and they often depend on animals for pollination or to move their seeds around. Different plants survive better in different settings because they have varied needs for water, minerals, and sunlight. (2-LS2-3(MA)), (Note: This Disciplinary Core Idea is also addressed by PreK-LS2-2(MA), and PreK-LS2-3(MA))
 |
| *ELA/Literacy –***SL.2.4** Tell a story, recount an experience, or explain how to solve a mathematical problem with appropriate facts and relevant, descriptive details, speaking audibly in coherent sentences and using appropriate vocabulary. **(2-LS2-3(MA))****W.2.6** With guidance and support from adults, use a variety of digital tools to produce and publish writing, including in collaboration with peers. **(2-LS2-3(MA))***Mathematics –***◊2.MD.D.10** Draw a picture graph and a bar graph (with single-unit scale) to represent a data set with up to four categories. Solve simple put-together, take-apart, and compare problems using information presented in a bar graph.**(◊2-LS2-3(MA))****K.MD.A.2** Directly compare two objects with a measurable attribute in common, to see which object has “more of”/”less of” the attributes, and describe the difference. **(2-LS2-3(MA))****2.NBT.A.4** Compare two three-digit numbers based on meanings of the hundreds, tens, and ones digits, using >, =, and < symbols to record the results of comparisons **(2-LS2-3(MA))** |

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| **LS4. Biological Evolution: Unity and Diversity** |
| **2-LS4-1. Use texts, media, or local environments to observe and compare (a) different kinds of living things in an area, and (b) differences in the kinds of living things living in different types of areas.** **Clarification Statements:** * **Examples of areas to compare can include temperate forest, desert, tropical rain forest, grassland, arctic, and aquatic.**
* **Specific animal and plant names in specific areas are not expected.**
 |
| The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*: |
| **Science and Engineering Practices****Obtaining, Evaluating, and Communicating Information*** + Read grade-appropriate texts and/or use media to obtain scientific and/or technical information to determine patterns in and/or evidence about the natural and designed world(s). (2-LS4-1)
 | **Disciplinary Core Ideas****LS4.D: Biodiversity and Humans*** + There are many different kinds of living things in any area, and they exist in different places on land and in water. (2-LS4-1)
 |
| *ELA/Literacy –***◊RI.2.5** Know and use various text features (e.g., captions, bold print, subheadings, glossaries, indexes, electronic menus, icons) to locate key facts or information in a text efficiently. **(◊2-LS4-1)****◊RI.2.7** Explain how specific images (e.g., a diagram showing how a machine works) contribute to and clarify a text. **(◊2-LS4-1)***Mathematics –***1.MD.C.4** Organize, represent, and interpret data with up to three categories; ask and answer questions about the total number of data points, how many in each category, and how many more or less are in one category than in another. **(2-LS4-1)****2.MD.A.4** Measure to determine how much longer one object is than another, expressing the length difference in terms of a standard length unit. **(2-LS4-1)** |

**Grade 2: Physical Science**

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| **PS1. Matter and its Interactions** |
| **2-PS1-1. Describe and classify different kinds of materials by observable properties of color, flexibility, hardness, texture, and absorbency.****2-PS1-2. Test different materials and analyze the data obtained to determine which materials have the properties that are best suited for an intended purpose.\*** **Clarification Statements:** * **Examples of properties could include, color, flexibility, hardness, texture, and absorbency.**
* **Data should focus on qualitative and relative observations.**

**2-PS1-3. Analyze a variety of evidence to conclude that when a chunk of material is cut or broken into pieces, each piece is still the same material and, however small each piece is, has weight. Show that the material properties of a small set of pieces do not change when the pieces are used to build larger objects.** **Clarification Statements:** * **Materials should be pure substances or microscopic mixtures that appear contiguous at observable scales.**
* **Examples of pieces could include blocks, building bricks, and other assorted small objects.**

**2-PS1-4. Construct an argument with evidence that some changes to materials caused by heating or cooling can be reversed and some cannot.** **Clarification Statements:** * **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.**
 |
| The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*: |
| **Science and Engineering Practices****Analyzing and Interpreting Data*** Analyze data from tests of an object or tool to determine if it works as intended. (2-PS1-2)

**Constructing Explanations and Designing Solutions*** Use information from observations (first-hand or from media) to construct an evidence-based account for natural phenomena. (2-PS1-3)

**Engaging in Argument from Evidence*** Construct an argument with evidence to support a claim. (2-PS1-4)
 | **Disciplinary Core Ideas****PS1.A:Structure and Properties of Matter*** Different kinds of matter exist and many of them can be either solid or liquid, depending on temperature. Matter can be described and classified by its observable properties. (2-PS1-1)
* Different properties are suited to different purposes. (2-PS1-2)
* A great variety of objects can be built up from a small set of pieces. The individual pieces have the same properties (e.g., absorbency, color, flexibility, hardness, texture) whether they are assembled or disassembled. (2-PS1-3)
* Objects or samples of a substance can be weighed, and their size can be described and measured. (2-PS1-3)

**PS1.B: Chemical Reactions*** Heating or cooling a substance may cause changes that can be observed. Sometimes these changes are reversible, and sometimes they are not. (2-PS1-4)
 |
| *ELA Literacy –***W.2.2** Write informative/explanatory texts in which they introduce a topic, use facts and definitions to develop points, and provide a concluding statement or section. **(2-PS1-3), (2-PS1-4)****SL.5.2** Create audio recordings of stories or poems; add drawings or other visual displays to stories or descriptions of experiences when appropriate to clarify ideas, thoughts, and feelings. **(2-PS1-1), (2-PS1-2), (2-PS1-3)***Mathematics –***◊K.MD.B.3** Classify objects into given categories; count the number of objects in each category and sort the categories by count. **(◊2-PS1-1)****◊K.MD.A.1** Describe measurable attributes of objects, such as length or weight. Describe several measurable attributes of a single object. **(◊2-PS1-3)****◊1.MD.C.4** Organize, represent, and interpret data with up to three categories; ask and answer questions about the total number of data points, how many in each category, and how many more or less are in one category than another. **(◊2-PS1-1)** |

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| **PS3. Energy** |
| **2-PS3-1(MA). Design and conduct an experiment to show the effects of friction on the relative temperature and speed of objects that rub against each other.** **Clarification Statements:** * **Examples could include an object sliding on rough vs. smooth surfaces.**
* **Observations of temperature and speed should be qualitative.**
 |
| The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*: |
| **Science and Engineering Practices****Planning and Carrying Out Investigations*** Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence to answer a question. (2-PS3-1(MA))
 | **Disciplinary Core Ideas****PS3.D: Energy in Chemical Processes and Everyday Life*** When two objects rub against each other, this interaction is called friction. Friction between two surfaces can warm both of them (e.g., rubbing hands together). (2-PS3-1(MA))
 |
| *ELA/Literacy –***SL.2.5** Create audio recordings of stories or poems; add drawings or other visual displays to stories or descriptions of experiences when appropriate to clarify ideas, thoughts, and feelings. **(2-PS3-1(MA))****W.2.2** Write informative/explanatory texts that introduce a topic, use facts and definitions to develop points, and provide a concluding statement or section. **(2-PS3-1(MA))***Mathematics –***1.MD.C.4** Organize, represent, and interpret data with up to three categories; ask and answer questions about the total number of data points, how many in each category, and how many more or less are in one category than another. **(2-PS3-1(MA))****◊2.MD.D.10** Draw a picture graph and a bar graph (with single-unit scale) to represent a data set with up to four categories. Solve simple put-together, take-apart, and compare problems, using information presented in a bar graph. **(◊2-PS3-1(MA))****2.MD.D.9** Generate measurement data by measuring lengths of several objects to the nearest whole unit, or by making repeated measurements of the same object. Show the measurements by making a line plot, where the horizontal scale is marked off in whole-number units. **(2-PS3-1(MA))** |

**Grade 2: Technology/Engineering**

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| **ETS1. Engineering Design** |
| **2.K-2-ETS1-3. Analyze data from tests of two objects designed to solve the same design problem to compare the strengths and weaknesses of how each object performs.\*****Clarification Statements:** * **Data can include observations and be either qualitative or quantitative.**
* **Examples can include how different objects insulate cold water or how different types of grocery bags perform.**

**[Note: K-2-ETS1-1 and K-2-ETS1-2 are found in Grade 1]** |
| The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*: |
| **Science and Engineering Practices****Analyzing and Interpreting Data*** Analyze data from tests of an object or tool to determine if it works as intended. (2.K-2-ETS1-3)

**Engaging in Argument from Evidence*** Make a claim about the effectiveness of an object, tool, or solution that is supported by relevant evidence. (2.K-2-ETS1-3)
 | **Disciplinary Core Ideas****ETS1.C: Optimizing the Design Solution*** Because there is always more than one possible solution to a problem, it is useful to compare and test designs. (2.K-2-ETS1-3), *(Note: This Disciplinary Core Idea is secondary to 2-ESS2-1)*
 |
| *ELA/Literacy –***W.2.2** Write informative/explanatory texts that introduce a topic, use facts and definitions to develop points, and provide a concluding statement or section. **(2.K-2-ETS1-3)****SL.2.1b**Build on others’ talk in conversations by linking their comments to the remarks of others. **(2.K-2-ETS1-3)***Mathematics –***◊1.MD.C.4** Organize, represent, and interpret data with up to three categories; ask and answer questions about the total number of data points, how many in each category, and how many more or less are in one category than in another.**(◊2.K-2-ETS1-3)****2.NBT.A.4** Compare two three-digit numbers based on meanings of the hundreds, tens, and ones digits, using >, =, and < symbols to record the results of comparisons. **(2.K-2-ETS1-3)****2.MD.D.9** Generate measurement data by measuring lengths of several objects to the nearest whole unit, or by making repeated measurements of the same object. Show the measurements by making a line plot, where the horizontal scale is marked off in whole-number units. **(2.K-2-ETS1-3)** |

Grade 3

***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 humans’ 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. (STE Curriculum Framework, p.37)

**Grade 3: Earth and Space Sciences**

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| **ESS2. Earth’s Systems** |
| **3-ESS2-1. Use graphs and tables of local weather data to describe and predict typical weather during a particular season in an area.****Clarification Statements:** * **Examples of weather data could include temperature, amount and type of precipitation (e.g., rain, snow), wind direction, and wind speed.**
* **Graphical displays should focus on pictographs and bar graphs.**

**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.****Clarification Statement:** * **Examples of information can include climate data (average temperature, average precipitation, and average wind speed) or comparative descriptions of seasonal weather for different regions.**

**State Assessment Boundary:** * **An understanding of climate change is not expected in state assessment.**
 |
| The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*: |
| **Science and Engineering Practices****Analyzing and Interpreting Data*** Represent data in tables and various graphical displays (bar graphs, pictographs and/or pie charts) to reveal patterns that indicate relationships. (3-ESS2-1)

**Obtaining, Evaluating, and Communicating Information*** Obtain and combine information from books and other reliable media to explain phenomena. (3-ESS2-2)
 | **Disciplinary Core Ideas****ESS2.D: Weather and Climate*** Scientists record patterns of the weather across different times and areas so that they can make predictions about what kind of weather might happen next. (3-ESS2-1)
* Climate describes a range of an area's typical weather conditions and the extent to which those conditions vary over years. (3-ESS2-2)
 |
| *ELA/Literacy –***◊RI.3.1** Ask and answer questions to demonstrate understanding of a text, referring explicitly to the text as the basis for the answers. **(◊3-ESS2-2)****◊RI.3.2** Determine the main idea of a text; recount the key details and explain how they support the main idea. **(◊3-ESS2-2)****◊RI.3.9** Compare and contrast the most important points and key details presented in two texts on the same topic. **(◊3-ESS2-2)***Mathematics –* **◊2.MD.D.10** Draw a picture graph and a bar graph (with single-unit scale) to represent a data set with up to four categories. Solve simple put-together, take-apart, and compare problems, using information presented in a bar graph. **(◊3-ESS2-1)****◊3.MD.B.3** Draw a scaled picture graph and a scaled bar graph to represent a data set with several categories. Solve one- and two-step “how many more” and “how many less” problems using information presented in bar graphs. **(◊3-ESS2-1)** |

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| **ESS3. Earth and Human Activity** |
| **3-ESS3-1. Evaluate the merit of a design solution that reduces the damage caused by weather.\*****Clarification Statement:** * **Examples of design solutions to reduce weather-related damage could include a barrier to prevent flooding, a wind-resistant roof, and a lightning rod.**
 |
| The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*: |
| **Science and Engineering Practices****Engaging in Argument from Evidence*** Make a claim about the merit of a solution to a problem by citing relevant evidence about how it meets the criteria and constraints of the problem. (3-ESS3-1)
 | **Disciplinary Core Ideas****ESS3.B: Natural Hazards*** A variety of natural hazards result from natural processes (e.g., earthquakes, tsunamis, volcanic eruptions). Humans cannot eliminate natural hazards but can take steps to reduce their impacts. (3-ESS3-1) (Note: This Disciplinary Core Idea is also addressed by 4-ESS3-2.)
 |
| *ELA/Literacy-***W.3.2** Write informative/explanatory texts to examine a topic and convey ideas and information clearly. **(3-ESS3-1)***Mathematics –* **◊2.MD.D.10** Draw a picture graph and a bar graph (with single-unit scale) to represent a data set with up to four categories. Solve simple put-together, take-apart, and compare problems, using information presented in a bar graph. **(◊3-ESS3-1)****◊3.MD.B.3** Draw a scaled picture graph and a scaled bar graph to represent a data set with several categories. Solve one- and two-step “how many more” and “how many less” problems using information presented in bar graphs. **(◊3-ESS3-1)** |

**Grade 3: Life Science**

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| **LS1. From Molecules to Organisms: Structures and Processes** |
| **3-LS1-1. Use simple graphical representations to show that different types of organisms have unique and diverse life cycles. Describe that all organisms have birth, growth, reproduction, and death in common but there are a variety of ways in which these happen.** **Clarification Statements:** * **Examples can include different ways plants and animals begin (e.g., sprout from a seed, born from an egg), grow (e.g., increase in size and weight, produce a new part), reproduce (e.g., develop seeds, root runners, mate and lay eggs that hatch), and die (e.g., length of life).**
* **Plant life cycles should focus on those of flowering plants.**
* **Describing variation in organism life cycles should focus on comparisons of the general stages of each, not specifics.**

**State Assessment Boundary:** * **Detailed descriptions of any one organism’s cycle, the differences of “complete metamorphosis” and “incomplete metamorphosis,” or details of human reproduction are not expected in state assessment.**
 |
| The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*: |
| **Science and Engineering Practices****Analyzing and Interpreting Data*** Analyze and interpret data to make sense of phenomena, using logical reasoning, mathematics, and/or computation. (3-LS1-1)
 | **Disciplinary Core Ideas****LS1.B: Growth and Development of Organisms*** Reproduction is essential to the continued existence of every kind of organism. Plants and animals have unique and diverse life cycles. (3-LS1-1), (Note: This Disciplinary Core Idea is also addressed by 3-LS4-5(MA))
 |
| *ELA/Literacy-***SL.3.2** Determine the main ideas and supporting details of a text read aloud or information presented in diverse media and formats, including visually, quantitatively, or orally. **(3-LS1-1)***Mathematics –***◊3.MD.B.3** Draw a scaled picture graph and a scaled bar graph to represent the data set with several categories. Solve one- and two-step “how many more” and “how many less” problems using information presented in scaled bar graphs.**(◊3-LS1-1)** |

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| **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 Statements:** * **Examples of inherited traits that vary can include the color of fur, shape of leaves, length of legs, and size of flowers.**
* **Focus should be on non-human examples.**

**State Assessment Boundary:** * **Genetic mechanisms of inheritance or prediction of traits are not expected in state assessment.**

**3-LS3-2. Distinguish between inherited characteristics and those characteristics that result from a direct interaction with the environment. Give examples of characteristics of living organisms that are influenced by both inheritance and the environment.** **Clarification Statements:** * **Examples of the environment affecting a characteristic could include normally tall plants stunted because they were grown with insufficient water or light, a lizard missing a tail due to a predator, and a pet dog becoming overweight because it is given too much food and little exercise.**
* **Focus should be on non-human examples.**
 |
| The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*: |
| **Science and Engineering Practices****Analyzing and Interpreting Data*** Analyze and interpret data to make sense of phenomena using logical reasoning. (3-LS3-1)

**Constructing Explanations and Designing Solutions*** Use evidence (e.g., observations, patterns) to support an explanation.(3-LS3-2)
 | **Disciplinary Core Ideas****LS3.A: Inheritance of Traits*** Many characteristics of organisms are inherited from their parents. (3-LS3-1)
* Other characteristics result from individuals’ interactions with the environment, which can range from diet to learning. Many characteristics involve both inheritance and environment. (3-LS3-2)

**LS3.B: Variation of Traits*** Different organisms vary in how they look and function because they have different inherited information. (3-LS3-1)
* The environment also affects the traits that an organism develops or has. (3-LS3-2)
 |
| *ELA/Literacy-**RI.3.7* Use information gained from illustrations (e.g., maps, photographs) and the words, numbers, and symbols in a text to demonstrate understanding of the text (e.g., where, when, why, and how key events occur). **(3-LS3-1), (3-LS3-2)***RI.3.9*  Compare and contrast the most important points and key details presented in two texts on the same topic. **(3-LS3-1), (3-LS3-2)***Mathematics –***◊2.MD.A.1** Measure the length of an object by selecting and using appropriate tools such as rulers, yardsticks, meter sticks, and measuring tapes. **(◊3-LS3-1)****◊2.MD.A.3** Estimate lengths using units of inches, feet, centimeters, and meters. **(◊3-LS3-1)****◊2.MD.A.4** Measure to determine how much longer one object is than another, expressing the length difference in terms of a standard length unit. **(◊3-LS3-1)****3.MD.B.4** Generate measurement data by measuring lengths using rulers marked with halves and fourths of an inch. Show the data by making a line plot where the horizontal scale is marked off in appropriate units-whole numbers, halves, or quarters. **(3-LS3-1)** |

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| **LS4. Biological Evolution: Unity and Diversity** |
| **3-LS4-1. Use fossils to describe types of organisms and their environments that existed long ago and compare those to living organisms and their environments. Recognize that most kinds of plants and animals that once lived on Earth are no longer found anywhere.** **Clarification Statement:** * **Comparisons should focus on physical or observable features.**

**State Assessment Boundary:** * **Identification of specific fossils or specific present-day plants and animals, dynamic processes, or genetics are not expected in state assessment.**

**3-LS4-2. Use evidence to construct an explanation for how the variations in characteristics among individuals within the same species may provide advantages to these individuals in their survival and reproduction.** **Clarification Statements:** * **Examples can include rose bushes of the same species, one with slightly longer thorns than the other which may prevent its predation by deer, and color variation within a species that may provide advantages so one organism may be more likely to survive and therefore more likely to produce offspring.**
* **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 different organisms (species) and habitats involved.**

**3-LS4-4. Analyze and interpret given data about changes in a habitat and describe how the changes may affect the ability of organisms that live in that habitat to survive and reproduce.****Clarification Statements:** * **Changes should include changes to landforms, distribution of water, climate, and availability of resources.**
* **Changes in the habitat could range in time from a season to a decade.**
* **While it is understood that ecological changes are complex, the focus should be on a single change to the habitat.**

**3-LS4-5(MA). Provide evidence to support a claim that the survival of a population is dependent upon reproduction.** **State Assessment Boundary:** * **Details of reproduction are not expected in state assessment.**
 |
| The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*: |
| **Science and Engineering Practices****Analyzing and Interpreting Data*** Analyze and interpret data to make sense of phenomena using logical reasoning.

(3-LS4-1), (3-LS4-4)**Constructing Explanations and Designing Solutions*** Use evidence (e.g., observations, patterns) to construct an explanation.(3-LS4-2)
* Identify the evidence that supports particular points in an explanation. (3-LS4-5(MA))

**Engaging in Argument from Evidence*** Construct an argument with evidence.

(3-LS4-3) | **Disciplinary Core Ideas****LS1.B: Growth and Development of Organisms*** Reproduction is essential to the continued existence of every kind of organism. Plants and animals have unique and diverse life cycles. (3-LS4-5(MA)), (Note: This Disciplinary Core Idea is also addressed by 3-LS1-1),

**LS2.C: Ecosystem Dynamics, Functioning, and Resilience*** When the environment changes in ways that affect a place’s physical characteristics, temperature, or availability of resources, some organisms survive and reproduce, others move to new locations, yet others move into the transformed environment, and some die. *(secondary to 3-LS4-4)*

**LS4.A: Evidence of Common Ancestry and Diversity*** Most kinds of plants and animals that once lived on Earth are no longer found anywhere. *(Note: moved from K-2*) (3-LS4-1)
* Fossils provide evidence about the types of organisms that lived long ago and also about the nature of their environments. Fossils can be compared with one another and to living organisms according to their similarities and differences. (3-LS4-1)

**LS4.B: Natural Selection*** Sometimes the differences in characteristics between individuals of the same species provide advantages in surviving, finding mates, and reproducing. (3-LS4-2)

**LS4.C: Adaptation*** For any particular environment, some kinds of organisms survive well, some survive less well, and some cannot survive at all. (3-LS4-3), *(secondary to 3-LS4-5(MA))*

**LS4.D: Biodiversity and Humans*** Populations live in a variety of habitats, and change in those habitats affects the organisms living there. (3-LS4-4)
 |
| *ELA/Literacy–***◊W.3.2** Write informative/explanatory texts to examine a topic and convey ideas and information clearly.**(◊3-LS4-2)****W.3.7** Conduct short research projects that build knowledge about a topic. **(3-LS4-2)***Mathematics-***◊3.MD.B.3** Draw a scaled picture graph and a scaled bar graph to represent a data set with several categories. Solve one- and two-step “how many more” and “how many less” problems using information presented in scaled bar graphs. For example, draw a bar graph in which each square in the bar graph might represent 5 pets.**(◊3-LS4-4)****3.OA.A.2** Interpret whole-number quotients of whole numbers, e.g., interpret 56÷8 as the number of objects in each share when 56 objects are partitioned equally into 8 shares, or as a number of shares when 56 objects are partitioned into 8 objects each.**(3-LS4-4)** |

**Grade 3: Physical Science**

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| **PS2. Motion and Stability: Forces and Interactions** |
| **3-PS2-1. Provide evidence to explain the effect of multiple forces, including friction, on an object. Include balanced forces that do not change the motion of the object and unbalanced forces that do change the motion of the object.** **Clarification Statements:** * **Descriptions of force magnitude should be qualitative and relative.**
* **Force due to gravity is appropriate but only as a force that pulls objects down.**

**State Assessment Boundaries:*** **Quantitative force magnitude is not expected in state assessment.**
* **State assessment will be limited to one variable at a time: number, size, or direction of forces.**

**3-PS2-3. Conduct an investigation to determine the nature of the forces between two magnets based on their orientations and distance relative to each other.** **Clarification Statement:** * **Focus should be on forces produced by magnetic objects that are easily manipulated.**

**3-PS2-4. Define a simple design problem that can be solved by using 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.]** |
| The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*: |
| **Science and Engineering Practices****Asking Questions and Defining Problems*** Define a simple problem that can be solved through the development of a new or improved object or tool. (3-PS2-4)

**Planning and Carrying Out Investigations*** Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered. (3-PS2-3)
 | **Disciplinary Core Ideas****PS2.A: Forces and Motion*** Each force acts on one particular object and has both strength and a direction. An object at rest typically has multiple forces acting on it, but they add to give zero net force on the object. Forces that do not sum to zero can cause changes in the object’s speed or direction of motion. (Boundary: Qualitative and conceptual, but not quantitative additions of forces are used at this level.) (3-PS2-1)
* When a force causes one surface to pull against another surface, a frictional force can result. The frictional force acts in the opposite direction of the original force. (3-PS2-1)

**PS2.B: Types of Interactions** * Objects in contact exert forces on each other. (3-PS2-1)
* Magnetic forces between a pair of objects do not require that the objects be in contact. The sizes of the forces in each situation depend on the properties of the objects and their distances apart and, for forces between two magnets, on their orientation relative to each other. (3-PS2-3),(3-PS2-4)
 |
| *ELA/Literacy-***RI.3.3**Describe the relationship between a series of historical events, scientific ideas or concepts, mathematical ideas or concepts, or steps in technical procedures in a text, using language that pertains to time, sequence, and cause/effect. **(3-PS2-1), (3-PS2-3), (3-PS2-4)****W.3.2**Write informative/explanatory texts to examine a topic and convey ideas and information clearly. **(3-PS2-1), (3-PS2-3), (3-PS2-4)***Mathematics –***2.NBT.A.4** Compare two three-digit numbers based on meanings of the hundreds, tens, and ones digits, using >, =, and < symbols to record the results of comparisons. **(3-PS2-1)****3.MD.B.4** Generate measurement data by measuring lengths using rulers marked with halves and fourths of an inch. Show the data by making a line plot, where the horizontal scale is marked off in appropriate units - whole numbers, halves, or quarters. **(3-PS2-3)** |

**Grade 3: Technology/Engineering**

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| **ETS1. Engineering Design** |
| **3.3-5-ETS1-1. Define a simple design problem that reflects a need or a want. Include criteria for success and constraints on materials, time, or cost that a potential solution must meet.\*****3.3-5-ETS1-2. Generate several possible solutions to a given design problem. Compare each solution based on how well each is likely to meet the criteria and constraints of the design problem.\*** **Clarification Statement:** * **Examples of design problems can include adapting a switch on a toy for children who have a motor coordination disability, designing a way to clear or collect debris or trash from a storm drain, or creating safe moveable playground equipment for a new recess game.**

**3.3-5-ETS1-4(MA). Gather information using various informational resources on possible solutions to a design problem. Present different representations of a design solution.\*** **Clarification Statements:** * **Examples of informational resources can include books, videos, and websites.**
* **Examples of representations can include graphic organizers, sketches, models, and prototypes.**

**[Note: 3-5-ETS1-3 and 3-5-ETS1-5(MA) are found in Grade 4.]** |
| The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*: |
| **Science and Engineering Practices****Asking Questions and Defining Problems** * Define a simple design problem that can be solved through the development of an object, tool, process, or system and includes several criteria for success and constraints on materials, time, or cost. (3.3-5-ETS1-1)

**Constructing Explanations and Designing Solutions** * Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design problem. (3.3-5-ETS1-2)

**Obtaining, Evaluating, and Communicating Information*** Obtain and combine information from books and/or other reliable media to explain phenomena or solutions to a design problem. (3.3-5 ETS1-4(MA))
 | **Disciplinary Core Ideas****ETS1.A: Defining and Delimiting Engineering Problems*** Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account. (3.3-5-ETS1-1) *(Note: This Disciplinary Core Idea is also secondary to 4-PS3-4)*

**ETS1.B: Developing Possible Solutions*** Research on a problem should be carried out before beginning to design a solution. Testing a solution involves investigating how well it performs under a range of likely conditions. (3.3-5-ETS1-4(MA))
* At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs. (3.3-5-ETS1-2)

**ETS1.C: Optimizing the Design Solution*** Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints. (3.3-5-ETS1-2)
 |
| *ELA/Literacy–***◊RI.3.5** Use text features and search tools (e.g., key words, sidebars, hyperlinks) to locate information relevant to a given topic efficiently. **(◊3.3-5-ETS1-4(MA))****◊RI.3.7** Use information gained from illustrations (e.g., maps, photographs) and the words in a text to demonstrate understanding of the text (e.g., where, when, why, and how key events occur). **(◊3.3-5-ETS1-4(MA))****SL.3.4** Report on a topic, text, or solution to a mathematical problem, tell a story, or recount an experience with appropriate facts and relevant, descriptive details, speaking clearly at an understandable pace and using appropriate vocabulary. **(3.3-5-ETS1-1), (3.3-5-ETS1-2)***Mathematics –***2.MD.C.8** Solve word problems involving dollar bills, quarters, dimes, nickels, and pennies, using $ and ₵ symbols appropriately. **(3.3-5-ETS1-1), (3.3-5-ETS1-2)****3.MD.A.1** Tell and write time to the nearest minute and measure time intervals in minutes. Solve word problems involving addition and subtraction of time intervals in minutes, e.g. by representing the problem on a number line diagram. **(3.3-5-ETS1-1), (3.3-5-ETS1-2)** |

Grade 4

***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 change over time as related to the deposition and erosion in landscape formation. They study today’s landscapes to provide evidence for past processes. Students learn that animals’ internal and external structures 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. (STE Curriculum Framework, p.41)

**Grade 4: Earth and Space Sciences**

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| **ESS1. Earth’s Place in the Universe** |
| **4-ESS1-1. 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 over long periods of time.** **Clarification Statements:** * **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.**
* **Examples of simple landforms can include valleys, hills, mountains, plains, and canyons.**
* **Focus should be on relative time.**

**State Assessment Boundary:** * **Specific details of the mechanisms of rock formation or specific rock formations and layers are not expected in state assessment.**
 |
| The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*: |
| **Science and Engineering Practices****Constructing Explanations and Designing Solutions*** Identify the evidence that supports particular points in an explanation. (4-ESS1-1)
 | **Disciplinary Core Ideas****ESS1.C: The History of Planet Earth*** Local, regional, and global patterns of rock formations reveal changes over time due to earth forces, such as earthquakes. The presence and location of certain fossil types indicate the order in which rock layers were formed. (4-ESS1-1)
* Earth has changed over time. Understanding how landforms develop, are weathered (broken down into smaller pieces), and erode (get transported elsewhere) can help infer the history of the current landscape. (4-ESS1-1)

**ESS2.A: Earth Materials and Systems*** Rainfall helps to shape the land and affects the types of living things found in a region. Water, ice, wind, and living organisms break rocks, soils, and sediments into smaller particles and move them around. (4-ESS1-1), (Note: This Disciplinary Core Idea is also addressed by 4-ESS2-1)
 |
| *ELA/Literacy –***◊W.4.9** Draw evidence from literary or informational texts to support written analysis, reflection, and research, applying one or more grade 4 standards for Reading Literature or Reading Informational Text as needed. **(◊4-ESS1-1)***Mathematics –***3. MD.A** Solve problems involving measurement and estimation of intervals of time, liquid volumes, and masses of objects. . **(4-ESS1-1)** |

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| **ESS2. Earth’s Systems** |
| **4-ESS2-1. Make observations and collect data to provide evidence that rocks, soils, and sediments are broken into smaller pieces through mechanical weathering and moved around through erosion.** **Clarification Statements:** * **Mechanical weathering processes can include frost wedging, abrasion, and tree root wedging.**
* **Erosion can include movement by blowing wind, flowing water, and moving ice.**

**State Assessment Boundary:** * **Chemical processes are not expected in state assessment.**

**4-ESS2-2. Analyze and interpret maps of Earth’s mountain ranges, deep ocean trenches, volcanoes, and earthquake epicenters to describe patterns of these features and their locations relative to boundaries between continents and oceans.** |
| The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*: |
| **Science and Engineering Practices****Planning and Carrying Out Investigations*** Make observations and measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon. (4-ESS2-1)

**Analyzing and Interpreting Data*** Analyze and interpret data to make sense of phenomena using logical reasoning. (4-ESS2-2)
 | **Disciplinary Core Ideas****ESS2.A: Earth Materials and Systems*** Rainfall helps to shape the land and affects the types of living things found in a region. Water, ice, wind, and living organisms break rocks, soils, and sediments into smaller particles and move them around. (4-ESS2-1), (Note: This Disciplinary Core Idea is also addressed by 4-ESS1-1)

**ESS2.B: Plate Tectonics and Large-Scale System Interactions*** The locations of mountain ranges, deep ocean trenches, ocean floor structures, earthquakes, and volcanoes occur in patterns. Most earthquakes and volcanoes occur in bands that are often along the boundaries between continents and oceans. Major mountain chains form inside continents or near their edges. Maps can help locate the different land and water features areas of Earth. (4-ESS2-2)

**ESS2.E: Biogeology*** Living things affect the physical characteristics of their regions, such as root wedging. (4-ESS2-1)
 |
| *ELA/Literacy –***RI.4.9** Integrate information from two texts on the same topic in order to write or speak knowledgeably about the subject. **(4-ESS2-1)***Mathematics –* **◊4.MD.A.1** Know relative sizes of measurement units within one system of units including km, m, cm; kg, g; lb, oz.; l, ml; hr, min, sec. Within a single system of measurement, express measurements in a larger unit in terms of a smaller unit. Record measurement equivalents in a two-column table. For example, know that 1 ft is 12 times as long as 1 in. Express the length of a 4 ft snake as 48 in. Generate a conversion table for feet and inches listing the number pairs (1, 12), (2, 24), (3, 36)….**(◊4-ESS2-1), (4-ESS2-2)** **3.MD.B.4** Generate measurement data by measuring lengths using rulers marked with halves and fourths of an inch. Show the data by making a line plot, where the horizontal scale is marked off in appropriate units – whole numbers, halves, or quarters.**(4-ESS2-2)** |

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| **ESS3. Earth and Human Activity** |
| **4-ESS3-1. Obtain information to describe that energy and fuels humans use are derived from natural resources and that some energy and fuel sources are renewable and some are not.** **Clarification Statements:** * **Examples of renewable energy resources could include wind energy, water behind dams, tides, and sunlight.**
* **Non-renewable energy resources are fossil fuels and nuclear materials.**

**4-ESS3-2. Evaluate different solutions to reduce the impacts of a natural event such as an earthquake, blizzard, or flood on humans.\*** **Clarification Statement:** * **Examples of solutions could include an earthquake-resistant building or a constructed wetland to mitigate flooding.**
 |
| **Science and Engineering Practices****Obtaining, Evaluating, and Communicating Information*** Obtain and combine information from books and other reliable media to explain phenomena. (4-ESS3-1)

**Constructing Explanations and Designing Solutions*** Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design solution. (4-ESS3-2)
 | **Disciplinary Core Ideas****ESS3.A: Natural Resources** * Energy and fuels that humans use are derived from natural sources. Some resources are renewable over time, and others are not. (4-ESS3-1)

**ESS3.B: Natural Hazards*** A variety of hazards result from natural processes (e.g., earthquakes, tsunamis, volcanic eruptions). Humans cannot eliminate the hazards but can take steps to reduce their impacts. (4-ESS3-2) (Note: This Disciplinary Core Idea is also addressed by 3-ESS3-1)
 |
| *ELA/Literacy –***◊RI.4.9** Integrate information from two texts on the same topic in order to write or speak knowledgably about the subject. **(◊4-ESS3-1)****◊W.4.9** Draw evidence from literary or informational texts to support analysis, reflection, and research. **(◊4-ESS3-1)***Mathematics –***4.MD.A.2** Use the four operations to solve word problems involving distances, intervals of time, liquid volumes, masses of objects, and money, including problems involving simple fractions or decimals, and problems that require expressing measurements given in a larger unit in terms of a smaller unit. Represent measurement quantities using diagrams such as number line diagrams that feature a measurement scale. **(4-ESS3-1)** |

**Grade 4: Life Science**

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| **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 Statements:** * **Animal structures can include legs, wings, fins, feathers, trunks, claws, horns, antennae, eyes, ears, nose, heart, stomach, lung, brain, and skin.**
* **Plant structures can include leaves, roots, stems, bark, branches, flowers, fruit, and seeds.**

**State Assessment Boundary:** * **State assessment will be limited to macroscopic structures.**

 **[Note: 4-LS1-2 from NGSS is not included.]** |
| The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*: |
| **Science and Engineering Practices****Engaging in Argument from Evidence*** Construct an argument with evidence, data, and/or a model. (4-LS1-1)
 | **Disciplinary Core Ideas****LS1.A: Structure and Function*** Plants and animals have both internal and external structures that serve various functions in growth, survival, behavior, and reproduction. (4-LS1-1)
 |
| *ELA/Literacy –***◊SL.4.4** Report on a topic, text, procedure, or solution to a mathematical problem, tell a story, or recount an experience in an organized manner, using appropriate facts and relevant, descriptive details to support main ideas or themes; speak clearly at an understandable pace and use appropriate vocabulary. **(◊4-LS1-1)***Mathematics –***SMP3** Construct viable arguments and critique the reasoning of others**. (4-LS1-1)****SMP7** Look for and make use of structure*.* **(4-LS1-1)** |

**Grade 4: Physical Science**

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| **PS3. Energy** |
| **4-PS3-1. Use evidence to construct an explanation relating the speed of an object to the energy of that object.** **State Assessment Boundaries:** * **State assessment will be limited to analysis of kinetic energy.**
* **Accounting for mass, quantitative measures of changes in the speed of an object, or any precise or quantitative definition of energy is not expected in state assessment.**

**4-PS3-2. Make observations to show that energy can be transferred from place to place by sound, light, heat, and electric currents.** **Clarification Statement:** * **Evidence of energy being transferred can include vibrations felt a small distance from a source, a solar-powered toy that moves when placed in direct light, warming a metal object on one end and observing the other end getting warm, and a wire carrying electric energy from a battery to light a bulb.**

**State Assessment Boundary:** * **Quantitative measurements of energy are not expected in state assessment.**

**4-PS3-3. Ask questions and predict outcomes about the changes in energy that occur when objects collide.** **Clarification Statement:** * **Changes in energy can include a change in the object’s motion, position, and the generation of heat and/or sound.**

**State Assessment Boundary:** * **Analysis of forces or quantitative measurements of energy are not expected in state assessment.**

**4-PS3-4. Apply scientific principles of energy and motion to test and refine a device that converts kinetic energy to electrical energy or uses stored energy to cause motion or produce light or sound.\*** **Clarification Statement:** * **Sources of stored energy can include water in a bucket or a weight suspended at a height, and a battery.**
 |
| **Science and Engineering Practices****Asking Questions and Defining Problems*** Ask questions that can be investigated and predict reasonable outcomes based on patterns such as cause and effect relationships. (4-PS3-3)

**Planning and Carrying Out Investigations** * Make observations to produce data to serve as the basis for evidence for an explanation of a phenomenon or test a design solution.(4-PS3-2)

**Constructing Explanations and Designing Solutions*** Use evidence (e.g., measurements, observations, patterns) to construct an explanation. (4-PS3-1)
* Apply scientific ideas to solve design problems. (4-PS3-4)
 | **Disciplinary Core Ideas****PS3.A: Definitions of Energy** * The faster a given object is moving, the more energy it possesses. This is called kinetic energy. (4-PS3-1), *(secondary to 4-PS3-4)*
* Energy can be moved from place to place by moving objects or through sound, light, or electric currents. (4-PS3-2), (4-PS3-3)

**PS3.B: Conservation of Energy and Energy Transfer*** Energy is present whenever there are moving objects, sound, light, or heat. When objects collide, energy can be transferred from one object to another, thereby changing their motion. In such collisions, some energy is typically also transferred to the surrounding air; as a result, the air gets heated and sound is produced. (4-PS3-2) (4-PS3-3)
* Light also transfers energy from place to place. (4-PS3-2)
* Energy can also be transferred from place to place by electric currents, which can then be used locally to produce motion, sound, heat, or light. The currents may have been produced to begin with by transforming the kinetic energy into electrical energy. (4-PS3-2) (4-PS3-4)

**PS3.C: Relationship Between Energy and Forces*** When objects collide, the contact forces transfer energy so as to change the objects’ motions. (4-PS3-3)

**PS3.D: Energy in Chemical Processes and Everyday Life*** The expression “produce energy” typically refers to the conversion of stored energy into a desired form for practical use. (4-PS3-4)

**ETS1.A: Defining and Delimiting Engineering Problems*** Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account. *(secondary to 4-PS3-4)* (Note: This Disciplinary Core Idea is also addressed by 3.3-5-ETS1-1)
 |
| *ELA/Literacy –***◊W**.**4.8** Recall relevant information from experiences or gather relevant information from print and digital sources; take notes and categorize information, and provide a list of sources. **(◊4-PS3-1), (4-PS3-2)****◊W**.**4.9** Draw evidence from literary or informational texts to support analysis, reflection, and research. **(◊4-PS3-1)****SL.4.3** Identify the reasons and evidence a speaker provides to support particular points. **(4-PS3-1)****SL.4.1** Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 4 topics and texts, building on others’ ideas and expressing their own clearly. **(4-PS3-3)***Mathematics –***3.MD.A.2** Measure and estimate liquid volumes and masses of objects using standard units of grams (g), kilograms (kg), and liters (l). Add, subtract, multiply, or divide to solve one-step word problems involving masses or volumes that are given in the same units, e.g., by using drawings (such as a beaker with a measurement scale) to represent the problem.**(4-PS3-4)****3.MD.B.4** Generate measurement data by measuring lengths using rulers marked with halves and fourths of an inch. Show the data by making a line plot, where the horizontal scale is marked off in appropriate units – whole numbers, halves, or quarters.**(4-PS3-4)** |

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| **PS4. Waves and their Applications in Technologies for Information Transfer** |
| **4-PS4-1. Develop a model of a simple mechanical wave (including sound) to communicate that waves (a) are regular patterns of motion along which energy travels and (b) can cause objects to move.** **Clarification Statement:** * **Examples of models could include diagrams, analogies, and physical models.**

**State Assessment Boundary:** * **Interference effects, electromagnetic waves, or non-periodic waves are not expected in state assessment.**

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

**4-PS4-3. Develop and compare multiple ways to transfer information through encoding, sending, receiving, and decoding a pattern.\*** **Clarification Statement:** * **Examples of solutions could include drums sending coded information through sound waves, using a grid of 1s and 0s representing black and white to send information about a picture, and using Morse code to send text.**
 |
| **Science and Engineering Practices****Developing and Using Models*** Develop a model using an analogy, example, or abstract representation to describe a scientific principle. (4-PS4-1)
* Develop a model to describe phenomena. (4-PS4-2)

**Constructing Explanations and Designing Solutions*** Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design solution. (4-PS4-3)
 | **Disciplinary Core Ideas****PS4.A: Wave Properties*** Waves, which are regular patterns of motion, can be made in water by disturbing the surface. When waves move across the surface of deep water, the water goes up and down in place; it does not move in the direction of the wave except when the water meets the beach. *(Note: This grade band endpoint was moved from K–2.)* (4-PS4-1)
* Waves of the same type can differ in amplitude (height of the wave, or volume of a sound wave) and wavelength (spacing between wave peaks of the wave, or the pitch of a sound wave). (4-PS4-1)

**PS4.B: Electromagnetic Radiation** * An object can be seen when light reflected from its surface enters the eyes. (4-PS4-2)
* Objects can be seen only when light is available to illuminate them. Some objects give off their own light. *(Note: This grade band endpoint was moved from K–2.) (secondary to 4-PS4-2)*

**PS4.C: Information Technologies and Instrumentation*** High-tech devices, such as computers or cell phones, can receive and decode information—convert it from digitized form to voice—and vice versa. (4-PS4-3)

**ETS1.C: Optimizing the Design Solution*** Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints. *(secondary to 4-PS4-3),* (Note: This Disciplinary Core Idea is also addressed by 4.3-5-ETS1-3),
 |
| *ELA/Literacy-***RI.4.3**Explain events, procedures, ideas, or concepts in a historical, scientific, mathematical, or technical text, including what happened and why, based on specific information in the text. **(4-PS4-1), (4-PS4-2), (4-PS4-3)****W**.**4.8** Recall relevant information from experiences or gather relevant information from print and digital sources; take notes and categorize information, and provide a list of sources. **(4-PS4-1), (4-PS4-2), (4-PS4-3)***Mathematics –***◊4.G.A.3** Recognize a line of symmetry for two-dimensional figure as a line across the figure such that the figure can be folded along the line into matching parts. Identify line-symmetric figures and draw lines of symmetry. **(◊4-PS4-1), (4-PS4-2)****4.MD.C.5** Recognize angles as geometric shapes that are formed wherever two rays share a common endpoint, and understand concepts and angle measurement. **(4-PS4-2)** |

**Grade 4: Technology/Engineering**

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| **ETS1. Engineering Design** |
| **4.3-5-ETS1-3. Plan and carry out tests of one or more design features of a given model or prototype in which variables are controlled and failure points are considered to identify which features need to be improved. Apply the results of tests to redesign a model or prototype.\*****Clarification Statement:*** **Examples of design features can include materials, size, shape, and weight.**

**4.3-5-ETS1-5(MA). Evaluate relevant design features that must be considered in building a model or prototype of a solution to a given design problem.\*** **[Note: 3-5-ETS1-1, 3-5-ETS1-2, and 3-5-ETS1-4(MA) are found in Grade 3.]** |
| The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*: |
| **Science and Engineering Practices****Analyzing and Interpreting Data*** Use data to evaluate and refine design solutions. (3-5-ETS1-5(MA))

**Planning and Carrying Out Investigations** * Plan and conduct fair tests in which variables are controlled and the number of trials considered. (3-5-ETS1-3)
 | **Disciplinary Core Ideas****ETS1.A: Defining and Delimiting an Engineering Problem*** The success of a designed solution is determined by considering the desired features of a solution (criteria). (3-5-ETS1-5)

**ETS1.B: Developing Possible Solutions*** Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved. (3-5-ETS1-3), *(Note: This Disciplinary Core idea is also secondary to 5-ESS3-2(MA))*

**ETS1.C: Optimizing the Design Solution*** Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints. (4.3-5-ETS1-3), *(Note: This Disciplinary Core Idea is also secondary to 4-PS4-3)*
 |
| *ELA/Literacy-***W.4.1** Write opinion pieces on topics or texts, supporting a point of view with reasons and information. **(4.3-5-ETS1-3), (4.3-5-ETS1-5)** **L.4.6** Acquire and use accurately grade-appropriate general academic and domain-specific words and phrases, including those that signal precise actions, emotions, or states of being (e.g., quizzed, whined, and that are basic to a particular topic (e.g., wildlife, conservation, and endangered when discussing animal preservation). **(4.3-5-ETS1-3), (4.3-5-ETS1-5)***Mathematics –***3.MD.B.4** Generate measurement data by measuring lengths using rulers marked with halves and fourths of an inch. Show the data by making a line plot, where the horizontal scale is marked off in appropriate units – whole numbers, halves, or quarters.**(4.3-5-ETS1-3)****4.NF.C.7** Compare two decimals to hundredths by reasoning about their size. Recognize that comparisons are valid only when two decimals refer to the same whole. Record results of comparisons with the symbols >, =, or <, and justify the conclusions, e.g. by using a visual mode.**(4.3-5-ETS1-3), (4.3-5-ETS1-5)****3.MD.A.2** Measure and estimate liquid volumes and masses of objects using standard units of grams (g), kilograms (kg), and liters (l). Add, subtract, multiply, or divide to solve one-step word problems involving masses or volumes that are given in the same units, e.g., by using drawings (such as a beaker with a measurement scale) to represent the problem.**(4.3-5-ETS1-3)** |

Grade 5

***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 about the connections and relationships among plants and animals, and the ecosystems within which they live, to show how matter and energy are cycled through these (building on the theme of grade 4). An ability to describe, analyze, and model connections and relationships of observable components of different systems is key to understanding the natural and designed world. (STE Curriculum Framework, p.44)

**Grade 5: Earth and Space Sciences**

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| **ESS1. Earth’s Place in the Universe** |
| **5-ESS1-1. Use observations, first-hand and from various media, to argue that the Sun is a star that appears larger and brighter than other stars because it is closer to Earth.** **State Assessment Boundary:** * **Other factors that affect apparent brightness (such as stellar masses, age, or stage) are not expected in state assessment.**

**5-ESS1-2. Use a model to communicate Earth’s relationship to the Sun, Moon, and other stars that explain (a) why people on Earth experience day and night, (b) patterns in daily changes in length and direction of shadows over a day, and (c) changes in the apparent position of the Sun, Moon, and stars at different times during a day, over a month, and over a year.** **Clarification Statement:** * **Models should illustrate that the Earth, Sun, and Moon are spheres; include orbits of the Earth around the Sun and of the Moon around Earth; and demonstrate Earth’s rotation about its axis.**

**State Assessment Boundary:** * **Causes of lunar phases or seasons, or use of Earth’s tilt are not expected in state assessment.**
 |
| The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*: |
| **Science and Engineering Practices****Developing and Using Models*** Use a model to test cause and effect relationships or interactions concerning the functioning of a natural or designed system. (5-ESS1-2)

**Engaging in Argument from Evidence** * Support an argument with evidence, data, or a model. (5-ESS1-1)
 | **Disciplinary Core Ideas****ESS1.A: The Universe and its Stars** * The sun is a star that appears larger and brighter than other stars because it is closer. Stars range greatly in their distance from Earth. (5-ESS1-1)

**ESS1.B: Earth and the Solar System*** The orbits of Earth around the sun and of the moon around Earth, together with the rotation of Earth about an axis between its North and South poles, cause observable patterns. These include day and night; daily changes in the length and direction of shadows; and different positions of the sun, moon, and stars at different times of the day, month, and year. (5-ESS1-2)
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| *ELA/Literacy –***◊W.5.2** Write informative/explanatory texts to examine a topic and convey ideas and information clearly. **(◊5-ESS1-1)****◊W.5.9** Draw evidence from literary or informational texts to support analysis, reflection, and research. **(◊5-ESS1-1)****◊RI.5.3** Explain the relationships or interactions between two or more individuals, events, ideas, or concepts in a historical, scientific, or technical text based on specific information in the text. **(◊5-ESS1-2)****SL.5.4** Report on a topic, text, procedure, or solution to a mathematical problem, or present an opinion, sequencing ideas logically and using appropriate facts and relevant, descriptive details to support main ideas or themes; speak clearly at an understandable pace and use appropriate vocabulary. **(5-ESS1-1)***Mathematics –* **5.NBT.A.2** Explain patterns in the number of zeros of the product when multiplying a number by powers of 10, and explain patterns in the placement of the decimal point when a decimal is multiplied or divided by a power of 10. Use whole-number exponents to denote powers of 10. **(5-ESS1-1)****5.NF.B.5** Interpret multiplication as scaling (resizing) by: a) comparing the size of a product to the size of one factor on the basis of the size of the other factor, without performing the indicated multiplication and b) Explaining why multiplying a given number by a fraction greater than 1 results in a product greater than the given number (recognizing multiplication by whole numbers greater than 1 as a familiar case); explaining why multiplying a given number by a fraction less than 1 results in a product smaller than the given number; and relating the principle of fraction equivalence $\frac{a}{b}=\frac{(n\*a)}{(n\*b)}$. **(5-ESS1-1)** **5.G.A.2** Represent real-world and mathematical problems by graphing points in the first quadrant of the coordinate plane, and interpret coordinate values of points in the context of the situation. **(5-ESS1-2)****4.MD.C.3** Recognize angles as geometric shapes that are formed wherever two rays share a common endpoint, and understand concepts of angle measurement.**(5-ESS1-2)** |
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| **ESS2. Earth’s Systems** |
| **5-ESS2-1. Use a model to describe the cycling of water through a watershed through evaporation, precipitation, absorption, surface runoff, and condensation.** **State Assessment Boundary:** * **Transpiration or explanations of mechanisms that drive the cycle are not expected in state assessment.**

**5-ESS2-2. Describe and graph the relative amounts of salt water in the ocean; fresh water in lakes, rivers, and groundwater; and fresh water frozen in glaciers and polar ice caps to provide evidence about the availability of fresh water in Earth’s biosphere.** **State Assessment Boundary:** * **Inclusion of the atmosphere is expected in state not assessment.**
 |
| The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*: |
| **Science and Engineering Practices****Developing and Using Models*** Develop a model using an example to describe a scientific principle. (5-ESS2-1)

**Using Mathematics and Computational Thinking*** Describe and graph quantities such as area and volume to address scientific questions. (5-ESS2-2)
 | **Disciplinary Core Ideas****ESS2.A: Earth Materials and Systems*** Earth’s major systems are the geosphere (solid and molten rock, soil, and sediments), the hydrosphere (water and ice), the atmosphere (air), and the biosphere (living things, including humans). (5-ESS2-1)

**ESS2.C: The Roles of Water in Earth’s Surface Processes*** Nearly all of Earth’s available water is in the ocean. Most fresh water is in glaciers or underground; only a tiny fraction is in streams, lakes, wetlands, and the atmosphere. (5-ESS2-2), *(secondary to 5-ESS2-1)*
* *(Moved from middle school)* Water continually cycles among land, ocean, and atmosphere via transpiration, evaporation, condensation and crystallization, and precipitation, as well as downhill flows on land. (5-ESS2-1)
 |
| *ELA/Literacy-***RI.5.3** Describe how an author uses one or more structures (e.g., chronology, comparison, cause/effect, problem/solution) of events, to present information in a text. **(5-ESS2-1), (5 ESS2-2)** *Mathematics –* **◊3.MD.B.3** Draw a scaled picture graph and a scaled bar graph to represent a data set with several categories. Solve one- and two-step “how many more” and “how many less" Problems using information presented in scaled bar graphs. **(◊5-ESS2-2)** **4.NF.B.3d** Solve word problems involving addition and subtraction of fractions referring to the same whole and having like denominators, e.g., by using visual fraction models and equations to represent the problem. **(5-ESS2-2)** |

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| **ESS3. Earth and Human Activity** |
| **5-ESS3-1. Obtain and combine information about ways communities reduce human impact on the Earth’s resources and environment by changing an agricultural, industrial, or community practice or process.** **Clarification Statement:** * **Examples of changed practices or processes include treating sewage, reducing the amounts of materials used, capturing polluting emissions from factories or power plants, and preventing runoff from agricultural activities.**

**State Assessment Boundary:** * **Science of climate change or social science aspects of practices such as regulation or policy are not expected in state assessment.**

**5-ESS3-2(MA). Test a simple system designed to filter particulates out of water and propose one change to the design to improve it.\***  |
| The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*: |
| **Science and Engineering Practices****Obtaining, Evaluating, and Communicating Information*** Obtain and combine information from books and/or other reliable media to explain phenomena or solutions to a design problem. (5-ESS3-1)

**Planning and Carrying Out Investigations*** Make observations and/or measurements to test a design solution. (5-ESS3-2(MA))
 | **Disciplinary Core Ideas****ESS3.C: Human Impacts on Earth Systems*** Human activities in agriculture, industry, and everyday life have had major effects on the land, vegetation, streams, ocean, air, and even outer space. But individuals and communities are doing things to help protect Earth’s resources and environments. For example, they are treating sewage, reducing the amounts of materials they use, and regulating sources of pollution such as emissions from factories and power plants or the runoff from agricultural activities. (5-ESS3-1)

**PS1.A: Structure and Properties of Matter*** Filters can be made from a variety of materials to collect and remove different sized particles from water. (5-ESS3-2(MA))

**ETS1.B: Developing Possible Solutions*** Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved. (4.3-5-ETS1-3), *(secondary to 5-ESS3-2(MA))*
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| *ELA/Literacy –* **◊RI.5.1** Quote or paraphrase a text accurately when explaining what the text states explicitly and when drawing inferences from the text. **(5-ESS3-1)****◊RI.5.7** Draw on information from multiple print or digital sources, demonstrating the ability to locate an answer to a question quickly or to solve a problem efficiently. **(5-ESS3-1)****◊RI.5.9** Integrate information from several texts on the same topic in order to write or speak knowledgeably about the subject. **(5-ESS3-1)****◊W.5.9** Draw evidence from literary or informational texts to support analysis, reflection, and research. **(5-ESS3-1)***Mathematics –***4.MD.A.2** Use the four operations to solve word problems involving distances, intervals of time, liquid volumes, masses of objects, and money, including problems involving simple fractions or decimals, and problems that require expressing measurements given in a larger unit in terms of a smaller unit. Represent measurement quantities using diagrams such as number line diagrams that feature a measurement scale. **(5-ESS3-2)** |
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**Grade 5: Life Science**

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| **LS1. From Molecules to Organisms: Structures and Processes** |
| **5-LS1-1. Ask testable questions about the process by which plants use air, water, and energy from sunlight to produce sugars and plant materials needed for growth and reproduction.** **State Assessment Boundary:** * **The chemical formula or molecular details about the process of photosynthesis are not expected in state assessment.**
 |
| The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*: |
| **Science and Engineering Practices****Engaging in Argument from Evidence*** Support an argument with evidence, data, or a model. (5-LS1-1)
 | **Disciplinary Core Ideas****LS1.C: Organization for Matter and Energy Flow in Organisms*** Plants acquire their material for growth chiefly from air and water. (5-LS1-1), (Note: This Disciplinary Core Idea is also addressed by 5-LS2-1)

**PS3.D: Energy in Chemical Processes and Everyday Life*** The energy released [from] food was once energy from the sun that was captured by plants in the chemical process that forms plant matter (from air and water). (5-LS1-1), (Note: This Disciplinary Core Idea is also addressed by 5-PS2-1 and 5-PS3-1)
 |
| *ELA/Literacy-***SL.5.1**Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 5 topics and texts, building on others’ ideas and expressing their own clearly. **(5-LS1-1)****W.5.8**Recall relevant information from experiences or gather relevant information from print and digital sources; summarize or paraphrase information in notes and finished work, and provide a list of sources. **(5-LS1-1)***Mathematics* –**5.G.A.2** Represent real-world problems and mathematical problems by graphing points in the first quadrant of the coordinate plan, and interpret coordinate values of points in the context of the situation. **(5-LS1-1)** |

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| **LS2. Ecosystems: Interactions, Energy, and Dynamics** |
| **5-LS2-1. Develop a model to describe the movement of matter among producers, consumers, decomposers, and the air, water, and soil in the environment to (a) show that plants produce sugars and plant materials, (b) show that animals can eat plants and/or other animals for food, and (c) show that some organisms, including fungi and bacteria, break down dead organisms and recycle some materials back to the air and soil.****Clarification Statement:** * **Emphasis is on matter moving throughout the ecosystem.**

**State Assessment Boundary:** * **Molecular explanations, or distinctions among primary, secondary, and tertiary consumers, are not expected in state assessment.**

**5-LS2-2(MA). Compare at least two designs for a composter to determine which is most likely to encourage decomposition of materials.\*** **Clarification Statement:** * **Measures or evidence of decomposition should be on qualitative descriptions or comparisons.**
 |
| The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*: |
| **Science and Engineering Practices****Developing and Using Models*** Develop a model to describe phenomena.

(5-LS2-1)**Planning and Carrying Out Investigations*** Test two different models of the same proposed object, tool, or process to determine which better meets criteria for success. (5-LS2-2(MA))
 | **Disciplinary Core Ideas****LS1.C: Organization for Matter and Energy Flow in Organisms*** Plants acquire their material for growth chiefly from air and water. (5-LS2-1), (Note: This Disciplinary Core Idea is also addressed by 5-LS1-1)

**LS2.A: Interdependent Relationships in Ecosystems*** Organisms are related in food webs in which some animals eat plants for food and other animals eat the animals that eat plants. (5-LS2-1)
* Some organisms, such as fungi and bacteria, break down dead organisms (both plants or plants parts and animals) and therefore operate as “decomposers.” Decomposition eventually restores (recycles) some materials back to the soil.

(5-LS2-1), *(secondary to 5-LS2-2(MA))***LS2.B: Cycles of Matter and Energy Transfer in Ecosystems*** Matter cycles between the air and soil and among plants, animals, and microbes as these organisms live and die. Organisms obtain gases, and water, from the environment, and release waste matter (gas, liquid, or solid) back into the environment. (5-LS2-1)
* Compost is a nutrient-rich material made from organic matter that is broken down by decomposers. Plants can use the nutrient-rich matter from compost to grow. Making compost is called “composting,” and can be optimized by adjusting the heat, wetness, composting materials, and mixing of the compost. (5-LS2-2(MA))

**PS3.D: Energy in Chemical Processes and Everyday Life*** The energy released [from] food was once energy from the sun that was captured by plants in the chemical process that forms plant matter (from air and water). (5-PS2-1), (Note: This Disciplinary Core Idea is also addressed by 5-LS1-1 and 5-PS3-1)
 |
| *ELA/Literacy-***SL.5.4** Report on a topic, text, procedure, or solution to a mathematical problem, or present an opinion, sequencing ideas logically and using appropriate facts and relevant, descriptive details to support main ideas or themes; speak clearly at an understandable pace and use appropriate vocabulary. **(5-LS2-1), (5-LS2-2(MA))****RI.5.6**Analyze multiple accounts of the same event or topic, noting important similarities and differences among the points of view they represent. **(5-LS2-2(MA))***Mathematics* –**5.G.A.2** Represent real-world problems and mathematical problems by graphing points in the first quadrant of the coordinate plan, and interpret coordinate values of points in the context of the situation. **(5-LS2-1)** |

**Grade 5: Physical Science**

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| **PS1. Matter and Its Interactions** |
| **5-PS1-1. Use a particle model of matter to explain common phenomena involving gases, and phase changes between gas and liquid and between liquid and solid.** **Clarification Statement:** * **Examples of common phenomena the model should be able to describe include adding air to expand a balloon, compressing air in a syringe, and evaporating water from a salt water solution.**

**State Assessment Boundary:** * **Atomic-scale mechanisms of evaporation and condensation or defining unseen particles are not expected in state assessment.**

**5-PS1-2. Measure and graph the weights (masses) 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 (mass) of matter is conserved.** **Clarification Statement:** * **Assume that reactions with any gas production are conducted in a closed system.**

**State Assessment Boundary:** * **Distinguishing mass and weight is not expected in state assessment.**

**5-PS1-3. Make observations and measurements of substances to describe characteristic properties of each, including color, hardness, reflectivity, electrical conductivity, thermal conductivity, response to magnetic forces, and solubility.** **Clarification Statements:** * **Emphasis is on describing how each substance has a unique set of properties.**
* **Examples of substances could include baking soda and other powders, metals, minerals, and liquids.**

**State Assessment Boundary:** * **Density, distinguishing mass and weight, or specific tests or procedures are not expected in state assessment.**

**5-PS1-4. Conduct an experiment to determine whether the mixing of two or more substances results in new substances with new properties (a chemical reaction) or not (a mixture).**  |
| The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*: |
| **Science and Engineering Practices****Developing and Using Models*** Use a model to describe phenomena. (5-PS1-1)

**Planning and Carrying Out Investigations*** Make observations and measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon. (5-PS1-2), (5-PS1-3)

**Using Mathematics and Computational Thinking*** Measure and graph quantities such as weight to address scientific questions and problems.

(5-PS1-2) | **Disciplinary Core Ideas****PS1.A: Structure and Properties of Matter*** Matter of any type can be subdivided into particles that are too small to see, but even then the matter still exists and can be detected by other means. A model shows that gases are made from matter particles that are too small to see and are moving freely around in space can explain many observations, including the inflation and shape of a balloon; the effects of air on larger particles or objects. (5-PS1-1)
* The amount (weight) of matter is conserved when it changes form, even in transitions in which it seems to vanish.

(5-PS1-2)* Measurements of a variety of properties can be used to identify materials. (Boundary: At this grade level, mass and weight are not distinguished, and no attempt is made to define the unseen particles or explain the atomic-scale mechanism of evaporation and condensation.) (5-PS1-3)
* Matter transitions from a solid to a liquid when the particles in the solid have enough energy added so that the particles can move more freely over one another; the opposite happens when matter turns from liquid to solid. Matter transitions from liquid to gas when the particles in the liquid have enough energy added so that the particles can move away from each other; the opposite happens when matter turns from gas to liquid. (5-PS1-1)

**PS1.B: Chemical Reactions*** Mixtures are formed when two or more different substances are combined. When two or more different substances are mixed, a new substance with different properties may be formed. If new substances are formed, this is called a “chemical reaction.” (5-PS1-4)
* No matter what reaction or change in properties occurs, the total weight of the substances does not change. (Boundary: Mass and weight are not distinguished at this grade level.) (5-PS1-2)
 |

| *ELA/Literacy-***W.5.2**Write informative/explanatory texts to examine a topic and convey ideas and information clearly. **(5-PS1-3), (5-PS1-4)****W.5.9**Draw evidence from literary or informational texts to support written analysis, reflection, and research, applying one or more grade 5 standards for Reading Literature or Reading Informational Text as needed. **(5-PS1-1)***Mathematics –*[**5.MD.A.1**](http://www.corestandards.org/Math/Content/5/MD)[Convert among different-sized standard measurement units within a given measurement system (e.g., convert 5 cm to 0.05 m), and use these conversions in solving multi-step, real- world problems. **(5-PS1-2)**](http://www.corestandards.org/Math/Content/5/MD)[**5.MD.C.3**](http://www.corestandards.org/Math/Content/5/MD)[Recognize volume as an attribute of solid figures and understand concepts of volume measurement. **(5-PS1-1)**](http://www.corestandards.org/Math/Content/5/MD)[**5.MD.C.4**](http://www.corestandards.org/Math/Content/5/MD)[Measure volumes by counting unit cubes, using cubic cm, cubic in, cubic ft, and improvised units. **(5-PS1-1)**](http://www.corestandards.org/Math/Content/5/MD) |
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| **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 Earth’s center.** **State Assessment Boundary:** * **Mathematical representations of gravitational force are not expected in state assessment.**
 |
| The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*: |
| **Science and Engineering Practices****Engaging in Argument from Evidence** * Support an argument with evidence, data, or a model.

(5-PS2-1) | **Disciplinary Core Ideas****PS2.B: Types of Interactions*** The gravitational force of Earth acting on an object near Earth’s surface pulls that object toward the planet’s center. (5-PS2-1)
 |
| *ELA/Literacy –***◊W.5.1** Write opinion pieces on topics or texts, supporting a point of view with reasons and information. **(◊5-PS2-1)****SL.5.4** Report on a topic, text, procedure, or solution to a mathematical problem, or present an opinion, sequencing ideas logically and using appropriate facts and relevant, descriptive details to support main ideas or themes; speak clearly at an understandable pace and use appropriate vocabulary. **(5-PS2-1)***Mathematics* –**SMP.3** Construct viable arguments and critique the reasoning of others. **(5-PS2-1)** |

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| **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 nutrients for life processes, including body repair, growth, motion, body warmth, and reproduction.** **Clarification Statement:** * **Examples of models could include diagrams and flow charts.**

**State Assessment Boundary:** * **Details of cellular respiration, ATP, or molecular details of the process of photosynthesis or respiration are not expected in state assessment.**
 |
| The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*: |
| **Science and Engineering Practices****Developing and Using Models*** Use a model to describe phenomena. (5-PS3-1)
 | **Disciplinary Core Ideas****PS3.D: Energy in Chemical Processes and Everyday Life*** The energy released [from] food was once energy from the sun that was captured by plants in the chemical process that forms plant matter (from air and water). (5-PS3-1), (Note: This Disciplinary Core Idea is also addressed by 5-LS1-1 and 5-LS2-1)
* Food also releases energy when digested. (5-PS3-1)

**LS1.C: Organization for Matter and Energy Flow in Organisms*** Food provides animals with the materials they need for body repair and growth and the energy they need to maintain body warmth and for motion. *(secondary to 5-PS3-1)*

**LS2.A: Interdependent Relationships in Ecosystems*** The food of almost any kind of animal can be traced back to plants. (5-PS3-1)
 |
| *ELA/Literacy-***W.5.8** Recall relevant information from experiences or gather relevant information from print and digital sources; summarize or paraphrase information in notes and finished work, and provide a list of sources. **(5-PS3-1)***Mathematics* –**5.G.A.2** Represent real-world problems and mathematical problems by graphing points in the first quadrant of the coordinate plan, and interpret coordinate values of points in the context of the situation. **(5-PS3-1)** |

**Grade 5: Technology/Engineering**

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| **ETS3. Technological Systems** |
| **5.3-5-ETS3-1(MA). Use informational text to provide examples of improvements to existing technologies (innovations) and the development of new technologies (inventions). Recognize that technology is any modification of the natural or designed world done to fulfill human needs or wants.****5.3-5-ETS3-2(MA). Use sketches or drawings to show how each part of a product or device relates to other parts in the product or device.\*** |
| The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*: |
| **Science and Engineering Practices****Developing and Using Models*** Develop a diagram or simple physical prototype to convey a proposed object, tool, or process. (5.3-5-ETS3-2)

**Obtaining, Evaluating, and Communicating Information*** Obtain and combine information from books and/or other reliable media to explain phenomena or solutions to a design problem. (5.3-5-ETS3-1)
 | **Disciplinary Core Ideas****ETS3.B Technological Systems Society Relies On (examples)*** Technology is the modification of the natural or designed world to meet people’s needs, often made of parts that work together. (5.3-5-ETS3-1), (5.3-5-ETS3-2)
 |
| *ELA/Literacy –***◊W.4.2** Write informative/explanatory texts to examine a topic and convey ideas and information clearly. **(5.3-5-ETS3-2)****SL.5.5** Include multimedia and visual displays in presentations when appropriate to enhance the development of main ideas or themes. **(5.3-5-ETS3-2)***Mathematics* –**SMP5** Use appropriate tools strategically. **(5.3-5-ETS3-1, (5.3-5-ETS3-2)** |

Grade 6

***Structure and Function***

The integration of Earth and space, life, and physical sciences with technology/engineering gives grade 6 students relevant and engaging opportunities with natural phenomena and design problems that highlight the relationship of structure and function in the world around them. Students relate structure and function through analyzing the macro- and microscopic world, such as Earth features and processes, the role of cells and anatomy in supporting living organisms, and properties of materials and waves. Students use models and provide evidence to make claims and explanations about structure-function relationships in different STE domains. (STE Curriculum Framework, p.49)

**Grade 6: Earth and Space Sciences**

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| **ESS1. Earth’s Place in the Universe** |
| **6.MS-ESS1-1a. Develop and use a model of the Earth-Sun-Moon system to explain the causes of lunar phases and eclipses of the Sun and Moon.** **Clarification Statement:** * **Examples of models can be physical, graphical, or conceptual and should emphasize relative positions and distances.**

**6.MS-ESS1-4. Analyze and interpret rock layers and index fossils to determine the relative ages of rock formations that result from processes occurring over long periods of time.** **Clarification Statements:** * **Analysis includes laws of superposition and crosscutting relationships limited to minor displacement faults that offset layers.**
* **Processes that occur over long periods of time include changes in rock types through weathering, erosion, heat, and pressure.**

**State Assessment Boundary:** * **Strata sequences that have been reordered or overturned, names of specific periods or epochs and events within them, or the identification and naming of minerals or rock types are not expected in state assessment.**

**6.MS-ESS1-5(MA). Use graphical displays to illustrate that Earth and its solar system are one of many in the Milky Way galaxy, which is one of billions of galaxies in the universe.** **Clarification Statement:** * **Graphical displays can include maps, charts, graphs, and data tables.**

**[Note: MS-ESS1-1b and MS-ESS1-2 are found in Grade 8. MS-ESS1-3 from NGSS is not included.]** |
| The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*: |
| **Science and Engineering Practices****Developing and Using Models*** Develop and use a model to describe phenomena. (6.MS-ESS1-1)
* Develop a model to show the relationships among variables, including those that are not observable but predict observable phenomena. (6.MS-ESS1-5)

**Analyzing and Interpreting Data*** Analyze and interpret data to determine similarities and differences in findings. (6.MS-ESS1-4)
 | **Disciplinary Core Ideas****ESS1.A: The Universe and Its Stars*** Patterns of the apparent motion of the sun, the moon, and stars in the sky can be observed, described, predicted, and explained with models. (6.MS-ESS1-1)
* Earth and its solar system are part of the Milky Way galaxy, which is one of many galaxies in the universe. (6.MS-ESS1-5)

**ESS1.B: Earth and the Solar System*** This model of the solar system can explain eclipses of the sun and the moon. (6.MS-ESS1-1)

**ESS1.C: The History of Planet Earth*** The geologic time scale interpreted from rock strata provides a way to organize Earth’s history. Analyses of rock strata and the fossil record provide only relative dates, not an absolute scale. (6.MS-ESS1-4)
 |
| *ELA/Literacy –***RCA-ST.6-8.7** Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). **(6.MS-ESS1-5), (6.MS-ESS1-1a)****SL.6.2** Interpret information presented in diverse media and formats (e.g., visually, quantitatively, orally) and explain how it contributes to a topic, text, or issue under study. **(◊6.MS-ESS1-4)***Mathematics –***5.NBT.A.2** Explain patterns in the number of zeros of the product when multiplying a number by powers of 10, and explain patterns in the placement of the decimal point when a decimal is multiplied or divided by a power of 10. Use whole-number exponents to denote powers of 10. **(6.MS-ESS1-5)****5.NF.B.5** Interpret multiplication as scaling (resizing). **(6.MS-ESS1-1a)****6.RP.A.3d** Use ratio reasoning to convert measurement units; manipulate and transform units appropriately when multiplying or dividing quantities*.* **(6.MS-ESS1-4), (6.MS-ESS1-5)** |

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| **ESS2. Earth’s Systems** |
| **6.MS-ESS2-3. Analyze and interpret maps showing the distribution of fossils and rocks, continental shapes, and seafloor structures to provide evidence that Earth’s plates have moved great distances, collided, and spread apart.** **Clarification Statement:** * **Maps may show similarities of rock and fossil types on different continents, the shapes of the continents (including continental shelves), and the locations of ocean structures (such as ridges, fracture zones, and trenches), similar to Wegener’s visuals.**

**State Assessment Boundary:** * **Mechanisms for plate motion or paleo-magnetic anomalies in oceanic and continental crust are not expected in state assessment.**

**[Note: MS-ESS2-2 and MS-ESS2-4 are found in Grade 7. MS-ESS2-1, MS-ESS2-5 and MS-ESS2-6 are found in Grade 8.]** |
| The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*: |
| **Science and Engineering Practices****Analyzing and Interpreting Data*** Analyze and interpret data to provide evidence for phenomena. (6.MS-ESS2-3)
 | **Disciplinary Core Ideas****ESS2.B: Plate Tectonics and Large-Scale System Interactions*** Maps of ancient land and water patterns, based on investigations of rocks and fossils, make clear how Earth’s plates have moved great distances, collided, and spread apart. (6.MS-ESS2-3)

**ESS1.C: The History of Planet Earth*** Tectonic processes continually generate new ocean seafloor at ridges and destroy old seafloor at trenches. (6.MS-ESS2-3), (Note: This Disciplinary Core Idea is also addressed by 8.MS-ESS2-1)
 |
| *ELA/Literacy –***RCA-ST.6-8.7** Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). **(6.MS-ESS2-3)***Mathematics –***4.MD.A.1 `**Know relative sizes of measurement units within one system of units, including km, m, cm; kg, g; lb, oz.; l, ml; hr, min, sec. Within a single system of measurement express measurements in a larger unit in terms of a smaller unit. Record measurement equivalents in a two column table.**(6.MS-ESS2-3)****5.NF.B.5** Interpret multiplication as scaling (resizing). **(6.MS-ESS2-3)** |

**Grade 6: Life Science**

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| **LS1. From Molecules to Organisms: Structures and Processes** |
| **6.MS-LS1-1. Provide evidence that all organisms (unicellular and multicellular) are made of cells.** **Clarification Statement:** * **Evidence can be drawn from multiple types of organisms, such as plants, animals, and bacteria.**

**6.MS-LS1-2. Develop and use a model to describe how parts of cells contribute to the cellular functions of obtaining food, water, and other nutrients from its environment, disposing of wastes, and providing energy for cellular processes.** **Clarification Statement:** * **Parts of plant and animal cells include (a) the nucleus, which contains a cell’s genetic material and regulates its activities; (b) chloroplasts, which produce necessary food (sugar) and oxygen through photosynthesis (in plants); (c) mitochondria, which release energy from food through cellular respiration; (d) vacuoles, which store materials, including water, nutrients, and waste; (e) the cell membrane, which is a selective barrier that enables nutrients to enter the cell and wastes to be expelled; and (f) the cell wall, which provides structural support (in plants).**

**State Assessment Boundary:** * **Specific biochemical steps or chemical processes, the role of ATP, active transport processes involving the cell membrane, or identifying or comparing different types of cells are not expected in state assessment.**

**6.MS-LS1-3. Construct an argument supported by evidence that the body systems interact to carry out essential functions of life.** **Clarification Statements:** * **Emphasis is on the functions and interactions of the body systems, not specific body parts or organs.**
* **An argument should convey that different types of cells can join together to form specialized tissues, which in turn may form organs that work together as body systems.**
* **Body systems to be included are the circulatory, digestive, respiratory, excretory, muscular/skeletal, and nervous systems.**
* **Essential functions of life include obtaining food and other nutrients (water, oxygen, minerals), releasing energy from food, removing wastes, responding to stimuli, maintaining internal conditions, and growing/developing.**
* **An example of interacting systems could include the respiratory system taking in oxygen from the environment which the circulatory system delivers to cells for cellular respiration, or the digestive system taking in nutrients which the circulatory system transports to cells around the body.**

**State Assessment Boundaries:** * **The mechanism of one body system independent of others or the biochemical processes involved in body systems are not expected in state assessment.**
* **Describing the function or comparing different types of cells, tissues, or organs are not expected in state assessment.**

**[Note: MS-LS1-3, MS-LS1-4, MS-LS1-5, and MS-LS1-7 are found in Grade 7. MS-LS1-6 and MS-LS1-8 from NGSS are not included.]** |
| **Science and Engineering Practices****Constructing Explanations and Designing Solutions*** Construct an explanation based on valid and reliable evidence obtained from sources (including the students’ own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to in the future. (6.MS-LS1-1), (6.MS-LS1-3)

**Engaging in Argument with Evidence*** Construct an oral or written argument supported by empirical evidence and scientific reasoning to support or refute an explanation. (6.MS-LS1-1), (6.MS-LS1-3)

**Developing and Using Models*** Develop and use a model to describe phenomena. (6.MS-LS1-2)
 | **Disciplinary Core Ideas****LS1.A: Structure and Function*** All living things are made up of cells, which is the smallest unit that can be said to be alive. An organism may consist of one single cell (unicellular) or many different numbers and types of cells (multicellular). (6.MS-LS1-1)
* Within cells, special structures are responsible for particular functions, and the cell membrane forms the boundary that controls what enters and leaves the cell. (6.MS-LS1-2)
* In multicellular organisms, the body is a system of multiple interacting subsystems. These subsystems are groups of cells that work together to form tissues and organs that are specialized for particular body functions. (6.MS-LS1-3)
 |
| *ELA/Literacy –***◊WCA.6-8.1** Write arguments focused on *discipline-specific content*. **(◊6.MS-LS1-3)****WCA.6-8.7** Conduct short as well as more sustained research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration. **(6-MS-LS1-3)***Mathematics –***SMP7:** Look for and make use of structure. (**6.MS-LS1-2).**  |

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| **LS4. Evolution: Unity and Diversity** |
| **6.MS-LS4-1. Analyze and interpret evidence from the fossil record to describe organisms and their environment, extinctions, and changes to life forms throughout the history of Earth.** **Clarification Statement:** * **Examples of evidence include sets of fossils that indicate a specific type of environment, anatomical structures that indicate the function of an organism in the environment, and fossilized tracks that indicate behavior of organisms.**

**State Assessment Boundary:** * **Names of individual species, geological eras in the fossil record, or mechanisms for extinction or speciation are not expected in state assessment.**

**6.MS-LS4-2. Construct an argument using anatomical structures to support evolutionary relationships among and between fossil organisms and modern organisms.****Clarification Statement:** * **Evolutionary relationships include (a) some organisms have similar traits with similar functions because they were inherited from a common ancestor, (b) some organisms have similar traits that serve similar functions because they live in similar environments, and (c) some organisms have traits inherited from common ancestors that no longer serve their original function because their environments are different than their ancestors’ environments.**

**[Note: MS-LS4-4 and MS-LS4-5 are found in Grade 8. MS-LS4-3 and MS-LS4-6 from NGSS are not included.]** |
| The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*: |
| **Science and Engineering Practices****Analyzing and Interpreting Data*** Analyze and interpret data to determine similarities and differences in findings. (6.MS-LS4-1)

**Engaging in Argument from Evidence** * Construct an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem. (6.MS-LS4-2)
 | **Disciplinary Core Ideas****LS4.A: Evidence of Common Ancestry and Diversity** * The collection of fossils and their placement in chronological order (e.g., through the location of the sedimentary layers in which they are found or through radioactive dating) is known as the fossil record. It documents the existence, diversity, extinction, and change of many life forms throughout the history of life on Earth. (6.MS-LS4-1)
* Anatomical similarities and differences between various organisms living today and between them and organisms in the fossil record, enable the reconstruction of evolutionary history and the inference of lines of evolutionary descent. (6.MS-LS4-2)
 |
| *ELA/Literacy –***◊SL.6.2** Interpret information presented in diverse media and formats (e.g., visually, quantitatively, orally) and explain how it contributes to a topic, text, or issue under study. **(◊6.MS-LS4-1)****◊WCA.6-8.1** Write arguments focused on *discipline-specific content*. **(◊6.MS-LS4-2)***Mathematics –***5.MD.B** Represent and interpret data. **(6.MS-LS4-1).** |

**Grade 6: Physical Science**

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| **PS1. Matter and Its Interactions** |
| **6.MS-PS1-6. Plan and conduct an experiment involving exothermic and endothermic chemical reactions to measure and describe the release or absorption of thermal energy.** **Clarification Statements:** * **Emphasis is on describing transfer of energy to and from the environment.**
* **Examples of chemical reactions could include dissolving ammonium chloride or calcium chloride.**

**6.MS-PS1-7(MA). Use a particulate model of matter to explain that density is the amount of matter (mass) in a given volume. Apply proportional reasoning to describe, calculate, and compare relative densities of different materials.****6.MS-PS1-8(MA). Conduct an experiment to show that many materials are mixtures of pure substances that can be separated by physical means into their component pure substances.** **Clarification Statement:** * **Examples of common mixtures include salt water, oil and vinegar, milk, and air.**

**[Note: MS-PS1-1, MS-PS1-2, MS-PS1-4, MS-PS1-5, and MS-PS1-9(MA) are found in Grade 8. MS-PS1-3 from NGSS is not included.]** |
| The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*: |
| **Science and Engineering Practices****Planning and Carrying Out Investigations*** Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim. (6.MS-PS1-6)
* Conduct an investigation and/or evaluate and/or revise the experimental design to produce data to serve as the basis for evidence that meet the goals of the investigation. (6.MS-PS1-6), (6.MS-PS1-8(MA))

**Developing and Using Models*** Use a model to describe phenomena. (6.MS-PS1-7(MA))
 | **Disciplinary Core Ideas****PS1.A: Structures and Properties of Matter*** Density is the amount of mass in a given volume. A higher density means that there is more matter packed into the same space, and lower density means that there is less matter packed into the same space. (6.MS-PS1-7(MA))
* Some mixtures of substances can be separated into component substances. (6.MS-PS1-8(MA)), (Note: This Disciplinary Core Idea is also addressed by 8.MS-PS1-1)

**PS1.B: Chemical Reactions*** Some chemical reactions release energy, others store energy. (6.MS-PS1-6)
 |
| *ELA /Literacy–***WCA.6-8.2** Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes. **(6.MS-PS1-6), (6.MS-PS1-8(MA))****RCA-ST.6-8.3** Follow precisely a multi-step procedure when carrying out experiments, taking measurements, or performing technical tasks. **(6.MS-PS1-6), (6.MS-PS1-8(MA))***Mathematics –***5.MD.C** Understand concepts of volume and relate volume to multiplication and to addition **(6.MS-PS1-7(MA))****◊6.RP.A.1** Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities. **(◊6.MS-PS1-7(MA))****6.NS.C.5** Understand that positive and negative numbers are used together to describe quantities having opposite directions or values (e.g. temperature above/below zero, elevation above/below sea level, credits/debits, positive/negative electric charge); use positive and negative numbers to represent quantities in real-world contexts, explaining the meaning of 0 in each situation. **(6.MS-PS1-6)** |

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| **PS2. Motion and Stability: Forces and Interactions** |
| **6.MS-PS2-4. Use evidence to support the claim that gravitational forces between objects are attractive and are only noticeable when one or both of the objects have a very large mass.** **Clarification Statement:** * **Examples of objects with very large masses include the Sun, Earth, and other planets.**

**State Assessment Boundary:** * **Newton’s law of gravitation or Kepler’s laws are not expected in state assessment.**

**[Note: MS-PS2-3 and MS-PS2-5 are found in Grade 7. MS-PS2-1 and MS-PS2-2 are found in Grade 8.]** |
| The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*: |
| **Science and Engineering Practices****Engaging in Argument from Evidence*** Construct and present oral and written arguments supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem. (6.MS-PS2-4)
 | **Disciplinary Core Ideas****PS2.B: Types of Interactions*** Gravitational forces are always attractive. There is a gravitational force between any two masses, but it is very small except when one or both of the objects have large mass—e.g., Earth and the sun. (6.MS-PS2-4), *(Note: This Disciplinary Core Idea is also secondary to 8.MS-ESS1-2)*
 |
| *ELA/Literacy –* **WCA.6-8.1** Write arguments focused on *discipline-specific content*. **(MS-PS2-4)***Mathematics* –**5.G.A.2** Represent real-world problems and mathematical problems by graphing points in the first quadrant of the coordinate plan, and interpret coordinate values of points in the context of the situation. **(5-PS3-1)** |

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| **PS4. Waves and Their Applications in Technologies for Information Transfer** |
| **6.MS-PS4-1. Use diagrams of a simple wave to explain that (a) a wave has a repeating pattern with a specific amplitude, frequency, and wavelength, and (b) the amplitude of a wave is related to the energy of the wave.** **State Assessment Boundaries:** * **Electromagnetic waves are not expected in state assessment.**
* **State assessment will be limited to standard repeating waves.**

**6.MS-PS4-2. Use diagrams and other models to show that both light rays and mechanical waves are reflected, absorbed, or transmitted through various materials.** **Clarification Statements:** * **Materials may include solids, liquids, and gases.**
* **Mechanical waves (including sound) need a material (medium) through which they are transmitted.**
* **Examples of models could include drawings, simulations, and written descriptions.**

**State Assessment Boundary:** * **State assessment will be limited to qualitative applications.**

**6.MS-PS4-3. Present qualitative scientific and technical information to support the claim that digitized signals (sent as wave pulses representing 0s and 1s) can be used to encode and transmit information.** **State Assessment Boundary:** * **Binary counting or the specific mechanism of any given device are not expected in state assessment.**
 |
| The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*: |
| **Science and Engineering Practices****Developing and Using Models*** Develop and/or use a model to describe phenomena. (6.MS-PS4-1), (6.MS-PS4-2)

**Constructing Explanations and Designing Solutions*** Construct an explanation that includes qualitative or quantitative relationships between variables that predict(s) and/or describe(s) phenomena. (6.MS-PS4-1)

**Obtaining, Evaluating, and Communicating Information*** Communicate scientific and/or technical information (e.g. about a proposed object, tool, process, system) in writing and/or through oral presentations. (6.MS-PS4-3)
 | **Disciplinary Core Ideas****PS4.A: Wave Properties*** A simple wave has a repeating pattern with a specific wavelength, frequency, and amplitude. (6.MS-PS4-1)
* A sound wave needs a medium through which it is transmitted. (6.MS-PS4-2)

**PS4.B: Electromagnetic Radiation*** When light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on the object’s materials and the frequency (color) of the light. (6.MS-PS4-2), *(Note: This Disciplinary Core Idea is also secondary to HS-PS4-5)*
* The path that light travels can be traced as straight lines, except at surfaces between different transparent materials (e.g., air and water, air and glass) where the light path bends. (6.MS-PS4-2)
* A wave model of light is useful for explaining brightness, color, and the frequency-dependent bending of light at a surface between media. (6.MS-PS4-2)
* However, because light can travel through space, it cannot be a matter wave, like sound or water waves. (6.MS-PS4-2)

**PS4.C: Information Technologies and Instrumentation*** Digitized signals (sent as wave pulses) are a more reliable way to encode and transmit information. (6.MS-PS4-3)
 |
| *ELA/Literacy –* **RCA-ST.6-8.1** Cite specific textual evidence to support analysis of science and technical texts, quoting or paraphrasing as appropriate. **(6.MS-PS4-3)****WCA.6-8.9** Draw evidence from informational texts to support analysis, reflection, and research. **(6.MS-PS4-3)****WCA.6-8.7** Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). **(6.MS-PS4-2)***Mathematics –* **4.G.A.1◊** Draw points, lines, line segments, rays, angles (right, acute, obtuse), and perpendicular and parallel lines. Identify these in two-dimensional figures. **(◊6.MS-PS4-2)****6.RP.A.2** Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities. **(6.MS-PS4-1)** |

**Grade 6: Technology/Engineering**

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| **ETS1. Engineering Design** |
| **6.MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution. Include potential impacts on people and the natural environment that may limit possible solutions.\*****6.MS-ETS1-5(MA). Create visual representations of solutions to a design problem. Accurately interpret and apply scale and proportion to visual representations.\*** **Clarification Statements:** * **Examples of visual representations can include sketches, scaled drawings, and orthographic projections.**
* **Examples of scale can include ¼ʺ = 1ʹ0ʺ and 1 cm = 1 m.**

**6.MS-ETS1-6(MA). Communicate a design solution to an intended user, including design features and limitations of the solution.** **Clarification Statement:*** **Examples of intended users can include students, parents, teachers, manufacturing personnel, engineers, and customers.**

**[Note: MS-ETS1-2, MS-ETS1-4, and MS-ETS1-7(MA) are found in Grade 7. MS-ETS1-3 from NGSS is not included.]** |
| The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*: |
| **Science and Engineering Practices****Asking Questions and Defining Problems** * Define a design problem that can be solved through the development of an object, tool, process, or system and includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions. (6.MS-ETS1-1)

**Using Mathematics and Computational Thinking*** Apply mathematical concepts and/or processes (such as ratio, rate, percentage, basic operations, and simple algebra) to scientific and engineering questions and problems. (6.MS-ETS1-5(MA))

**Obtaining, Evaluating, and Communicating Information*** Communicate scientific and/or technical information (e.g. about a proposed object, tool, process, system) in writing and/or through oral presentations. (6.MS-ETS1-6(MA))
 | **Disciplinary Core Ideas****ETS1.A: Defining and Delimiting Engineering Problems*** The more precisely a design task’s criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions. (6.MS-ETS1-1)

**ETS1.B: Developing Possible Solutions*** Parts of different solutions can be combined to create new solutions. (6.MS-ETS1-5(MA))

**ETS1.C: Optimizing the Design Solution*** Systematic processes are used to iteratively test and refine a solution. (6.MS-ETS1-6(MA))
 |
| *ELA/Literacy –* **◊WCA.6-8.2** Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes. **(◊6.MS-ETS1-6(MA))****SLCA.6-8.1** Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on discipline-specific topics, texts, and issues, building on others’ ideas and expressing their own clearly. **(6.MS-ETS1-6(MA))****WCA.6-8.7** Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). **(6.MA-ETS1-5(MA))***Mathematics –***5.NF.B.5** Interpret multiplication as scaling (resizing) **(6.MS-ETS1-5(MA))****6.RP.A.2** Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities. **(6.MS-ETS1-5(MA))****6.RP.A.3d** Use ratio reasoning to convert measurement units; manipulate and transform units appropriately when multiplying or dividing quantities. **(6.MS-ETS1-5(MA))** |

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| **ETS2. Materials, Tools and Manufacturing** |
| **6.MS-ETS2-1(MA). Analyze and compare properties of metals, plastics, wood, and ceramics, including flexibility, ductility, hardness, thermal conductivity, electrical conductivity, and melting point.****6.MS-ETS2-2(MA). Given a design task, select appropriate materials based on specific properties needed in the construction of a solution.\*** **Clarification Statement:** * **Examples of materials can include metals, plastics, wood, and ceramics.**

**6.MS-ETS2-3(MA). Choose and safely use appropriate measuring tools, hand tools, fasteners, and common hand-held power tools used to construct a prototype.\*** **Clarification Statements:** * **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 jigsaw, drill, and sander.**

**[Note: MS-ETS2-5(MA), MS-ETS2-6(MA), and MS-ETS2-7(MA) are found in Grade 8.]** |
| The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*: |
| **Science and Engineering Practices** **Planning and Carrying Out Investigations*** Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim. (MS-ETS2-2(MA)), (MS-ETS2-3(MA))

**Analyzing and Interpreting Data*** Analyze and interpret data to determine similarities and differences in findings. (MS-ETS2-1(MA))
 | **Disciplinary Core Ideas****ETS2.A Materials and Tools** * Materials used in technologies are chosen based on the material properties needed for a particular purpose. Physical processing can change the particulate structure of materials and their properties. (6.MS-ETS2-1(MA)), (6.MS-ETS2-2(MA))

**ETS2.B Manufacturing*** The design and structure of any particular technology product reflects its function. Products can be manufactured using common processes controlled by either people or computers. (6.MS-ETS2-3(MA))
 |
| *ELA/Literacy –* **WCA.6-8.2** Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes. **(6.MS-ETS2-3(MA))****RCA-ST.6-8.7** Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). **(6.MS-ETS2-1(MA))****RCA-ST.6-8.3** Follow precisely a multi-step procedure when carrying out experiments, taking measurements, or performing technical tasks. **(6.MS-ETS2-2(MA))***Mathematics –***◊5.MD.A.1** Convert among different-sized standard measurement units within a given measurement system (e.g., convert 5 cm to 0.05 m), and use these conversions in solving multi-step, real-world problems. **(◊6.MS-ETS2-3(MA))** |

Grade 7

***Systems and Cycles***

Students in grade 7 focus on systems and cycles using their understanding of structures and functions, connections and relationships in systems, and flow of matter and energy developed in earlier grades. A focus on systems requires students to apply concepts and skills across disciplines, since most natural and designed systems and cycles are complex and interactive. They gain experience with plate tectonics, interactions of humans and Earth processes, organism systems to support and propagate life, ecosystem dynamics, motion and energy systems, and key technological systems used by society. Through grade 7, students begin a process of moving from a more concrete to an abstract perspective, since many of the systems and cycles studied are not directly observable or experienced. This also creates a foundation for exploring cause and effect relationships in more depth in grade 8. (STE Curriculum Framework, p.54)

**Grade 7: Earth and Space Sciences**

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| **ESS2. Earth’s Systems** |
| **7.MS-ESS2-2. Construct an explanation based on evidence for how Earth’s surface has changed over scales that range from local to global in size.** **Clarification Statements:** * **Examples of processes occurring over large, global spatial scales include plate motion, formation of mountains and ocean basins, and ice ages.**
* **Examples of changes occurring over small, local spatial scales include earthquakes and seasonal weathering and erosion.**

**7.MS-ESS2-4. Develop a model to explain how the energy of the Sun and Earth’s gravity drive the cycling of water, including changes of state, as it moves through multiple pathways in Earth’s hydrosphere.** **Clarification Statement:** * **Examples of models can be conceptual or physical.**

**State Assessment Boundary:** * **A quantitative understanding of the latent heats of vaporization and fusion is not expected in state assessment.**

**[Note: MS-ESS2-3 is found in Grade 6. MS-ESS2-1, MS-ESS2-5 and MS-ESS2-6 are found in Grade 8.]**  |
| The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*: |
| **Science and Engineering Practices****Developing and Using Models*** Develop a model to describe unobservable mechanisms. (7.MS-ESS2-4)

**Constructing Explanations and Designing Solutions*** Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students’ own experiments) and the assumption that theories and laws that describe nature operate today as they did in the past and will continue to do so in the future. (7.MS-ESS2-2)
 | **Disciplinary Core Ideas****ESS2.A: Earth’s Materials and Systems*** The planet’s systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth’s history and will determine its future. (7.MS-ESS2-2)

**ESS2.C: The Roles of Water in Earth’s Surface Processes*** Water continually cycles among land, ocean, and atmosphere via transpiration, evaporation, condensation and crystallization, and precipitation, as well as downhill flows on land. (7.MS-ESS2-4)
* Global movements of water and its changes in form are propelled by sunlight and gravity. (7.MS-ESS2-4)
* Water’s movements—both on the land and underground—cause weathering and erosion, which change the land’s surface features and create underground formations. (7.MS-ESS2-2)
 |
| *ELA/Literacy –* **◊W.7.9** Draw evidence from literary or informational texts to support analysis, reflection, and research. **(◊7.MS-ESS2-2)****WCA.6-8.7** Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). **(7.MS-ESS2-4)***Mathematics –***6.SP.B.5** Summarize numerical data sets in relation to their context. **(7.MS-ESS2-2)** |

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| **ESS3. Earth and Human Activity** |
| **7.MS-ESS3-2. Obtain and communicate information on how data from past geologic events are analyzed for patterns and used to forecast the location and likelihood of future catastrophic events.****Clarification Statements:** * **Geologic events include earthquakes, volcanic eruptions, floods, and landslides.**
* **Examples of data typically analyzed can include the locations, magnitudes, and frequencies of the natural hazards.**

**State Assessment Boundary:*** **Active analysis of data or forecasting is not expected in state assessment.**

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

**[Note: MS-ESS3-5 is found in Grade 8. MS-ESS3-3 from NGSS has been merged with MS-ESS3-4.]** |
| The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*: |
| **Science and Engineering Practices****Constructing Explanations and Designing Solutions*** Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students’ own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (7.MS-ESS3-4)

**Engaging in Argument from Evidence*** Construct an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem. (7.MS-ESS3-4)

**Obtaining, Evaluating, and Communicating Information*** Critically read scientific texts adapted for classroom use to determine the central ideas and/or obtain scientific and/or technical information to describe patterns in and/or evidence about the natural and designed world(s). (7.MS-ESS3-2)
* Communicate scientific and/or technical information (e.g. about a proposed object, tool, process, system) in writing and/or through oral presentations. (7.MS-ESS3-2)
 | **Disciplinary Core Ideas****ESS3.B: Natural Hazards** * Mapping the history of natural hazards in a region, combined with an understanding of related geologic forces can help forecast the locations and likelihoods of future events. (7.MS-ESS3-2)

**ESS3.C: Human Impacts on Earth Systems*** Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth’s environments can have different impacts (negative and positive) for different living things. *(secondary to 7.MS-ESS3-4)*
* Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise. (7.MS-ESS3-4)
* Scientists and engineers can make major contributions by developing technologies reduce pollution, waste and ecosystem degradation. (7.MS-ES3-4)
 |
| *ELA/Literacy –* **◊WCA.6-8.1** Write arguments focused on *discipline-specific content*. **(◊7.MS-ESS3-4)****WCA.6-8.7** Conduct short as well as more sustained research projects to answer a question (including a self0generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration. **(7.MS-ESS3-4)****◊WCA.6-8.9** Draw evidence from informational texts to support analysis, reflection, and research. **(◊7.MS-ESS3-2)***Mathematics –***6.SP.A.1** Recognize a statistical question as one that anticipates variability in the data related to the question and accounts for it in the answers. **(7.MS-ESS3-2), (7.MS-ESS3-4)****◊7.EE.B.4c** Extend analysis of patterns to include analyzing, extending, and determining an expression for simple arithmetic and geometric sequence (e.g. compounding, increasing area), using tables, graphs, words, and expressions. **(◊7.MS-ESS3-2)** |

**Grade 7: Life Science**

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| **LS1. From Molecules to Organisms: Structures and Processes** |
| **7.MS-LS1-4. Construct an explanation based on evidence for how characteristic animal behaviors and specialized plant structures increase the probability of successful reproduction of animals and plants.** **Clarification Statements:** * **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 vocalizations and colorful plumage to attract mates for breeding.**
* **Examples of animal behaviors that affect the probability of plant reproduction could include (a) transferring pollen or seeds and (b) 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.**

**[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.]** |
| The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*: |
| **Science and Engineering Practices****Engaging in Argument from Evidence*** Use an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem. (7.MS-LS1-4)
 | **Disciplinary Core Ideas****LS1.B: Growth and Development of Organisms** * Animals engage in characteristic behaviors that increase the odds of reproduction. (7.MS-LS1-4)
* Plants reproduce in a variety of ways, sometimes depending on animal behavior and specialized features for reproduction. (7.MS-LS1-4)
 |
| *ELA/Literacy –* **◊WCA.6-8.9** Draw evidence from informational texts to support analysis, reflection, and research. **(◊7.MS-LS1-4)***Mathematics-* **7.SP.A.1** Understand that statistics can be used to gain information about a population by examining a sample of the population; generalizations about a population from a sample are valid only if the sample is representative of that population. Understand that random sampling tends to produce representative samples and support valid inferences. **(7.MS-LS1-4)****7.SP.C.5** Understand that the probability of a chance event is a number between 0 and 1 that expresses the likelihood of the event occurring. Larger numbers indicate greater likelihood. A probability near 0 indicates an unlikely event, a probability around ½ indicates an event that is neither unlikely nor likely, and a probability near 1 indicates that it is neither unlikely nor likely, and a probability near 1 indicates a likely event. **(7.MS-LS1-4)** |

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| **LS2. Ecosystems: Interactions, Energy, and Dynamics** |
| **7.MS-LS2-1. Analyze and interpret data to provide evidence for the effects of periods of abundant and scarce resources on the growth of organisms and the size of populations in an ecosystem.** **7.MS-LS2-2. Describe how relationships among and between organisms in an ecosystem can be competitive, predatory, parasitic, and mutually beneficial and that these interactions are found across multiple ecosystems.** **Clarification Statement:** * **Emphasis is on describing consistent patterns of interactions in different ecosystems in terms of relationships among and between organisms.**

**7.MS-LS2-3. Develop a model to describe that matter and energy are transferred among living and nonliving parts of an ecosystem and that both matter and energy are conserved through these processes.** **Clarification Statements:** * **Cycling of matter should include the role of photosynthesis, cellular respiration, and decomposition, as well as transfer among producers, consumers (primary, secondary, and tertiary), and decomposers.**
* **Models may include food webs and food chains.**

**State Assessment Boundary:** * **Cycling of specific atoms (such as carbon or oxygen), or the biochemical steps of photosynthesis, cellular respiration, and decomposition are not expected in state assessment.**

**7.MS-LS2-4. Analyze data to provide evidence that disruptions (natural or human-made) to any physical or biological component of an ecosystem can lead to shifts in all its populations.** **Clarification Statement:** * **Focus should be on ecosystem characteristics varying over time, including disruptions such as hurricanes, floods, wildfires, oil spills, and construction.**

**7.MS-LS2-5. Evaluate competing design solutions for protecting an ecosystem. Discuss benefits and limitations of each design.\*** **Clarification Statements:** * **Examples of design solutions could include water, land, and species protection and the prevention of soil erosion.**
* **Examples of design solution constraints could include scientific, economic, and social considerations.**

**7.MS-LS2-6(MA). Explain how changes to the biodiversity of an ecosystem—the variety of species found in the ecosystem—may limit the availability of resources humans use.** **Clarification Statement:** * **Examples of resources can include food, energy, medicine, and clean water.**
 |
| The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*: |
| **Science and Engineering Practices****Developing and Using Models*** Develop a model to describe phenomena. (7.MS-LS2-3)

**Analyzing and Interpreting Data*** Analyze and interpret data to provide evidence for phenomena. (7.MS-LS2-1), (7.MS-LS2-4)

**Constructing Explanations and Designing Solutions*** Construct an explanation that includes qualitative or quantitative relationships between variables that predict phenomena. (7.MS-LS2-2)

**Engaging in Argument from Evidence*** Evaluate competing design solutions based on jointly developed and agreed-upon design criteria. (7.MS-LS2-5)
 | **Disciplinary Core Ideas****LS1.C: Organization for Matter and Energy Flow in Organisms*** Plants, algae (including phytoplankton), and many microorganisms use the energy from light to make sugars (food) from carbon dioxide from the atmosphere and water through the process of photosynthesis, which also releases oxygen. These sugars can be used immediately or stored for growth or later use. (7.MS-LS2-3)

**LS2.A: Interdependent Relationships in Ecosystems*** Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors. (7.MS-LS2-1)
* In any ecosystem, organisms and populations with similar requirements for food, water, oxygen, or other resources may compete with each other for limited resources, access to which consequently constrains their growth and reproduction. (7.MS-LS2-1) (7.MS-LS2-2)
* Growth of organisms and population increases are limited by access to resources. (7.MS-LS2-1)
* Similarly, predatory interactions may reduce the number of organisms or eliminate whole populations of organisms. Mutually beneficial interactions, in contrast, may become so interdependent that each organism requires the other for survival. Although the species involved in these competitive, predatory, and mutually beneficial interactions vary across ecosystems, the patterns of interactions of organisms with their environments, both living and nonliving, are shared. (7.MS-LS2-2)

**LS2.B: Cycle of Matter and Energy Transfer in Ecosystems*** Food webs are models that demonstrate how matter and energy is transferred between producers~~,~~ consumers, and decomposers as the three groups interact within an ecosystem. Transfers of matter into and out of the physical environment occur at every level. Decomposers recycle nutrients from dead plant or animal matter back to the soil in terrestrial environments or to the water in aquatic environments. The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem. (7.MS-LS2-3)

**LS2.C: Ecosystem Dynamics, Functioning, and Resilience** * Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations. (7.MS-LS2-4)
* Biodiversity describes the variety of species found in Earth’s terrestrial and oceanic ecosystems. (*secondary to 7.MS-LS2-5),* (7.MS-LS2-6(MA))
* The completeness or integrity of an ecosystem’s biodiversity is often used as a measure of its health. (7.MS-LS2-5)

**LS4.D: Biodiversity and Humans** * Changes in biodiversity can influence humans’ resources, such as food, energy, and medicines, as well as ecosystem services that humans rely on—for example, water purification and recycling. (*secondary to 7.MS-LS2-5),* (7.MS-LS2-6(MA))

**PS3.D: Energy in Chemical Processes and Everyday Life*** The chemical reaction by which plants produce complex food molecules (sugars) requires an energy input (i.e., from sunlight) to occur. In this reaction, carbon dioxide and water combine to form carbon-based organic molecules and release oxygen. (7.MS-LS2-3)
* Cellular respiration in plants and animals involve chemical reactions with oxygen that release stored energy. In these processes, complex molecules containing carbon react with oxygen to produce carbon dioxide and other materials. (7.MS-LS2-3), (Note: This Disciplinary Core Idea is also addressed by 8.MS-LS1-7)

**ETS1.B: Developing Possible Solutions*** There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. (7.MS-LS2-5)
 |
| *ELA/Literacy –* **◊W.7.9** Draw evidence from literary or informational texts to support analysis, reflection, and research. **(◊7.MS-LS2-5), (7.MS-LS2-6(MA)),****RCA-H.6.8.2** Determine the central ideas or information of a primary or secondary source; provide an accurate summary of the source distinct form prior knowledge or opinions. **(7.MS-LS2-2)****WCA.6-8.7** Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). **(7.MS-LS2-2), (7.MS-LS2-3)***Mathematics-* **7.SP.A.1** Understand that statistics can be used to gain information about a population by examining a sample of the population; generalizations about a population from a sample are valid only if the sample is representative of that population. Understand that random sampling tends to produce representative samples and support valid references. **(7.MS-LS2-1) (7.MS-LS2-4)****7.SP.B.4** Use measures of center and measures of variability for numerical data from random samples to draw informal comparative inferences about two populations. **(7.MS-LS2-1) (7.MS-LS2-4)****7.EE.B.4** Use variables to represent quantities in a real-world or mathematical problem, and construct simple equations and inequalities to solve problems by reasoning about the quantities. **(7.MS-LS2-2) (7.MS-LS2-4)** |

**Grade 7: Physical Science**

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| **PS2. Motion and Stability: Forces and Interactions** |
| **7.MS-PS2-3. Analyze data to describe the effect of distance and magnitude of electric charge on the strength of electric forces.** **Clarification Statement:** * **Includes both attractive and repulsive forces.**

**State Assessment Boundaries:** * **State assessment will be limited to proportional reasoning.**
* **Calculations using Coulomb’s law or interactions of sub-atomic particles are not expected in state assessment.**

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

**State Assessment Boundary:** * **Calculations of force are not expected in state assessment.**

**[Note: MS-PS2-4 is found in Grade 6. MS-PS2-1 and MS-PS2-2 are found in Grade 8.]** |
| The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*: |
| **Science and Engineering Practices****Engaging in Argument from Evidence*** Construct, use, and/or present an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem. (7.MS-PS2-5)
 | **Disciplinary Core Ideas****PS2.B: Types of Interactions*** Electric forces can be attractive or repulsive, and their sizes depend on the magnitudes of the charges involved and on the distances between the interacting objects. (7.MS-PS2-3)
* Electrical currents can induce a magnetic field and magnetic fields can induce an electrical current. The strength of the induced field or current is dependent on the magnitude of the inducing current or field and the distances between the interacting objects. ,(7.MS-PS2-5)
* Forces that act at a distance (electric and magnetic) can be explained by fields that extend through space and can be mapped by their effect on a test object (a ball, a charged object, or a magnet, respectively). (7.MS-PS2-3), (7.MS-PS2-5)
 |
| *ELA/Literacy –* **RCA-ST.6-8.1** Cite specific textual evidence to support analysis of science and technical texts, quoting or paraphrasing as appropriate. **(7.MS-PS2-5)****WCA.6-8.1** Write arguments focused on *discipline-specific content*. **(7.MS-PS2-5)***Mathematics-* **6.SP.B.5** Summarize numerical data sets in relation to their context. **(7.MS-PS2-3)****◊7.RP.A.2** Recognize and represent proportional relationships between quantities. **(◊7.MS-PS2-3)****7.NS.A.1.a** Describe situations in which opposite quantities combine to make zero. *For example: A hydrogen atom has zero charge because its two constituents are oppositely charged; if you open a new bank account with a deposit of $30 and then withdraw $30 you are left with a $0 balance.*  |

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| **PS3. Energy** |
| **7.MS-PS3-1. Construct and interpret data and graphs to describe the relationships among kinetic energy, mass, and speed of an object.** **Clarification Statements:** * **Examples could include riding a bicycle at different speeds and rolling different-sized rocks downhill.**
* **Consider relationships between kinetic energy vs. mass and kinetic energy vs. speed separate from each other; emphasis is on the difference between the linear and exponential relationships.**

**State Assessment Boundary:** * **Calculation or manipulation of the formula for kinetic energy is not expected in state assessment.**

**7.MS-PS3-2. Develop a model to describe the relationship between the relative positions of objects interacting at a distance and their relative potential energy in the system.** **Clarification Statements:** * **Examples of objects within systems interacting at varying distances could include Earth and either a roller coaster cart at varying positions on a hill or objects at varying heights on shelves, changing the direction/orientation of a magnet, and a balloon with static electrical charge being brought closer to a stream of water.**
* **Examples of models could include representations, diagrams, pictures, and written descriptions of systems.**

**State Assessment Boundaries:** * **State assessment will be limited to electric, magnetic, and gravitational interactions and to interactions of two objects at a time.**
* **Calculations of potential energy are not expected in state assessment.**

**7.MS-PS3-3. Apply scientific principles of energy and heat transfer to design, construct, and test a device to minimize or maximize thermal energy transfer.\*** **Clarification Statement:** * **Examples of devices could include an insulated box, a solar cooker, and a vacuum flask.**

**State Assessment Boundary:** * **Accounting for specific heat or calculations of the total amount of thermal energy transferred is not expected in state assessment.**

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

**7.MS-PS3-5. Present evidence to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object.** **Clarification Statement:** * **Examples of empirical evidence could include an inventory or other representation of the energy before and after the transfer in the form of temperature changes or motion of an object.**

**State Assessment Boundary:** * **Calculations of energy are not expected in state assessment.**

**7.MS-PS3-6(MA). Use a model to explain how thermal energy is transferred out of hotter regions or objects and into colder ones by convection, conduction, and radiation.****7.MS-PS3-7(MA). Use informational text to describe the relationship between kinetic and potential energy and illustrate conversions from one form to another.** **Clarification Statement:** * **Types of kinetic energy include motion, sound, thermal, and light; types of potential energy include gravitational, elastic, and chemical.**
 |
| The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*: |
| **Science and Engineering Practices****Analyzing and Interpreting Data*** Construct and interpret graphical displays of data to identify linear and nonlinear relationships. (7.MS-PS3-1)

**Constructing Explanations and Designing Solutions*** Apply scientific ideas or principles to design, construct, and test a design of an object, tool, process, or system. (7.MS-PS3-3)

**Developing and Using Models*** Develop a model to describe unobservable mechanisms. (7.MS-PS3-2)

**Engaging in Argument from Evidence*** Construct, use, and present oral and written arguments supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon. (7.MS-PS3-5)
 | **Disciplinary Core Ideas****PS3.A: Definitions of Energy** * Motion energy is properly called kinetic energy; it is proportional to the mass of the moving object and grows with the square of its speed. (7.MS-PS3-1)
* A system of objects may also contain stored (potential) energy, depending on their relative positions. (7.MS-PS3-2)
* The term “heat” as used in everyday language refers both to thermal energy (the motion of atoms or molecules within a substance) and the transfer of that thermal energy from one object to another. In science, heat is used only for this second meaning; it refers to the energy transferred due to the temperature difference between two objects. *(secondary to 7.MS-PS3-4), (Note: This Disciplinary Core Idea is also secondary to 8.MS-PS1-4)*
* Temperature is a measure of the average kinetic energy of particles of matter. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present. (7.MS-PS3-3) (7.MS-PS3-4)

**PS3.B: Conservation of Energy and Energy Transfer*** When the kinetic energy of an object changes, there is inevitably some other change in energy at the same time. (7.MS-PS3-5), (7.MS-PS3-7(MA))
* Energy is transferred out of hotter regions or objects and into colder ones by the processes of conduction, convection, and radiation. (7.MS-PS3-3), (7.MS-PS3-6(MA))
* The amount of energy transfer needed to change the temperature of a matter sample by a given amount depends on the nature of the matter, the size of the sample, and the environment. (7.MS-PS3-4)

**PS3.C: Relationship Between Energy and Forces*** When two objects interact, each one exerts a force on the other that can cause energy to be transferred to or from the object. (7.MS-PS3-2), (7.MS-PS3-5)
 |
| *ELA/Literacy –* **WCA.6-8.7** Conduct short as well as more sustained research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration. **(7.MS-PS3-4)****◊WCA.6-8.1** Write arguments focused on *discipline-specific content*. **(◊7.MS-PS3-5)****W.7.9** Draw evidence from literary or informational texts to support analysis, reflection, and research. **(7.MS-PS3-7(MA))****WCA.6-8.7** Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). **(7.MS-PS3-2), (7.MS-PS3-6(MA))***Mathematics –* **◊6.SP.B.5** Summarize numerical data sets in relation to their context. **(◊7.MS-PS3-4), (7.MS-PS3-1)****6.NS.C.5** Understand that positive and negative numbers are used together to describe quantities having opposite directions or values (e.g., temperature above/below zero, elevation above/below sea level, credits/debits, positive/negative electric charge); use positive and negative numbers to represent quantities in real-world contexts, explaining the meaning of 0 in each situation. **(7.MS-PS3-3), (7.MS-PS3-4), (7.MS-PS3-5), (7.MS-PS3-6(MA))****6.EE.C.9** Use variables to represent two quantities in a real-world problem that change in relationship to one another; write an equation to express one quantity, thought of as the dependent variable, in terms of the other quantity, thought of as the independent variable. Analyze the relationship between the dependent and independent variables using graphs and tables, and relate these to the equation. **(7.MS-PS3-4), (7.MS-PS3-5)****6.NS.C.8** Solve real-world and mathematical problems by graphing points in all four quadrants of the coordinate plane. Include use of coordinates and absolute value to find distances between points with the same first coordinate or the same second coordinate. **(7.MS-PS3-1), (7.MS-PS3-4)****◊7.RP.A.2** Recognize and represent proportional relationships between quantities. **(◊7.MS-PS3-1), (7.MS-PS3-5)** |

**Grade 7: Technology/Engineering**

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| **ETS1. Engineering Design** |
| **7.MS-ETS1-2. Evaluate competing solutions to a given design problem using a decision matrix to determine how well each meets the criteria and constraints of the problem. Use a model of each solution to evaluate how variations in one or more design features, including size, shape, weight, or cost, may affect the function or effectiveness of the solution.\*** **7.MS-ETS1-4. Generate and analyze data from iterative testing and modification of a proposed object, tool, or process to optimize the object, tool, or process for its intended purpose.\*****7.MS-ETS1-7(MA). Construct a prototype of a solution to a given design problem.\*****[Note: MS-ETS1-1, MS-ETS1-5(MA), and MS-ETS1-6(MA) are found in Grade 6. MS-ETS1-3 from NGSS is not included.]** |
| The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*: |
| **Science and Engineering Practices****Developing and Using Models*** Develop a model to generate data to test ideas about designed systems, including those representing inputs and outputs. (7.MS-ETS1-2)

**Engaging in Argument from Evidence*** Evaluate competing design solutions based on jointly developed and agreed-upon design criteria. (7.MS-ETS1-2)
* Optimize performance of a design by prioritizing criteria, making tradeoffs, testing, revising, and re-testing. (7.MS-ETS1-4)
 | **Disciplinary Core Ideas****ETS1.B: Developing Possible Solutions*** A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. (7.MS-ETS1-4)
* There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. (7.MS-ETS1-2)
* Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. (7.MS-ETS1-4)
* Models of all kinds are important for testing solutions. (7.MS-ETS1-4), (7.MS-ETS1-7(MA))

**ETS1.C: Optimizing the Design Solution*** Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of the characteristics may be incorporated into the new design. (7.MS-ETS1-4)
* The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution. (7.MS-ETS1-4)
 |
| *ELA/Literacy –* **WCA.6-8.9** Draw evidence from informational texts to support analysis, reflection, and research. **(7.MS-ETS1-2)***Mathematics –***◊6.SP.B.4** Display numerical data in plots on a number line, including dot plots, histograms, and box plots. **(◊7.MS-ETS1-4)****◊6.SP.B.5** Summarize numerical data sets in relation to their context. **(◊7.MS-ETS1-4)****7.RP.A.2a** Recognize and represent proportional relationships between quantities: Decide whether two quantities are in a proportional relationship, e.g. by testing for equivalent ratios in a table, or graphing on a coordinate plane and observing whether the graph is a straight line through the origin. **(7.MS-ETS1-2), (7.MS-ETS1-4)****7.RP.A.2b** Identify the constant of proportionality (unit rate) in tables, graphs, equations, diagrams, and verbal descriptions of the proportional relationships. **(7.MS-ETS1-2), (7.MS-ETS1-4), (7.MS-ETS1-7(MA))****7.G.A.1** Solve problems involving scale drawings of geometric figures, such as computing actual lengths and areas from a scale drawing and reproducing a scale drawing at a different scale. **(7.MS-ETS1-7(MA))** |

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| **ETS3. Technological Systems** |
| **7.MS-ETS3-1(MA). Explain the function of a communication system and the role of its components, including a source, encoder, transmitter, receiver, decoder, and storage.****7.MS-ETS3-2(MA). Compare the benefits and drawbacks of different communication systems.** **Clarification Statements:** * **Examples of communications systems can include radio, television, print, and Internet.**
* **Examples of benefits and drawbacks can include speed of communication, distance or range, number of people reached, audio only vs. audio and visual, and one-way vs. two-way communication.**

**7.MS-ETS3-3(MA). Research and communicate information about how transportation systems are designed to move people and goods using a variety of vehicles and devices. Identify and describe subsystems of a transportation vehicle, including structural, propulsion, guidance, suspension, and control subsystems.** **Clarification Statements:** * **Examples of design elements include vehicle shape to maximize cargo or passenger capacity, terminals, travel lanes, and communications/controls.**
* **Examples of vehicles can include a car, sailboat, and small airplane.**

**7.MS-ETS3-4(MA). Show how the components of a structural system work together to serve a structural function. Provide examples of physical structures and relate their design to their intended use.** **Clarification Statements:** * **Examples of components of a structural system could include foundation, decking, wall, and roofing.**
* **Explanations of function should include identification of live vs. dead loads and forces of tension, torsion, compression, and shear.**
* **Examples of uses include carrying loads and forces across a span (such as a bridge), providing livable space (such as a house or office building), and providing specific environmental conditions (such as a greenhouse or cold storage).**

**State Assessment Boundary:** * **Calculations of magnitude or direction of loads or forces are not expected in state assessment.**

**7.MS-ETS3-5(MA). Use the concept of systems engineering to model inputs, processes, outputs, and feedback among components of a transportation, structural, or communication system.** |
| The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*: |
| **Science and Engineering Practices****Constructing Explanations and Designing Solutions*** Construct an explanation using models or representations. (7.MS-ETS3-1(MA))

**Developing and Using Models*** Develop and/or use a model to generate data to test ideas about phenomena in natural or designed systems, including those representing inputs and outputs, and those at unobservable scales. (7.MS-ETS3-5(MA))

**Obtaining, Evaluating, and Communicating Information*** Critically read scientific texts adapted for classroom use to determine the central ideas and/or obtain scientific and/or technical information to describe patterns in and/or evidence about the natural and designed world(s). (7.MS-ETS3-3(MA))
* Communicate scientific and/or technical information (e.g. about a proposed object, tool, process, system) in writing and/or through oral presentations. (7.MS-ETS3-3(MA))
 | **Disciplinary Core Ideas****ETS3.B** **Technological Systems Society Relies On (examples)*** Three critical systems society relies on are communications, transportation, and structural systems. (7.MS-ETS3-2(MA)), (7.MS-ETS3-4(MA)), (7.MS-ETS3-5(MA))
* Components of a communication system allow messages to be sent long distances. (7.MS-ETS3-1(MA))
* Transportation systems move people and goods using vehicles and devices. And structural systems allow for physical structures that meet human needs. (7.MS-ETS3-3(MA))
 |
| *ELA/Literacy –* **WCA.6-8.7** Conduct short as well as more sustained research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration. **(7.MS-ETS3-4(MA)),** **(7.MS-ETS3-4(MA))****WCA.6-8.9** Draw evidence from informational texts to support analysis, reflection, and research. **(7.MS-ETS3-2(MA))****WCA.6-8.7** Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). **(7.MS-ETS3-5(MA))***Mathematics –***7.RP.A.2a** Recognize and represent proportional relationships between quantities: Decide whether two quantities are in a proportional relationship, e.g. by testing for equivalent ratios in a table, or graphing on a coordinate plane and observing whether the graph is a straight line through the origin. **(7.MS-ETS3-2(MA))** **7.G.A.1** Solve problems involving scale drawings of geometric figures, such as computing actual lengths and areas from a scale drawing and reproducing a scale drawing at a different scale. **(7.MS-ETS3-5(MA))** |

Grade 8

***Cause and Effect***

Grade 8 students use more robust abstract thinking skills to explain causes of complex phenomena and systems. Many causes are not immediately or physically visible to students. An understanding of cause and effect of key natural phenomena and designed processes allows students to explain patterns and make predictions about future events. 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 reproduction, heredity, and artificial selection; and how atoms and molecules interact to explain the substances that make up the world and how materials change. 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 outcome for grade 8 students. (STE Curriculum Framework, p.60)

**Grade 8: Earth and Space Sciences**

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

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

**[Note: MS-ESS1-1a, MS-ESS1-4, MS-ESS1-5 and MS-ESS1-6 are found in Grade 6. MS-ESS1-3 from NGSS is not included.]** |
| The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*: |
| **Science and Engineering Practices****Developing and Using Models*** Develop and use a model to describe phenomena. (8.MS-ESS1-1b)

**Developing and Using Models*** Apply scientific ideas, principles, and/or evidence to construct, revise, or use an explanation for real-world phenomena. (8.MS-ESS1-2)
 | **Disciplinary Core Ideas****ESS1.A: The Universe and Its Stars*** Patterns of the apparent motion of the sun, the moon, and stars in the sky can be observed, described, predicted, and explained with models. (8.MS-ESS1-1b)

**ESS1.B: Earth and the Solar System*** The solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them. (8.MS-ESS1-2)
* The Earth has a gravitational pull on the Moon, which holds it in orbit, and the moon has an equal gravitational pull on the Earth. An observable effect of the gravitational pull from the moon on the Earth is the ocean tides. (8.MS-ESS1-2)
* Earth’s spin axis is fixed in direction over the short-term but tilted relative to its orbit around the sun. The seasons are a result of that tilt and are caused by the differential intensity of sunlight on different areas of Earth across the year. (8.MS-ESS1-1b)

**PS1.A: Forces and Motion*** For any pair of interacting objects, the force exerted by the first object on the second object is equal in strength to the force that the second object exerts on the first, but in the opposite direction (Newton’s third law). *(secondary to 8.MS-ESS1-2),* (Note: This Disciplinary Core Idea is also addressed by 8.MS-PS2-1)

**PS2.B: Types of Interactions*** Gravitational forces are always attractive. There is a gravitational force between any two masses, but it is very small except when one or both of the objects have large mass-e.g., Earth and the Sun. *(secondary to 8.MS-ESS1-2),* (Note: This Disciplinary Core Idea is also addressed by 6.MS-PS2-4)
 |
| *ELA/Literacy –* **SLCA-6-8.4**Present information, findings, and supporting evidence clearly, concisely, and logically such that listeners can follow the line of reasoning and the organization, development, vocabulary, substance, and style are appropriate to purpose, audience, and task. **(8.MS-ESS1-2)****RCA-ST-6-8.9**Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic. **(8.MS-ESS1-1b).****WCA-6-8.9** Draw evidence from informational texts to support analysis, interpretation, reflection, and research*.* **(8.MS-ESS1-2)***Mathematics –***8.F.B.5** Describe qualitatively the functional relationship between two quantities by analyzing a graph (e.g. where the function is increasing or decreasing, linear or non-linear). Sketch a graph that exhibits the qualitative features of a function that has been described verbally. **(8.MS-ESS1-1b), (8.MS-ESS1-2)** |

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| **ESS2. Earth’s Systems** |
| **8.MS-ESS2-1. Use a model to illustrate that energy from Earth’s interior drives convection that cycles Earth’s crust, leading to melting, crystallization, weathering, and deformation of large rock formations, including generation of ocean sea floor at ridges, submergence of ocean sea floor at trenches, mountain building, and active volcanic chains.** **Clarification Statement:** * **The emphasis is on large-scale cycling resulting from plate tectonics.**

**8.MS-ESS2-5. Interpret basic weather data to identify patterns in air mass interactions and the relationship of those patterns to local weather.** **Clarification Statements:** * **Data includes temperature, pressure, humidity, precipitation, and wind.**
* **Examples of patterns can include air masses flow from regions of high pressure to low pressure, and how sudden changes in weather can result when different air masses collide.**
* **Data can be provided to students (such as in weather maps, data tables, diagrams, or visualizations) or obtained through field observations or laboratory experiments.**

**State Assessment Boundary:** * **Specific names of cloud types or weather symbols used on weather maps are not expected in state assessment.**

**8.MS-ESS2-6. Describe how interactions involving the ocean affect weather and climate on a regional scale, including the influence of the ocean temperature as mediated by energy input from the Sun and energy loss due to evaporation or redistribution via ocean currents.** **Clarification Statement:** * **A regional scale includes a state or multi-state perspective.**

**State Assessment Boundary:** * **Koppen Climate Classification names are not expected in state assessment.**

**[Note: MS-ESS2-3 is found in Grade 6. MS-ESS2-2 and MS-ESS2-4 are found in Grade 7.]** |
| The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*: |
| **Science and Engineering Practices****Developing and Using Models*** Develop and use a model to describe phenomena. (8.MS-ESS2-1)

**Analyzing and Interpreting Data*** Analyze and interpret data to determine similarities and differences in findings. (8.MS-ESS2-5)
 | **Disciplinary Core Ideas****ESS1.C: The History of Planet Earth*** Tectonic processes continually generate new ocean sea floor at ridges and destroy old sea floor at trenches. (8.MS-ESS2-1) (Note: This Disciplinary Core Idea is also addressed by 6.MS-ESS2-3)

**ESS2.A: Earth Materials and Systems*** All Earth processes are the result of energy flowing and matter cycling within and among the planet’s systems. This energy is derived from the sun and Earth’s hot interior. The energy that flows and matter that cycles produce chemical and physical changes in Earth’s materials and living organisms. (8.MS-ESS2-1)
* *(Moved from grade 5)* These systems interact in multiple ways to affect Earth’s surface materials and processes. The ocean shapes landforms, and influences climate. Winds and clouds in the atmosphere interact with the landforms to determine patterns of weather. (8.MS-ESS2-6)

**ESS2.B: Plate Tectonics and Large-Scale System Interactions*** *(Moved from high school.)* Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth’s surface and provides a framework for understanding its geologic history. Plate movements are responsible for most continental and ocean-floor features. (8.MS-ESS2-1)

**ESS2.C: The Roles of Water in Earth’s Surface Processes*** The complex patterns of the changes and the movement of water in the atmosphere, determined by winds, landforms, and ocean temperatures and currents, are major determinants of local weather patterns. (8.MS-ESS2-5), (8.MS-ESS2-6)

**ESS2.D: Weather and Climate*** Weather and climate are influenced by interactions involving Sunlight, the ocean, the atmosphere, ice, landforms, and living things. These interactions vary with latitude, altitude, and local and regional geography, all of which can affect oceanic and atmospheric flow patterns. (8.MS-ESS2-6)
* The ocean exerts a major influence on weather and climate by absorbing energy from the sun, releasing it over time, and globally redistributing it through ocean currents. (8.MS-ESS2-6)
* Because these patterns are so complex, weather can only be predicted probabilistically. (8.MS-ESS2-5)
 |
| *ELA/Literacy –* **RCA-ST-6-8.9** Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic. **(8.MS-ESS2-1)****WCA-6-8.9** Draw evidence from informational texts to support analysis, interpretation, reflection, and research. **(8.MS-ESS2-6)***Mathematics –***7.SP.A.1** Understand that statistics can be used to gain information about a population by examining a sample of the population; generalizations about a population from a sample are valid only if the sample is representative of that population. Understand that random sampling tends to produce representative samples and support valid references. **(8.MS-ESS2-5)****8.EE.A.4** Perform operations with numbers expressed in scientific notation, including problems where both decimal and scientific notation are used. Use scientific notations and choose units of appropriate size for measurements of very large or very small quantities (e.g. use millimeters per year for sea floor spreading). Interpret scientific notation that has been generated by technology. **(8.MS-ESS2-1), (8.MS-ESS2-6)** |

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| **ESS3. Earth and Human Activity** |
| **8.MS-ESS3-1. Analyze and interpret data to explain that the Earth’s mineral and fossil fuel resources are unevenly distributed as a result of geologic processes.** **Clarification Statement:** * **Examples of uneven distributions of resources can include where petroleum is generally found (locations of the burial of organic marine sediments and subsequent geologic traps), and where metal ores are generally found (locations of past volcanic and hydrothermal activity).**

**8.MS-ESS3-5. Examine and interpret data to describe the role that human activities have played in causing the rise in global temperatures over the past century.** **Clarification Statements:** * **Examples of human activities include fossil fuel combustion, deforestation, 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-ESS3-2 and MS-ESS3-4 are found in Grade 7. MS-ESS3-3 from NGSS has been merged with MS-ESS3-4.]** |
| The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*: |
| **Science and Engineering Practices****Analyzing and Interpreting Data** * Analyze and interpret data to provide evidence for phenomena. (8.MS-ESS3-1),(8.MS-ESS3-5)
* Distinguish between causal and correlational relationships in data. (8.MS-ESS3-1),(8.MS-ESS3-5)
 | **Disciplinary Core Ideas****ESS3.A: Natural Resources*** Humans depend on the Earth’s land, ocean, atmosphere, and biosphere for many different resources. Minerals, fresh water, and biosphere resources are limited, and may not be renewable or replaceable over human lifetimes. These resources are distributed unevenly around the planet as a result of past geologic processes. (8.MS-ESS3-1)

**ESS3.D: Global Climate Change*** Human activities, such as the release of greenhouse gases from burning fossil fuels, are major factors in the current rise in Earth’s mean surface temperature (global warming). Reducing the level of climate change and reducing human vulnerability to whatever climate changes do occur depend on the understanding of climate science, engineering capabilities, and other kinds of knowledge, such as understanding of human behavior and on applying that knowledge wisely in decisions and activities. (8.MS-ESS3-5)
 |
| *ELA/Literacy –* **RCA-ST.6-8.7** Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (eg., in a flowchart, diagram, model, graph, or table). **(8.MS-ESS3-1), (8.MS-ESS3-5)***Mathematics –***7.SP.A.1** Understand that statistics can be used to gain information about a population by examining a sample of the population; generalizations about a population from a sample are valid only if the sample is representative of that population. Understand that random sampling tends to produce representative samples and support valid references. **(8.MS-ESS3-5)****8.F.B.5** Describe qualitatively the functional relationship between two quantities by analyzing a graph (e.g. where the function is increasing or decreasing, linear or non-linear). Sketch a graph that exhibits the qualitative features of a function that has been described verbally. **(8.MS-ESS3-5)****8.EE.A.4** Perform operations with numbers expressed in scientific notation, including problems where both decimal and scientific notation are used. Use scientific notations and choose units of appropriate size for measurements of very large or very small quantities (e.g. use millimeters per year for sea floor spreading). Interpret scientific notation that has been generated by technology. **(8.MS-ESS3-1), (8.MS-ESS3-5)** |

**Grade 8: Life Science**

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| **LS1. From Molecules to Organisms: Structures and Processes** |
| **8.MS-LS1-5. Construct an argument based on evidence for how environmental and genetic factors influence the growth of organisms.** **Clarification Statements:** * **Examples of environmental conditions could include availability of food, light, space, and water.**
* **Examples of genetic factors could include the genes responsible for size differences in different breeds of dogs, such as Great Danes and Chihuahuas.**
* **Examples of environmental factors could include drought decreasing plant growth, fertilizer increasing plant growth, and fish growing larger in large ponds than they do in small ponds.**
* **Examples of both genetic and environmental factors could include different varieties of plants growing at different rates in different conditions.**

**State Assessment Boundary:** * **Methods of reproduction, genetic mechanisms, gene regulation, biochemical processes, or natural selection are not expected in state assessment.**

**8.MS-LS1-7. Use informational text to describe that food molecules, including carbohydrates, proteins, and fats, are broken down and rearranged through chemical reactions forming new molecules that support cell growth and/or release of energy.** **State Assessment Boundary:** * **Specific details of the chemical reaction for cellular respiration, biochemical steps of breaking down food, or the resulting molecules (e.g., carbohydrates are broken down into monosaccharides) are not expected in state assessment.**

**[Note: MS-LS1-1 and MS-LS1-2 are found in Grade 6. MS-LS1-3 and MS-LS1-4 are found in Grade 7. MS-LS1-6 and MS-LS1-8 from NGSS are not included.]** |
| **Science and Engineering Practices****Constructing Explanations and Designing Solutions*** Construct a scientific explanation based on valid and reliable evidenceobtained from sources (including the students’ own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (8.MS-LS1-5)

**Obtaining, Evaluating, and Communicating Information*** Critically read scientific texts adapted for classroom use to obtain scientific or technical information to describe patterns in or evidence about the natural and designed worlds. (8.MS-LS1-7)
 | **Disciplinary Core Ideas****LS1.B: Growth and Development of Organisms** * Genetic factors as well as local conditions affect the growth of the adult plant. (8.MS-LS1-5)

**LS1.C: Organization for Matter and Energy Flow in Organisms*** Within individual organisms, food moves through a series of chemical reactions in which it is broken down and rearranged to form new molecules, to support growth, or to release energy. (8.MS-LS1-7)

**PS3.D: Energy in Chemical Processes and Everyday Life*** Cellular respiration in plants and animals involve chemical reactions with oxygen that release stored energy. In these processes, complex molecules containing carbon react with oxygen to produce carbon dioxide and other materials. (8.MS-LS1-7), (Note: This Disciplinary Core Idea is also addressed by 7.MS-LS2-3)
 |
| *ELA/Literacy –* **◊WCA.6-8.1** Write arguments focused on *discipline-specific content*. **(◊8.MS-LS1-5)****WCA-6-8.9** Draw evidence from informational texts to support analysis, interpretation, reflection, and research. **(8.MS-LS1-7)***Mathematics –***8.F.B.5** Describe qualitatively the functional relationship between two quantities by analyzing a graph (e.g. where the function is increasing or decreasing, linear or non-linear). Sketch a graph that exhibits the qualitative features of a function that has been described verbally. **(8.MS-LS1-5)** |

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| **LS3. Heredity: Inheritance and Variation of Traits** |
| **8.MS-LS3-1. Develop and use a model to describe that structural changes to genes (mutations) may or may not result in changes to proteins, and if there are changes to proteins there may be harmful, beneficial, or neutral changes to traits.** **Clarification Statements:** * **An example of a beneficial change to the organism may be a strain of bacteria becoming resistant to an antibiotic.**
* **A harmful change could be the development of cancer; a neutral change may change the hair color of an organism with no direct consequence.**

**State Assessment Boundary:** * **Specific changes at the molecular level (e.g., amino acid sequence change), mechanisms for protein synthesis, or specific types of mutations are not expected in state assessment.**

**8.MS-LS3-2. Construct an argument based on evidence for how asexual reproduction results in offspring with identical genetic information and sexual reproduction results in offspring with genetic variation. Compare and contrast advantages and disadvantages of asexual and sexual reproduction.** **Clarification Statements:** * **Examples of an advantage of sexual reproduction can include genetic variation when the environment changes or a disease is introduced, while examples of an advantage of asexual reproduction can include not using energy to find a mate and fast reproduction rates.**
* **Examples of a disadvantage of sexual reproduction can include using resources to find a mate, while a disadvantage in asexual reproduction can be the lack of genetic variation when the environment changes or a disease is introduced.**

**8.MS-LS3-3(MA). Communicate through writing and in diagrams that chromosomes contain many distinct genes and that each gene holds the instructions for the production of specific proteins, which in turn affects the traits of an individual.****State Assessment Boundary:** * **Specific changes at the molecular level or mechanisms for protein synthesis are not expected in state assessment.**

**8.MS-LS3-4(MA). Develop and use a model to show that sexually reproducing organisms have two of each chromosome in their cell nuclei, and hence two variants (alleles) of each gene that can be the same or different from each other, with one random assortment of each chromosome passed down to offspring from both parents.** **Clarification Statement:*** **Examples of models can include Punnett squares, diagrams (e.g., simple pedigrees), and simulations.**

**State Assessment Boundary:** * **State assessment will limit inheritance patterns to dominant-recessive alleles only.**
 |
| The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*: |
| **Science and Engineering Practices****Developing and Using Models*** Develop and use a model to describe phenomena. (8.MS-LS3-1)
* Develop a model to describe unobservable mechanisms. (8.MS-LS3-3), (8.MS-LS3-4)

**Obtaining, Evaluating, and Communicating Information** * Communicate scientific and/or technical information (e.g. about a proposed object, tool, process, system) in writing and/or through oral presentations. (8.MS-LS3-3)

**Engaging in Argument from Evidence*** Construct, use, or present an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem. (8.MS-LS3-2)
 | **Disciplinary Core Ideas****LS1.B: Growth and Development of Organisms** * Organisms reproduce, either sexually or asexually, and transfer their genetic information to their offspring. (8.MS-LS3-2)

**LS3.A: Inheritance of Traits*** Most genes are located in the chromosomes of cells, with each chromosome pair containing two variants of each of many distinct genes. Each distinct gene chiefly controls the production of specific proteins, which in turn affects the traits of the individual. Changes (mutations) to genes can result in changes to proteins, which can affect the structures and functions of the organism and thereby change traits. (8.MS-LS3-1), (8.MS-LS3-3)
* Variations of inherited traits between parent and offspring arise from genetic differences that result from the subset of chromosomes (and therefore genes) inherited. (8.MS-LS3-2)

**LS3.B: Variation of Traits** * In sexually reproducing organisms, each parent contributes half of the genes acquired (at random) by the offspring. Individuals have two of each chromosome and hence two alleles of each gene, one acquired from each parent. These versions may be identical or may differ from each other. (8.MS-LS3-2), (8.MS-LS3-4)
* In addition to variations that arise from sexual reproduction, genetic information can be altered because of mutations. Though rare, mutations may result in changes to the structure and function of proteins. Some changes are beneficial, others harmful, and some neutral to the organism. (8.MS-LS3-1)
 |
| *ELA/Literacy –* **◊RCA-ST.6-8.1** Cite specific textual evidence to support analysis of science and technical texts, quoting or paraphrasing as appropriate. **(◊6.MS-LS3-2)****◊WCA.6-8.2** Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes. **(◊6.MS-LS3-3)****RCA-ST.6-8.7** Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (eg., in a flowchart, diagram, model, graph, or table). **(8.MS-LS3-1), (8.MS-LS3-4)***Mathematics –***7. SP.C.8** Find probabilities of compound events using organized lists, tables, tree diagrams, and simulation. (**8.MS-LS3-4(MA)** |

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| **LS4. Biological Evolution: Unity and Diversity** |
| **8.MS-LS4-4. Use a model to describe the process of natural selection, in which genetic variations of some traits in a population increase some individuals’ likelihood of surviving and reproducing in a changing environment. Provide evidence that natural selection occurs over many generations.** **Clarification Statements:** * **The model should include simple probability statements and proportional reasoning.**
* **Examples of evidence can include Darwin’s finches, necks of giraffes, and peppered moths.**

**State Assessment Boundary:** * **Specific conditions that lead to natural selection are not expected in state assessment.**

**8.MS-LS4-5. Synthesize and communicate information about artificial selection, or the ways in which humans have changed the inheritance of desired traits in organisms.** **Clarification Statement:** * **Emphasis is on the influence of humans on genetic outcomes in artificial selection (such as genetic modification, animal husbandry, and gene therapy).**

**[Note: MS-LS4-1 and MS-LS4-2 are found in Grade 6. MS-LS4-3 and MS-LS4-6 from NGSS are not included.]** |
| The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*: |
| **Science and Engineering Practices****Constructing Explanations and Designing Solutions*** Apply scientific ideas to construct an explanation for real-world phenomena, examples, or events. (8.MS-LS4-4)
* Construct an explanation that includes qualitative or quantitative relationships between variables that describe phenomena. (8.MS-LS4-4)

**Obtaining, Evaluating, and Communicating Information*** Gather, read, and synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and methods used, and describe how they are supported or not supported by evidence. (8.MS-LS4-5)
 | **Disciplinary Core Ideas****LS4.B: Natural Selection*** Natural selection leads to the predominance of certain traits in a population, and the suppression of others. (8.MS-LS4-4)
* In *artificial* selection, humans have the capacity to influence certain characteristics of organisms by selective breeding. One can choose desired parental traits determined by genes, which are then passed on to offspring. (8.MS-LS4-5)

**LS4.C: Adaptation** * Adaptation by natural selection acting over generations is one important process by which species change over time in response to changes in environmental conditions. Traits that support successful survival and reproduction in the new environment become more common; those that do not become less common. Thus, the distribution of traits in a population changes. (8.MS-LS4-4)
 |
| *ELA/Literacy –* **◊SLCA.6-8.2** Analyze the purpose of information presented in diverse media and formats (e.g., visually, quantitatively, orally) and evaluate the motives (e.g.social, commercial, political) behind its presentation. **(◊8.MS-LS4-5)****RCA-ST.6-8.1** Cite specific textual evidence to support analysis of science and technical texts, quoting or paraphrasing as appropriate.  **(8.8.MS-LS4-5)****WCA.6-8.8** Gather relevant information from multiple print and digital sources; assess the credibility of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and providing basic bibliographic information for sources. **(8.MS-LS4-5)***Mathematics –* **7.RP.A.2** Recognize and represent proportional relationships between quantities. **(8.MS-LS4-4)****7.SP.B.1** Understand that the probability of a chance event is a number between 0 and 1 that expresses the likelihood of the event occurring. Larger numbers indicate greater likelihood. A probability near 0 indicates an unlikely event, a probability around ½ indicates an event that is neither unlikely nor likely, and a probability near 1 indicates that it is neither unlikely nor likely, and a probability near 1 indicates a likely event. **(8.MS-LS4-4)** |

**Grade 8: Physical Science**

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| **PS1. Matter and Its Interactions** |
| **8.MS-PS1-1. Develop a model to describe that (a) atoms combine in a multitude of ways to produce pure substances which make up all of the living and nonliving things that we encounter, (b) atoms form molecules and compounds that range in size from two to thousands of atoms, and (c) mixtures are composed of different proportions of pure substances.** **Clarification Statement:** * **Examples of molecular-level models could include drawings, three-dimensional ball and stick structures, and computer representations showing different molecules with different types of atoms.**

**State Assessment Boundary:** * **Valence electrons and bonding energy, the ionic nature of subunits of complex structures, complete depictions of all individual atoms in a complex molecule or extended structure, or calculations of proportions in mixtures are not expected in state assessment.**

**8.MS-PS1-2. Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.** **Clarification Statements:** * **Examples of reactions could include burning sugar or steel wool, fat reacting with sodium hydroxide, and mixing zinc with HCl.**
* **Properties of substances include density, melting point, boiling point, solubility, flammability, and odor.**

**8.MS-PS1-4. Develop a model that describes and predicts changes in particle motion, relative spatial arrangement, temperature, and state of a pure substance when thermal energy is added or removed.** **Clarification Statements:** * **Emphasis is on qualitative molecular-level models of solids, liquids, and gases to show that adding or removing thermal energy increases or decreases kinetic energy of the particles until a change of state occurs.**
* **Examples of models could include drawings and diagrams.**
* **Examples of pure substances could include water, carbon dioxide, and helium.**

**8.MS-PS1-5. Use a model to explain that atoms are rearranged during a chemical reaction to form new substances with new properties. Explain that the atoms present in the reactants are all present in the products and thus the total number of atoms is conserved.** **Clarification Statement:** * **Examples of models can include physical models or drawings, including digital forms, that represent atoms.**

**State Assessment Boundary:** * **Use of atomic masses, molecular weights, balancing symbolic equations, or intermolecular forces is not expected in state assessment.**

**[Note: MS-PS1-6, MS-PS1-7(MA), and MS-PS1-8(MA) are found in Grade 6. MS-PS1-3 from NGSS is not included.]** |
| The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*: |
| **Science and Engineering Practices****Developing and Using Models*** Develop a model to predict and/or describe phenomena. (8.MS-PS1-1), (8.MS-PS1-4)
* Develop a model to describe unobservable mechanisms. (8.MS-PS1-5)

**Analyzing and Interpreting Data*** Analyze and interpret data to determine similarities and differences in findings. (8.MS-PS1-2)
 | **Disciplinary Core Ideas****PS1.A: Structure and Properties of Matter*** Substances are made from some 100 different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms. (MS-PS1-1)
* Gases and liquids are made of molecules or inert atoms that are moving about relative to each other. (MS-PS1-4)
* In a liquid, the molecules are constantly in contact with others; in a gas, they are widely spaced except when they happen to collide. In a solid, atoms are closely spaced and may vibrate in position but do not change relative locations. (MS-PS1-4)
* Solids may be formed from molecules, or they may be extended structures with repeating subunits (e.g., crystals). (MS-PS1-1)
* The changes of state that occur with variations in temperature or pressure can be described and predicted using these models of matter. (MS-PS1-4)
* Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it. (MS-PS1-2)
* Pure substances are made from a single type of atom or molecule. (MS-PS1-1)
* Some mixtures of substances can be separated into component substances. (8.MS-PS1-1), (Note: This Disciplinary Core Idea is also addressed by 6.MS-PS1-8(MA))

**PS1.B: Chemical Reactions*** Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants. (MS-PS1-2),(MS-PS1-5)
* The total number of each type of atom is conserved, and thus the mass does not change. (MS-PS1-5)

**PS3.A: Definitions of Energy*** The term “heat” as used in everyday language refers both to thermal motion (the motion of atoms or molecules within a substance) and radiation (particularly infrared and light). In science, heat is used only for this second meaning; it refers to energy transferred when two objects or systems are at different temperatures. *(secondary to MS-PS1-4), (Note: This Disciplinary Core Idea is also secondary to 7.MS-PS3-4)*
* The temperature of a system is proportional to the average internal kinetic energy and potential energy per atom or molecule (whichever is the appropriate building block for the system’s material). The details of that relationship depend on the type of atom or molecule and the interactions among the atoms in the material. Temperature is not a direct measure of a system's total thermal energy. The total thermal energy (sometimes called the total internal energy) of a system depends jointly on the temperature, the total number of atoms in the system, and the state of the material. (8.MS-PS1-4)
 |
| *ELA/Literacy –* **SLCA.6-8.2** Integrate and evaluate information presented in diverse media and formats, including visually, quantitatively, and orally. **(8.MS-PS1-2)****SLCA.6-8.5** Integrate multimedia components and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest. **(8.MS-PS1-1), (8.MS-PS1-4)****RCA-ST.6-8.7** Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (eg., in a flowchart, diagram, model, graph, or table). **(8.MS-PS1-1), (8.MS-PS1-4)***Mathematics –* **◊7.RP.A.3** Use proportional relationships to solve multi-step ratio and percent problems. **(◊8.MS-PS1-1)****◊7.SP.A.2** Use data from a random sample to draw inferences about a population with an unknown characteristic of interest. Generate multiple samples (or simulated samples) of the same size to gauge the variation in estimates or predictions. **(◊8.MS-PS1-4)****8.EE.A.3** Use numbers expressed in the form of a single digit times an integer power of 10 to estimate very large or very small quantities, and to express how many times as much one is than the other. **(8.MS-PS1-1)** |

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| **PS2. Motion and Stability: Forces and Interactions** |
| **8.MS-PS2-1. Develop a model that demonstrates Newton’s third law involving the motion of two colliding objects.** **State Assessment Boundary:** * **State assessment will be limited to vertical or horizontal interactions in one dimension.**

**8.MS-PS2-2. Provide evidence that the change in an object’s speed 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 speed (Newton’s second law) in one dimension.**

**State Assessment Boundaries:** * **State assessment will be limited to forces and changes in motion in one dimension in an inertial reference frame and to change in one variable at a time.**
* **The use of trigonometry is not expected in state assessment.**

**[Note: MS-PS2-4 is found in Grade 6. MS-PS2-3 and MS-PS3-5 are found in Grade 6.]** |
| The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*: |
| **Science and Engineering Practices****Developing and Using Models*** Develop a model to describe phenomena. (8.MS-PS2-1)

**Engaging in Argument from Evidence*** Present an argument supported by empirical evidence and scientific reasoning to support an explanation for a phenomenon. (8.MS-PS1-2)
 | **Disciplinary Core Ideas****PS2.A: Forces and Motion*** For any pair of interacting objects, the force exerted by the first object on the second object is equal in strength to the force that the second object exerts on the first, but in the opposite direction (Newton’s third law). (8.MS-PS2-1), *(Note: This Disciplinary Core Idea is also secondary to 8.MS-ESS1-2.)*
* The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion. (8.MS-PS2-2)
* All positions of objects and the directions of forces and motions must be described in an arbitrarily chosen reference frame and arbitrarily chosen units of size. In order to share information with other people, these choices must also be shared. (8.MS-PS2-2)
 |
| *ELA/Literacy –* **RCA-ST.6-8.7** Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). **(8.MS-PS2-1)****RCA-ST.6-8.3** Follow precisely a multi-step procedure when carrying out experiments, taking measurements, or performing technical tasks. **(8.MS-PS2-2)***Mathematics –* **◊6.NS.C.5** Understand that positive and negative numbers are used together to describe quantities having opposite directions or values; use positive and negative numbers to represent quantities in real-world contexts, explaining the meaning of 0 in each situation. **(◊8.MS-PS2-1), (◊8.MS-PS2-2)****◊7.EE.B.3** Solve multi-step real-life and mathematical problems posed with positive and negative rational numbers in any form, using tools strategically. Apply properties of operations to calculate with numbers in any form; convert between forms as appropriate; and assess the reasonableness of answers using mental computation and estimation strategies. **(8.MS-PS2-1), (◊8.MS-PS2-2)****7.EE.B.4** Use variables to represent quantities in a real-world or mathematical problem, and construct simple equations and inequalities to solve problems by reasoning about the quantities. **(8.MS-PS2-1), (8.MS-PS2-2)** |

**Grade 8: Technology/Engineering**

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| **ETS2. Materials, Tools and Manufacturing** |
| **8.MS-ETS2-4(MA). Use informational text to illustrate that materials maintain their composition under various kinds of physical processing; however, some material properties may change if a process changes the particulate structure of a material.** **Clarification Statements:** * **Examples of physical processing can include cutting, forming, extruding, and sanding.**
* **Examples of changes in material properties can include a non-magnetic iron material becoming magnetic after hammering and a plastic material becoming rigid (less elastic) after heat treatment.**

**8.MS-ETS2-5(MA). Present information that illustrates how a product can be created using basic processes in manufacturing systems, including forming, separating, conditioning, assembling, finishing, quality control, and safety. Compare the advantages and disadvantages of human vs. computer control of these processes.** **[Note: MS-ETS2-1(MA), MS-ETS2-2(MA), MS-ETS2-3(MA), and MS-ETS2-4(MA) are found in Grade 6.]** |
| The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*: |
| **Science and Engineering Practices****Obtaining, Evaluating, and Communicating Information*** Critically read scientific texts adapted for classroom use to obtain scientific and technical information to describe evidence about the natural and designed worlds. (8.MS-ETS2-4(MA))
* Communicate scientific and technical information (e.g. about a proposed object, tool, process, system) in writing or through oral presentations. (8.MS-ETS2-5(MA))
 | **Disciplinary Core Ideas****ETS2.B Manufacturing*** The design and structure of any particular technology product reflects its function. Products can be manufactured using common processes controlled by either people or computers. (8.MS-ETS2-4(MA)), (8.MS-ETS2-5(MA))

**PS1.A: Structure and Properties of Matter*** Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it. (8.MS-ETS2-4(MA))
* The changes of state that occur with variations in temperature or pressure can be described and predicted using these models of matter. (8.MS-ETS2-4(MA))
 |
| *ELA/Literacy –* **RCA-ST.6-8.7** Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (eg., in a flowchart, diagram, model, graph, or table). **(8.MS-ETS2-5(MA))****SLCA.6-8.2** Analyze the purpose of information presented in diverse media and formats (e.g., visually, quantitatively, orally) and evaluate the motives (e.g. social, commercial, political) behind its presentation. **(8.MS-ETS2-4(MA))***Mathematics –***A-CED.A.2** [Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales.](http://www.corestandards.org/Math/Content/HSA/CED) **(8.MS-ETS2-4(MA))****N-Q.A.1** Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. **(8.MS-ETS2-4(MA))****N-Q.A.2** Define appropriate quantities for the purpose of descriptive modeling. **(8.MS-ETS2-4(MA))** |

High School: Earth and Space Science

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| **ESS1. Earth’s Place in the Universe** |
| **HS-ESS1-1. Use informational text to explain that the life span of the Sun over approximately 10 billion years is a function of nuclear fusion in its core. Communicate that stars, through nuclear fusion over their life cycle, produce elements from helium to iron and release energy that eventually reaches Earth in the form of radiation.****State Assessment Boundary:** * **Specific stages of the life of a star, details of the many different nucleosynthesis pathways for stars of differing masses, or calculations of energy released are not expected in state assessment.**

**HS-ESS1-2. Describe the astronomical evidence for the Big Bang theory, including the red shift of light from the motion of distant galaxies as an indication that the universe is currently expanding, the cosmic microwave background as the remnant radiation from the Big Bang, and the observed composition of ordinary matter of the universe, primarily found in stars and interstellar gases, which matches that predicted by the Big Bang theory (3/4 hydrogen and 1/4 helium).****HS-ESS1-4. Use Kepler’s laws to predict the motion of orbiting objects in the solar system. Describe how orbits may change due to the gravitational effects from, or collisions with, other objects in the solar system.** **Clarification Statements:** * **Kepler’s laws apply to human-made satellites as well as planets, moons, and other objects.**
* **Calculations involving Kepler’s laws of orbital motions should not deal with more than two bodies, nor involve calculus.**

**HS-ESS1-5. Evaluate evidence of the past and current movements of continental and oceanic crust, the theory of plate tectonics, and relative densities of oceanic and continental rocks to explain why continental rocks are generally much older than rocks of the ocean floor.** **Clarification Statement:** * **Examples include the ages of oceanic crust (less than 200 million years old) increasing with distance from mid-ocean ridges (a result of plate spreading at divergent boundaries) 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 at convergent boundaries).**

**[Note: HS-ESS1-6 from NGSS is not included. HS-ESS1-3 from NGSS has been combined with HS-ESS1-1.]** |
| The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*: |
| **Science and Engineering Practices****Constructing Explanations and Designing Solutions** * Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students’ own investigations, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (HS-ESS1-1), (HS-ESS1-2)

**Obtaining, Evaluating, and Communicating Information** * Communicate scientific ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically). (HS-ESS1-1)

**Using Mathematical and Computational Thinking*** Use mathematical or computational representations of phenomena to describe explanations. (HS-ESS1-4)

**Engaging in Argument with Evidence*** Evaluate the evidence behind currently accepted explanations or solutions to determine the merits of the argument. (HS-ESS1-5)
 | **Disciplinary Core Ideas****ESS1.A: The Universe and Its Stars*** The star called the sun is changing and will burn out over a lifespan of approximately 10 billion years.(HS-ESS1-1)
* The study of stars’ light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth. (HS-ESS1-1), (HS-ESS1-2)
* The Big Bang theory is supported by observations of distant galaxies receding from our own, of the measured composition of stars and non-stellar gases, and of the maps of spectra of the primordial radiation (cosmic microwave background) that still fills the universe. *Added beyond NRC.* (HS-ESS1-1), (HS-ESS1-2)
* Other than the hydrogen and helium formed at the time of the Big Bang, nuclear fusion within stars produces all atomic nuclei lighter than and including iron, and the process releases electromagnetic energy*. Added beyond NRC.* (HS-ESS1-1), (HS-ESS1-2)

**ESS1.B: Earth and the Solar System*** Kepler’s laws describe common features of the motions of orbiting objects, including their elliptical paths around the sun. Orbits may change due to the gravitational effects from, or collisions with, other objects in the solar system. (HS-ESS1-4)

**ESS1.C: The History of Planet Earth*** Continental rocks, which can be older than 4 billion years, are generally much older than the rocks of the ocean floor, which are less than 200 million years old. (HS-ESS1-5)

**ESS2.B: Plate Tectonics and Large-Scale System Interactions*** Plate movements are responsible for most continental and ocean-floor features and for the distribution of most rocks and minerals within Earth’s crust. *(secondary to HS-ESS1-5),* (Note: This Disciplinary Core Idea is also addressed by 8.MS-ESS2-1)
* Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth’s surface and provides a framework for understanding its geologic history. *(secondary to HS-ESS1-5)*, (Note: This Disciplinary Core Idea is also addressed by 8.MS-ESS2-1)

**PS1.C: Nuclear Processes*** Spontaneous radioactive decays follow a characteristic exponential decay law. Nuclear lifetimes allow radiometric dating to be used to determine the ages of rocks and other materials. *(secondary to HS-ESS1-5)*

**PS3.D: Energy in Chemical Processes and Everyday Life*** Nuclear Fusion processes in the center of the sun release the energy that ultimately reaches Earth as radiation. (secondary to HS-ESS1-1)

**PS4.B: Electromagnetic Radiation*** Atoms of each element emit and absorb characteristic frequencies of light. These characteristics allow identification of the presence of an element, even in microscopic quantities. *(secondary to HS-ESS1-2)*
 |
| *ELA/Literacy –***RCA-ST.9-10.1** Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions. **(HS-ESS1-1), (HS-ESS1-2)****RCA-ST.9-10.8** Assess the extent to which the reasoning and evidence in a text support the author’s claim or a recommendation for solving a scientific or technical problem. **(HS-ESS1-5)***Mathematics –***8.EE.A.4** Perform operations with numbers expressed in scientific notation, including problems where both decimal and scientific notation are used. Use scientific notation and choose units of appropriate size for measurements of vary large or very small quantities (e.g. millimeters per year for seafloor spreading). Interpret scientific notation that has been generated by technology. **(HS-ESS1-2), (HS-ESS1-4), (HS-ESS1-5)****◊F-BF.A.1.c** Compose functions. For example, if $T(y)$ is the temperature in the atmosphere as a function of height, and $h(t)$ is the height of a weather balloon as a function of time, then $T(h(t))$ is the temperature at the location of the weather balloon as a function of time. **(◊HS-ESS1-1)****◊A-CED.A.4** Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. **(◊HS-ESS1-4)****A-CED.A.2** [Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales.](http://www.corestandards.org/Math/Content/HSA/CED) **(HS-ESS1-4)****N-Q.A.1** Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. **(HS-ESS1-4)****N-Q.A.2** Define appropriate quantities for the purpose of descriptive modeling. **(HS-ESS1-2), (HS-ESS1-4)** |

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| **ESS2. Earth’s Systems** |
| **HS-ESS2-2. Analyze geoscience data to make the claim that one change to Earth’s hydrosphere can create feedbacks that cause changes to other Earth systems.** **Clarification Statement:** * **Examples can include how decreasing the amount of glacial ice reduces the amount of sunlight reflected from Earth’s surface, increasing surface temperatures and further reducing the amount of ice; how the loss of ground vegetation causes an increase in water runoff and soil erosion; how dammed rivers increase groundwater recharge, decrease sediment transport, and increase coastal erosion; and how the loss of wetlands causes a decrease in local humidity that further reduces the wetland extent.**

**HS-ESS2-3. Use a model based on evidence of Earth’s interior to describe the cycling of matter due to the outward flow of energy from Earth’s interior and gravitational movement of denser materials toward the interior.** **Clarification Statements:** * **Emphasis is on both a two-dimensional model of Earth, with radial layers determined by density, and a three-dimensional model, which is controlled by gravity and thermal convection.**
* **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 layers from high-pressure laboratory experiments.**

**HS-ESS2-4. Use a model to describe how variations in the flow of energy into and out of Earth’s systems over different time scales result in changes in climate. Analyze and interpret data to explain that long-term changes in Earth’s tilt and orbit result in cycles of climate change such as Ice Ages.** **Clarification Statement:** * **Examples of the causes of climate change differ by timescale: large volcanic eruption and ocean circulation over 1–10 years; changes in human activity, ocean circulation, and solar output over tens to hundreds of years; changes to Earth’s orbit and the orientation of its axis over tens to hundreds of thousands of years; and long-term changes in atmospheric composition over tens to hundreds of millions of years.**

**State Assessment Boundary:** * **Changes in climate will be limited to changes in surface temperatures, precipitation patterns, glacial ice volumes, sea levels, and biosphere distribution in state assessment.**

**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 Statements:** * **Examples of mechanical mechanisms involving water include stream transportation and deposition, erosion using variations in soil moisture content, and frost wedging by the expansion of water as it freezes.**
* **Examples of chemical mechanisms involving water include chemical weathering and recrystallization (based on solubility of different materials) and melt generation (based on water lowering the melting temperature of most solids).**

**HS-ESS2-6. Use a model to describe cycling of carbon through the ocean, atmosphere, soil, and biosphere and how increases in carbon dioxide concentrations due to human activity have resulted in atmospheric and climate changes.****[Note: HS-ESS2-1 has been merged with MS-ESS2-1. HS-ESS2-7 from NGSS is not included.]** |
| The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*: |
| **Science and Engineering Practices****Developing and Using Models*** Develop a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-ESS2-3),(HS-ESS2-6)
* Use a model to provide mechanistic accounts of phenomena. (HS-ESS2-4)

**Analyzing and Interpreting Data*** Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims. (HS-ESS2-2), (HS-ESS2-4)
 | **Disciplinary Core Ideas****ESS1.B: Earth and the Solar System*** Cyclical changes in the shape of Earth’s orbit around the sun, together with changes in the tilt of the planet’s axis of rotation, both occurring over hundreds of thousands of years, have altered the intensity and distribution of sunlight falling on the earth. These phenomena cause a cycle of ice ages and other gradual climate changes. *(secondary to HS-ESS2-4)*

**ESS2.A: Earth Materials and Systems*** Earth’s systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. (HS-ESS2-2)
* Evidence from deep probes and seismic waves, reconstructions of historical changes in Earth’s surface and its magnetic field, and an understanding of physical and chemical processes lead to a model of Earth with a hot but solid inner core, a liquid outer core, a solid mantle and crust. Motions of the mantle and its plates occur primarily through thermal convection, which involves the cycling of matter due to the outward flow of energy from Earth’s interior and gravitational movement of denser materials toward the interior. (HS-ESS2-3)
* The geological record shows that changes to global and regional climate can be caused by interactions among changes in the sun’s energy output or Earth’s orbit, tectonic events, ocean circulation, volcanic activity, glaciers, vegetation, and human activities. These changes can occur on a variety of time scales from sudden (e.g., volcanic ash clouds) to intermediate (ice ages) to very long-term tectonic cycles. (HS-ESS2-4)

**ESS2.B: Plate Tectonics and Large-Scale System Interactions*** The radioactive decay of unstable isotopes continually generates new energy within Earth’s crust and mantle, providing the primary source of the heat that drives mantle convection. Plate tectonics can be viewed as the surface expression of mantle convection. (HS-ESS2-3)

**ESS2.C: The Roles of Water in Earth’s Surface Processes*** The abundance of liquid water on Earth’s surface and its unique combination of physical and chemical properties are central to the planet’s dynamics. These properties include water’s exceptional capacity to absorb, store, and release large amounts of energy, transmit sunlight, expand upon freezing, dissolve and transport materials, and lower the viscosities and melting points of rocks. (HS-ESS2-5)

**ESS2.D: Weather and Climate*** The foundation for Earth’s global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy’s re-radiation into space. (HS-ESS2-2), (HS-ESS2-4)
* Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen. (HS-ESS2-6)
* Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate. (HS-ESS2-4), (HS-ESS2-6)
* Current models predict that, although future regional climate changes will be complex and varied, average global temperatures will continue to rise. The outcomes predicted by global climate models strongly depend on the amounts of human-generated greenhouse gases added to the atmosphere each year and by the ways in which these gases are absorbed by the ocean and biosphere. (HS-ESS2-6)

**PS4.A: Wave Properties*** Geologists use seismic waves and their reflection at interfaces between layers to probe structures deep in the planet. *(secondary to HS-ESS2-3)*
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| *ELA/Literacy-***RCA-ST.9-10.7** Translate quantitative or technical information expressed in words in a text into visual form (eg., table or chart) and translate information expressed visually or mathematically (e.g., in an equation into words **(HS-ESS2-3), (HS-ESS2-4), (HS-ESS2-)****RCA-ST.9-10.1** Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions. **(HS-ESS2-2), (HS-ESS2-4)***Mathematics –***◊8.F.B.5** Describe qualitatively the functional relationship between two quantities by analyzing a graph (e.g. where the function is increasing or decreasing, linear or nonlinear). Sketch a graph that exhibits the qualitative features of a function that has been described verbally. **(◊HS-ESS2-4),(HS-ESS2-2)****8.EE.A.4** Perform operations with numbers expressed in scientific notation, including problems where both decimal and scientific notation are used. Use scientific notation and choose units of appropriate size for measurements of vary large or very small quantities (e.g. millimeters per year for seafloor spreading). Interpret scientific notation that has been generated by technology. **(HS-ESS2-2), (HS-ESS2-3), (HS-ESS2-4), (HS-ESS2-6)****N-Q.A.1** Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. **(HS-ESS2-2), (HS-ESS2-4), (HS-ESS2-6)****N-Q.A.2** Define appropriate quantities for the purpose of descriptive modeling. **(HS-ESS2-3), (HS-ESS2-4), (HS-ESS2-6)****S-ID.B.6** Represent data on two quantitative variables on a scatter plot, and describe how the variables are related. **(HS-ESS2-2), (HS-ESS2-4)** |

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| **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 Statements:** * **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 Statements:** * **Examples of factors related to the management of natural resources include costs of resource extraction and waste management, per capita consumption, and the development of new technologies.**
* **Examples of factors related to human sustainability include agricultural efficiency, levels of conservation, and urban planning.**
* **Examples of factors related to biodiversity include habitat use and fragmentation, and land and resource conservation.**

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

**[Note: HS-ESS3-4 and HS-ESS3-6 from NGSS is not included.]** |
| The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*: |
| **Science and Engineering Practices** **Constructing Explanations and Designing Solutions*** Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students’ own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (HS-ESS3-1)

**Engaging in Argument from Evidence*** Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and logical arguments regarding relevant factors (e.g. economic, societal, environmental, ethical considerations). (HS-ESS3-2)
 | **Disciplinary Core Ideas****ESS3.A: Natural Resources*** Resource availability has guided the development of human society. (HS-ESS3-1)
* All forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors. (HS-ESS3-2)

**ESS3.B: Natural Hazards*** Natural hazards and other geologic events have shaped the course of human history; they have significantly altered the sizes of human populations and have driven human migrations. (HS-ESS3-1)

**ESS3.C: Human Impacts on Earth Systems*** The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources. (HS-ESS3-3)

**ESS3.D: Global Climate Change*** Though the magnitudes of human impacts are greater than they have ever been, so too are human abilities to model, predict, and manage current and future impacts. (HS-ESS3-5)

**ETS1.B: Developing Possible Solutions*** When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. *(secondary to HS-ESS3-2)*
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| *ELA/Literacy –***WCA.9-10.1** Write arguments focused on *discipline-specific content*. **(HS-ESS3-1)****WCA.9-10.2** Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes. **(◊HS-ESS3-1)****RCA-ST.9-10.7** Translate quantitative or technical information expressed in words in a text into visual form (e.g., table or chart) and translate information expressed visually or mathematically (e.g., in an equation into words **(HS-ESS3-5), (HS-ESS2-4), (HS-ESS3-3)****RCA-ST.9-10.1** Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions. **(HS-ESS3-2)***Mathematics –***◊8.F.B.5** Describe qualitatively the functional relationship between two quantities by analyzing a graph (e.g. where the function is increasing or decreasing, linear or nonlinear). Sketch a graph that exhibits the qualitative features of a function that has been described verbally. **(◊HS-ESS3-3), (◊HS-ESS3-5)****◊S-IC.A.2** Decide if a specified model is consistent with results from a given data-generating process, e.g., using a simulation. For example, a model says a spinning coin falls heads up with probability 0.5. Would a result of 5 tails in a row cause you to question the model? **(◊HS-ESS3-5)****S-IC.B.6** Evaluate reports based on data. **(HS-ESS3-5)****N-Q.A.1** Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (**HS-ESS3-5)**[**N-Q.A.2**](http://www.corestandards.org/Math/Content/HSN/Q) [Define appropriate quantities for the purpose of descriptive modeling.](http://www.corestandards.org/Math/Content/HSN/Q) (**HS-ESS3-5)****N-Q.A.3**  [Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.](http://www.corestandards.org/Math/Content/HSN/Q)  **(HS-ESS3-1),(HS-ESS3-5)** |

High School: Biology

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| **LS1. From Molecules to Organisms: Structures and Processes** |
| **HS-LS1-1. Construct a model of transcription and translation to explain the roles of DNA and RNA that code for proteins that regulate and carry out essential functions of life.** **Clarification Statements:** * **Proteins that regulate and carry out essential functions of life include enzymes (which speed up chemical reactions), structural proteins (which provide structure and enable movement), and hormones and receptors (which send and receive signals).**
* **The model should show the double-stranded structure of DNA, including genes as part of DNA’s transcribed strand, with complementary bases on the non-transcribed strand.**

**State Assessment Boundaries:** * **Specific names of proteins or specific steps of transcription and translation are not expected in state assessment.**
* **Cell structures included in transcription and translation will be limited to nucleus, nuclear membrane, and ribosomes for state assessment.**

**HS-LS1-2. Develop and use a model to illustrate the key functions of animal body systems, including (a) food digestion, nutrient uptake, and transport through the body; (b) exchange of oxygen and carbon dioxide; (c) removal of wastes; and (d) regulation of body processes.** **Clarification Statement:** * **Emphasis is on the primary function of the following body systems (and structures): digestive (mouth, stomach, small intestine [villi], large intestine, pancreas), respiratory (lungs [alveoli], diaphragm), circulatory (heart, veins, arteries, capillaries), excretory (kidneys, liver, skin), and nervous (neurons, brain, spinal cord).**

**State Assessment Boundary:** * **Chemical reactions in cells, details of particular structures (such as the structure of the neuron), or the identification of specific proteins in cells are not expected in state assessment.**

**HS-LS1-3. Provide evidence that homeostasis maintains internal body conditions through both body-wide feedback mechanisms and small-scale cellular processes.** **Clarification Statements:** * **Feedback mechanisms include the promotion of a stimulus through positive feedback (e.g., injured tissues releasing chemicals in blood that activate platelets to facilitate blood clotting), and the inhibition of stimulus through negative feedback (e.g., insulin reducing high blood glucose to normal levels).**
* **Cellular processes include (a) passive transport and active transport of materials across the cell membrane to maintain specific concentrations of water and other nutrients in the cell and (b) the role of lysosomes in recycling wastes, macromolecules, and cell parts into monomers.**

**State Assessment Boundary:*** **Interactions at the molecular level (for example, how insulin is produced) are not expected in state assessment.**

**HS-LS1-4. Construct an explanation using evidence for why the cell cycle is necessary for the growth, maintenance, and repair of multicellular organisms. Model the major events of the cell cycle, including (a) cell growth and DNA replication, (b) separation of chromosomes (mitosis), and (c) separation of cell contents.** **State Assessment Boundary:*** **Specific gene control mechanisms or specific details of each event (e.g., phases of mitosis) are not expected in state assessment.**

**HS-LS1-5. Use a model to illustrate how photosynthesis uses light energy to transform water and carbon dioxide into oxygen and chemical energy stored in the bonds of sugars and other carbohydrates.** **Clarification Statements:** * **Emphasis is on illustrating inputs and outputs of matter and the transfer and transformation of energy in photosynthesis by plants and other photosynthesizing organisms.**
* **Examples of models could include diagrams, chemical equations, and conceptual models.**

 **State Assessment Boundary:** * **Specific biochemical steps of light reactions or the Calvin Cycle, or chemical structures of molecules are not expected in state assessment.**

**HS-LS1-6. Construct an explanation based on evidence that organic molecules are primarily composed of six elements, where carbon, hydrogen, and oxygen atoms may combine with nitrogen, sulfur, and phosphorus to form monomers that can further combine to form large carbon-based macromolecules.** **Clarification Statements:** * **Monomers include amino acids, mono- and disaccharides, nucleotides, and fatty acids.**
* **Organic macromolecules include proteins, carbohydrates (polysaccharides), nucleic acids, and lipids.**

**State Assessment Boundary:** * **Details of specific chemical reactions or identification of specific macromolecule structures are not expected in state assessment.**

**HS-LS1-7. Use a model to illustrate that aerobic cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and new bonds form, resulting in new compounds and a net transfer of energy.** **Clarification Statements:** * **Emphasis is on the conceptual understanding of the inputs and outputs of the process of aerobic cellular respiration.**
* **Examples of models could include diagrams, chemical equations, and conceptual models.**
* **The model should include the role of ATP for energy transfer in this process.**
* **Food molecules include sugars (carbohydrates), fats (lipids), and proteins.**

 **State Assessment Boundary:*** **Identification of the steps or specific processes involved in cellular respiration is not expected in state assessment.**
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| The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*: |
| **Science and Engineering Practices****Developing and Using Models*** Develop and use a model based on evidence to illustratethe relationships between systems or between components of a system. (HS-LS1-1), (HS-LS1-2), (HS-LS1-4)
* Use a model based on evidence to illustratethe relationships between systems or between components of a system. (HS-LS1-5), (HS-LS1-7)

**Engaging in Argument from Evidence*** Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge, and student-generated evidence. (HS-LS1-3)

**Constructing Explanations and Designing Solutions*** Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students’ own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (HS-LS1-4), (HS-LS1-6)
 | **Disciplinary Core Ideas****LS1.A: Structure and Function*** Systems of specialized cells within organisms help them perform the essential functions of life. (HS-LS1-2)
* The structures in the digestive, respiratory, circulatory, excretory, and nervous systems work together to perform the essential functions of life. (HS-LS1-2)
* All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins, which carry out most of the work of cells. (HS-LS1-1), (HS-LS3-1)
* Multicellular organisms have a hierarchical structural organization, in which any one system is made up of numerous parts and is itself a component of the next level. (HS-LS1-2)
* Feedback mechanisms maintain a living system’s internal conditions within certain limits and mediate behaviors, allowing it to remain alive and functional even as external conditions change within some range. Feedback mechanisms can encourage (through positive feedback) or discourage (negative feedback) what is going on inside the living system. (HS-LS1-3)
* Proteins, such as enzymes, structural proteins, hormones, and receptors, contribute to feedback loops and small-scale processes. (HS-LS1-1), (HS-LS1-3)

**LS1.B: Growth and Development of Organisms*** In multicellular organisms individual cells grow and then divide via a process called mitosis, thereby allowing the organism to grow. The organism begins as a single cell (fertilized egg) that divides successively to produce many cells, with each parent cell passing identical genetic material (two variants of each chromosome pair) to both daughter cells. Cellular division produces and maintains a complex organism, composed of systems of tissues and organs that work together to meet the needs of the whole organism. (HS-LS1-4)

**LS1.C: Organization for Matter and Energy Flow in Organisms** * The process of photosynthesis converts light energy to stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen. (HS-LS1-5)
* The sugar molecules thus formed contain carbon, hydrogen, and oxygen: their hydrocarbon backbones are used to make amino acids and other carbon-based molecules that can be assembled into larger molecules (such as proteins or DNA), used for example to form new cells. (HS-LS1-6)
* As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products. (HS-LS1-6) (HS-LS1-7)
* As a result of these chemical reactions, energy is transferred from one system of interacting molecules to another. Cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and new compounds are formed that can transport energy to muscles. Cellular respiration also releases the energy needed to maintain body temperature despite ongoing energy transfer to the surrounding environment. (HS-LS1-7)
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| *ELA/Literacy –***WCA.9-10.1** Write arguments focused on *discipline-specific content*. **(HS-LS1-3), (HS-LS1-6),****RCA-ST.9-10.1** Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions. **(HS-LS1-4)****RCA-ST.9-10.7** Translate quantitative or technical information expressed in words in a text into visual form (eg., table or chart) and translate information expressed visually or mathematically (e.g., in an equation into words **(HS-LS1-1), (HS-LS1-2), (HS-LS1-5), (HS-LS1-7)***Mathematics –***F-IF.C.7** [Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases.](http://www.corestandards.org/Math/Content/HSF/IF) **(HS-LS1-4)****F-BF.A.1** [Write a function that describes a relationship between two quantities.](http://www.corestandards.org/Math/Content/HSF/BF) **(HS-LS1-4)** |

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| **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 Statements:** * **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 Statements:** * **Examples of biotic factors could include relationships among individuals (feeding relationships, symbiosis, competition) and disease.**
* **Examples of abiotic factors could include climate and weather conditions, natural disasters, and availability of resources.**
* **Examples of mathematical representations include finding the average, determining trends, and using graphical comparisons of multiple sets of data.**

**HS-LS2-4. Use a mathematical model to describe the transfer of energy from one trophic level to another. Explain how the inefficiency of energy transfer between trophic levels affects the relative number of organisms that can be supported at each trophic level and necessitates a constant input of energy from sunlight or inorganic compounds from the environment.** **Clarification Statement:** * **The model should illustrate the “10% rule” of energy transfer and show approximate amounts of available energy at each trophic level in an ecosystem (up to five trophic levels).**

**HS-LS2-5. Use a model that illustrates the roles of photosynthesis, cellular respiration, decomposition, and combustion to explain the cycling of carbon in its various forms among the biosphere, atmosphere, hydrosphere, and geosphere.** **Clarification Statements:*** **The primary forms of carbon include carbon dioxide, hydrocarbons, waste (dead organic matter), and biomass (organic materials of living organisms).**
* **Examples of models could include simulations and mathematical models.**

**State Assessment Boundary:** * **The specific chemical steps of respiration, decomposition, and combustion are not expected in state assessment.**

**HS-LS2-6. Analyze data to show ecosystems tend to maintain relatively consistent numbers and types of organisms even when small changes in conditions occur but that extreme fluctuations in conditions may result in a new ecosystem. Construct an argument supported by evidence that ecosystems with greater biodiversity tend to have greater resistance to change and resilience.** **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, the decline or loss of a keystone species, 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.] |
| The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*: |
| **Science and Engineering Practices****Developing and Using Models*** Use a model based on evidence to illustrate the relationships between systems or components of a system. (HS-LS2-5)

**Using Mathematics and Computational Thinking*** Use mathematical and/or computational representations of phenomena or design solutions to support and revise explanations or claims. (HS-LS2-1), (HS-LS2-2), (HS-LS2-4)

**Constructing Explanations and Designing Solutions*** Design, evaluate, and refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-LS2-7)

**Engaging in Argument from Evidence*** Evaluate the claims, evidence, and reasoningbehind currently accepted explanations or solutions to determine the merits of arguments. (HS-LS2-1), (HS-LS2-2), (HS-LS2-6)
* Construct an oral and written argument based on data and evidence. (HS-LS2-6)
 | **Disciplinary Core Ideas****LS2.A: Interdependent Relationships in Ecosystems*** Ecosystems have carrying capacities, which are limits to the numbers of organisms and populations they can support. These limits result from such factors as the availability of living and nonliving resources and from such challenges such as predation, competition, and disease. Organisms would have the capacity to produce populations of great size were it not for the fact that environments and resources are finite. This fundamental tension affects the abundance (number of individuals) of species in any given ecosystem. (HS-LS2-1), (HS-LS2-2)

**LS2.B: Cycles of Matter and Energy Transfer in Ecosystems** * Photosynthesis and cellular respiration (including anaerobic processes) provide most of the energy for life processes. (HS-LS2-5)
* Plants or algae form the lowest level of the food web. At each link upward in a food web, only a small fraction of the matter consumed at the lower level is transferred upward, to produce growth and release energy in cellular respiration at the higher level. Given this inefficiency, there are generally fewer organisms at higher levels of a food web. Some matter reacts to release energy for life functions, some matter is stored in newly made structures, and much is discarded. The chemical elements that make up the molecules of organisms pass through food webs and into and out of the atmosphere and soil, and they are combined and recombined in different ways. At each link in an ecosystem, matter and energy are conserved. (HS-LS2-4)
* Photosynthesis and cellular respiration are important components of the carbon cycle, in which carbon is exchanged among the biosphere, atmosphere, oceans, and geosphere through chemical, physical, geological, and biological processes. (HS-LS2-5)
* Decomposition releases molecules, such as carbon- and nitrogen-containing molecules, bound in organic matter back into soil, allowing the molecules to be used by organisms again. (HS-LS2-5)
* Combustion reactions, such as cellular respiration and combustion from fuel-burning technologies, release carbon dioxide into the atmosphere. (HS-LS2-5)

**LS2.C: Ecosystem Dynamics, Functioning, and Resilience*** A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions. If a modest biological or physical disturbance to an ecosystem occurs, it may return to its more or less original status (i.e., the ecosystem is resilient), as opposed to becoming a very different ecosystem. Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of ecosystems in terms of resources and habitat availability. (HS-LS2-2), (HS-LS2-6)
* Moreover, anthropogenic changes (induced by human activity) in the environment—including habitat destruction, pollution, introduction of invasive species, overexploitation, and climate change—can disrupt an ecosystem and threaten the survival of some species. (HS-LS2-7)

**LS4.D: Biodiversity and Humans*** Biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction). *(secondary to HS-LS2-7)*
* Humans depend on the living world for the resources and other benefits provided by biodiversity. But human activity is also having adverse impacts on biodiversity through overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change. Thus sustaining biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth. Sustaining biodiversity also aids humanity by preserving landscapes of recreational or inspirational value. *(secondary to HS-LS2-7)*

**PS3.D: Energy in Chemical Processes*** The main way that solar energy is captured and stored on Earth is through the complex chemical process known as photosynthesis. *(secondary to HS-LS2-5)*
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| *ELA/Literacy –* **◊WCA.9-10.1** Write arguments focused on *discipline-specific content*. **(◊HS-LS2-6)****◊WCA.9-10.9** Draw evidence from informational texts to support analysis, reflection, and research. **(◊HS-LS2-7)****RCA -ST.11-12.1** Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. *(***HS-LS2-1),(HS-LS2-2),(HS-LS2-3),(HS-LS2-6)****RST.11-12.7** Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. *(***HS-LS2-6),(HS-LS2-7)****RST.9-10.8** Assess the extent to which the reasoning and evidence in a text support the author’s claim or a recommendation for solving a scientific or technical problem. **(HS-LS2-6),(HS-LS2-7)****RST.11-12.8** Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. **(HS-LS2-6),(HS-LS2-7)****WCA.9-12.2** Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. ***(HS-LS2-1),(HS-LS2-2),*(HS-LS2-3)****WCA.9-12.5** Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.**(HS-LS2-3)****WCA.9-12.7** Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.**(HS-LS2-7)***Mathematics –* **◊F-LE.A.1** Distinguish between situations that can be modeled with linear functions and with exponential functions. **(◊HS-LS2-4)****◊F-LE.B.5** Understand the inverse relationship between exponents and logarithms and use this relationship to solve problems. **(◊HS-LS2-4)****◊S-ID.A.1** Represent data with plots on the real number line (dot plots, histograms, and box plots). . **(◊HS-LS2-2), (HS-LS2-6)****◊S-ID.A.2** Use statistics appropriate to the shape of the data distribution to compare center (median, mean) and spread (interquartile range, standard deviation) of two or more different data sets. **(◊HS-LS2-2), (HS-LS2-6)****◊S-ID.A.3** Interpret differences in shape, center, and spread in the context of the data sets, accounting for possible effects of extreme data points. **(◊HS-LS2-2), (HS-LS2-6)****N-Q.A.1** [Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.](http://www.corestandards.org/Math/Content/HSN/Q) **(HS-LS2-1),(HS-LS2-2),(HS-LS2-4),(HS-LS2-7)****N-Q.A.2** [Define appropriate quantities for the purpose of descriptive modeling.](http://www.corestandards.org/Math/Content/HSN/Q) **(HS-LS2-1),(HS-LS2-2),(HS-LS2-4),(HS-LS2-7)****N-Q.A.3** [Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.](http://www.corestandards.org/Math/Content/HSN/Q) **(HS-LS2-1),(HS-LS2-2),(HS-LS2-4),(HS-LS2-7)****S-IC.A.1** [Understand statistics as a process for making inferences about population parameters based on a random sample from that population.](http://www.corestandards.org/Math/Content/HSS/IC) (**HS-LS2-6)****S-IC.B.6** [Evaluate reports based on data.](http://www.corestandards.org/Math/Content/HSS/IC) **(HS-LS2-2),**(**HS-LS2-6)** |

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| **LS3 Heredity: Inheritance and Variation of Traits** |
| **HS-LS3-1. Develop and use a model to show how DNA in the form of chromosomes is passed from parents to offspring through the processes of meiosis and fertilization in sexual reproduction.** **Clarification Statement:** * **The model should demonstrate that an individual’s characteristics (phenotype) result, in part, from interactions among the various proteins expressed by one’s genes (genotype).**

**State Assessment Boundary:** * **Identification of specific phases of meiosis or the biochemical mechanisms involved are not expected in state assessment.**

**HS-LS3-2. Make and defend a claim based on evidence that genetic variations (alleles) may result from (a) new genetic combinations via the processes of crossing over and random segregation of chromosomes during meiosis, (b) mutations that occur during replication, and/or (c) mutations caused by environmental factors. Recognize that mutations that occur in gametes can be passed to offspring.** **Clarification Statement:*** **Examples of evidence of genetic variation can include the work of McClintock in crossing over of maize chromosomes and the development of cancer due to DNA replication errors and UV ray exposure.**

**State Assessment Boundary:*** **Specific phases of meiosis or identification of specific types of mutations are not expected in state assessment.**

**HS-LS3-3. Apply concepts of probability to represent possible genotype and phenotype combinations in offspring caused by different types of Mendelian inheritance patterns.****Clarification Statements:*** **Representations can include Punnett squares, diagrams, pedigree charts, and simulations.**
* **Inheritance patterns include dominant-recessive, codominance, incomplete dominance, and sex-linked.**

**HS-LS3-4(MA). Use scientific information to illustrate that many traits of individuals, and the presence of specific alleles in a population, are due to interactions of genetic factors and environmental factors.** **Clarification Statements:** * **Examples of genetic factors include the presence of multiple alleles for one gene and multiple genes influencing a trait.**
* **An example of the role of the environment in expressed traits in an individual can include the likelihood of developing inherited diseases (e.g., 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 because it confers partial resistance to malaria.**

**State Assessment Boundary:** * **Hardy-Weinberg calculations are not expected in state assessment.**
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| The performance expectations above were developed using the following elements from the NRC document, *A Framework for K-12 Science Education*: |
|  **Science and Engineering Practices****Asking Questions and Defining Problems** * Ask questions that arise from examining models or a theory to clarify relationships. (HS-LS3-1)

**Engaging in Argument from Evidence*** Make and defend a claim based on evidence about the natural world that reflects scientific knowledge, and student-generated evidence. (HS-LS3-2)

**Constructing Explanations and Designing Solutions*** Apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects. (HS-LS3-2) , (HS-LS3-3)

**Using Mathematical and Computational Thinking*** Use mathematical representations of phenomena to describe and support explanations. (HS-LS3-3)
 | **Disciplinary Core Ideas****LS3.A: Inheritance of Traits*** Each chromosome consists of a single very long DNA molecule, and each gene on the chromosome is a particular segment of that DNA. The instructions for forming species’ characteristics are carried in DNA. All cells in an organism have the same genetic content, but the genes used (expressed) by the cell may be regulated in different ways. Not all DNA codes for a protein; some segments of DNA code for RNAs, are involved in regulatory or structural functions, and some have no as-yet known function. (HS-LS3-1), (HS-LS3-3)
* Mendelian inheritance patterns; such as dominant-recessive, codominance, incomplete dominance, and sex-linked; explain some of the ways that genotypes of parents results in phenotypes of offspring. Parental genotypes can be used to predict the probability of genotypes and phenotypes in offspring. (HS-LS3-1), (HS-LS3-3)

**LS3.B: Variation of Traits*** In sexual reproduction, chromosomes can sometimes swap sections during the process of meiosis (cell division), thereby creating new genetic combinations and thus more genetic variation. Although DNA replication is tightly regulated and remarkably accurate, errors do occur and result in mutations, which are also a source of genetic variation. Environmental factors can also cause mutations in genes, and viable mutations are inherited. (HS-LS3-2)
* Environmental factors also affect expression of traits, and hence affect the probability of occurrences of traits in a population. Thus the variation and distribution of traits observed depends on both genetic and environmental factors. (HS-LS3-2), (HS-LS3-3), (HS-LS3-4(MA))

**LS4.B: Natural Selection*** The traits that positively affect survival are more likely to be reproduced, and thus are more common in the population. *(secondary to HS-LS3-4(MA)),* (HS-LS4-2)
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| *ELA/Literacy –* **WCA.9-10.7** Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation**. (HS-LS3-2)****◊WCA.9-10.1** Write arguments focused on *discipline-specific content*. **(◊HS-LS3-1)****RCA-ST.9-10.1** Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions. **(HS-LS3-4)****RCA-ST.9-10.7** Translate quantitative or technical information expressed in words in a text into visual form (eg., table or chart) and translate information expressed visually or mathematically (e.g., in an equation into words **(HS-LS3-1)***Mathematics –***◊S-IC.A.1** [Understand statistics as a process for making inferences about population parameters based on a random sample from that population.](http://www.corestandards.org/Math/Content/HSS/IC)  **(◊HS-LS3-3)****◊S-IC.A.2** Decide if a specified model is consistent with results from a given data-gathering process. **(◊HS-LS3-3)****S-CP.A.1** Describe events as subsets of a sample space (the set of outcomes) using characteristics (or categories) of the outcomes, or as unions, intersections, or complements of other events (“or”, “and”, “not”) **(HS-LS3-3)****S-CP.A.2** Understand that two events *A* and *B* are independent if the probability of *A* and *B* occurring together is the product of their probabilities, and use this characterization to determine if they are independent. **(HS-LS3-3)****S-CP.A.3** Understand the conditional probability that of *A* given *B* as *P(A* and *B)*/*P(B)*, and interpret independence of A and B as saying that the conditional probability of *A* given *B* is the same as the probability of *A,* and the conditional probability of *B* given *A* is the same as the probability of *B.* **(HS-LS3-3)****S-CP.A.5** Recognize and explain the concepts of conditional probability and independence in everyday language and everyday situations. **(HS-LS3-3)** |

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| **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 laboratory and field observations.** **Clarification Statement:*** **Examples of evidence can include the work of Margulis on endosymbiosis, examination of genomes, and analyses of vestigial or skeletal structures.**

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

**HS-LS4-4. Research and communicate information about key features of viruses and bacteria to explain their ability to adapt and reproduce in a wide variety of environments.****Clarification Statement:*** **Key features include high rate of mutations and the speed of reproduction which produces many generations with high variability in a short time, allowing for rapid adaptation.**

**State Assessment Boundary:** * **Specific types of viral reproduction (e.g., lytic and lysogenic) are not expected in state assessment.**

**HS-LS4-5. Evaluate models that demonstrate how changes in an environment may result in the evolution of a population of a given species, the emergence of new species over generations, or the extinction of other species due to the processes of genetic drift, gene flow, mutation, and natural selection.** **[Note: HS-LS4-6 from NGSS is not included.]** |
| The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*: |
| **Science and Engineering Practices****Constructing Explanations and Designing Solutions*** Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students’ own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (HS-LS4-2)

**Engaging in Argument from Evidence*** Evaluate the evidence behind currently accepted explanations or solutions to determine the merits of arguments. (HS-LS4-5)

**Obtaining, Evaluating, and Communicating Information*** Communicate scientific information (e.g., about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically). (HS-LS4-1), (HS-LS-4)
 | **Disciplinary Core Ideas****LS4.A: Evidence of Common Ancestry and Diversity*** Genetic information provides evidence of evolution. DNA sequences vary among species, but there are many overlaps; in fact, the ongoing branching that produces multiple lines of descent can be inferred by comparing the DNA sequences of different organisms. Such information is also derivable from the similarities and differences in amino acid sequences and from anatomical and embryological evidence. (HS-LS4-1)

**LS4.B: Natural Selection*** Natural selection occurs only if there is both (1) variation in the genetic information between organisms in a population and (2) variation in the expression of that genetic information—that is, trait variation—that leads to differences in performance among individuals. (HS-LS4-2)
* The traits that positively affect survival are more likely to be reproduced, and thus are more common in the population. (HS-LS4-2), *(secondary to HS-LS3-4(MA))*

**LS4.C: Adaptation*** Evolution is a consequence of the interaction of four factors: (1) the potential for a species to increase in number, (2) the genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for an environment’s limited supply of the resources that individuals need in order to survive and reproduce, and (4) the ensuing proliferation of those organisms that are better able to survive and reproduce in that environment. (HS-LS4-2)
* Natural selection leads to adaptation, that is, to a population dominated by organisms that are anatomically, behaviorally, and physiologically well suited to survive and reproduce in a specific environment. That is, the differential survival and reproduction of organisms in a population that have an advantageous heritable trait leads to an increase in the proportion of individuals in future generations that have the trait and to a decrease in the proportion of individuals that do not. (HS-LS4-2), *(secondary to HS-LS4-4)*, (HS-LS4-5)
* Adaptation also means that the distribution of traits in a population can change when conditions change. (HS-LS4-2), (HS-LS4-5)
* Changes in the physical environment, whether naturally occurring or human induced, have thus contributed to the expansion of some species, the emergence of new distinct species as populations diverge under different conditions, and the decline–and sometimes the extinction–of some species. (HS-LS4-5)
* Species become extinct because they can no longer survive and reproduce in their altered environment. If members cannot adjust to change that is too fast or drastic, the opportunity for the species’ evolution is lost. (HS-LS4-5)
* Bacteria reproduce quickly and with a high rate of mutation, equipping the bacterial population with genetic diversity and allowing for rapid adaptation. (HS-LS4-4)
* Viruses use host cells to reproduce quickly and with a high rate of mutation equipping the viral population with genetic diversity and allowing for rapid adaptation. (HS-LS4-4)
 |
| *ELA/Literacy –* **WCA.9-10.7** Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation**. (HS-LS4-4)****WCA .9-10.2** Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. **(HS-LS4-1),(HS-LS4-2),(HS-LS4-3),(HS-LS4-4)****WCA.9-10.5** Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience*.* **(HS-LS4-6)****WCA.9-10.9** Draw evidence from informational texts to support analysis, interpretation, reflection, and research**(HS-LS4-1),(HS-LS4-2),(HS-LS4-3),(HS-LS4-4),(HS-LS4-5)****SLCA.9-10.4** Present information, findings, and supporting evidence clearly, concisely, and logically such that listeners can follow the line of reasoning and the organization, development, vocabulary, substance and style appropriate to purpose, audience, and task. **(◊HS-LS4-1), (HS-LS4-2)***Mathematics –***7. RP.A** Analyze proportional relationships and use them to solve real-world and mathematical problems. (**HS-LS4-2), (HS-LS4-4)** |

High School: Chemistry

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| **PS1. Matter and Its Interactions** |
| **HS-PS1-1. Use the periodic table as a model to predict the relative properties of main group elements, including ionization energy and relative sizes of atoms and ions, based on the patterns of electrons in the outermost energy level of each element. Use the patterns of valence electron configurations, core charge, and Coulomb’s law to explain and predict general trends in ionization energies, relative sizes of atoms and ions, and reactivity of pure elements.** **Clarification Statement:** * **Size of ions should be relevant only for predicting strength of ionic bonding.**

**State Assessment Boundary:** * **State assessment will be limited to main group (s and p block) elements.**

**HS-PS1-2. Use the periodic table model to predict and design simple reactions that result in two main classes of binary compounds, ionic and molecular. Develop an explanation based on given observational data and the electronegativity model about the relative strengths of ionic or covalent bonds.** **Clarification Statements:** * **Simple reactions include synthesis (combination), decomposition, single displacement, double displacement, and combustion.**
* **Predictions of reactants and products can be represented using Lewis dot structures, chemical formulas, or physical models.**
* **Observational data include that binary ionic substances (i.e., substances that have ionic bonds), when pure, are crystalline salts at room temperature (common examples include NaCl, KI, Fe2O3); and substances that are liquids and gases at room temperature are usually made of molecules that have covalent bonds (common examples include CO2, N2, CH4, H2O, C8H18).**

**HS-PS1-3. Cite evidence to relate physical properties of substances at the bulk scale to spatial arrangements, movement, and strength of electrostatic forces among ions, small molecules, or regions of large molecules in the substances. Make arguments to account for how compositional and structural differences in molecules result in different types of intermolecular or intramolecular interactions.** **Clarification Statements:** * **Substances include both pure substances in solid, liquid, gas, and networked forms (such as graphite).**
* **Examples of bulk properties of substances to compare include melting point and boiling point, density, and vapor pressure.**
* **Types of intermolecular interactions include dipole-dipole (including hydrogen bonding), ion-dipole, and dispersion forces.**

**State Assessment Boundary:** * **Calculations of vapor pressure by Raoult’s law, properties of heterogeneous mixtures, and names and bonding angles in molecular geometries are not expected in state assessment.**

**HS-PS1-4. Develop a model to illustrate the energy transferred during an exothermic or endothermic chemical reaction based on the bond energy difference between bonds broken (absorption of energy) and bonds formed (release of energy).** **Clarification Statement:** * **Examples of models may include molecular-level drawings and diagrams of reactions or graphs showing the relative energies of reactants and products.**

**State Assessment Boundary:** * **Calculations using Hess’s law are not expected in state assessment.**

**HS-PS1-5. Construct an explanation based on kinetic molecular theory for why varying conditions influence the rate of a chemical reaction or a dissolving process. Design and test ways to slow down or accelerate rates of processes (chemical reactions or dissolving) by altering various conditions.\*** **Clarification Statements:** * **Explanations should be based on three variables in collision theory: (a) quantity of collisions per unit time, (b) molecular orientation on collision, and (c) energy input needed to induce atomic rearrangements.**
* **Conditions that affect these three variables include temperature, pressure, concentrations of reactants, agitation, particle size, surface area, and addition of a catalyst.**

**State Assessment Boundary:** * **State assessment will be limited to simple reactions in which there are only two reactants and to specifying the change in only one variable at a time.**

**HS-PS1-6. Design ways to control the extent of a reaction at equilibrium (relative amount of products to reactants) by altering various conditions using Le Chatelier’s principle. Make arguments based on kinetic molecular theory to account for how altering conditions would affect the forward and reverse rates of the reaction until a new equilibrium is established.\*** **Clarification Statements:** * **Conditions that can be altered to affect the extent of a reaction include temperature, pressure, and concentrations of reactants.**
* **Conditions that can be altered to affect the rates of a reaction include temperature, pressure, concentrations of reactants, agitation, particle size, surface area, and addition of a catalyst.**

**State Assessment Boundaries:*** **Calculations of equilibrium constants or concentrations are not expected in state assessment.**
* **State assessment will be limited to simple reactions in which there are only two reactants and to specifying the change in only one variable at a time.**

**HS-PS1-7. Use mathematical representations and provide experimental evidence to support the claim that atoms, and therefore mass, are conserved during a chemical reaction. Use the mole concept and proportional relationships to evaluate the quantities (masses or moles) of specific reactants needed in order to obtain a specific amount of product.** **Clarification Statements:** * **Mathematical representations include balanced chemical equations that represent the laws of conservation of mass and constant composition (definite proportions), mass-to-mass stoichiometry, and calculations of percent yield.**
* **Evaluations may involve mass-to-mass stoichiometry and atom economy comparisons, but only for single-step reactions that do not involve complexes.**

**HS-PS1-9(MA). Relate the strength of an aqueous acidic or basic solution to the extent of an acid or base reacting with water as measured by the hydronium ion concentration (pH) of the solution. Make arguments about the relative strengths of two acids or bases with similar structure and composition.** **Clarification Statements:** * **Reactions are limited to Arrhenius and Bronsted-Lowry acid-base reaction patterns with monoprotic acids.**
* **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, the electronegativity model of electron distribution, empirical dipole moments, and molecular geometry. Acid or base strength comparisons are limited to homologous series and should include dilution and evaporation of water.**

**HS-PS1-10(MA). Use an oxidation-reduction reaction model to predict products of reactions given the reactants, and to communicate the reaction models using a representation that shows electron transfer (redox). Use oxidation numbers to account for how electrons are redistributed in redox processes used in devices that generate electricity or systems that prevent corrosion.\*** **Clarification Statement:** * **Reactions are limited to simple oxidation-reduction reactions that do not require hydronium or hydroxide ions to balance half-reactions.**

**HS-PS1-11(MA). Design strategies to identify and separate the components of a mixture based on relevant chemical and physical properties.****Clarification Statements:** * **Emphasis is on compositional and structural features of components of the mixture.**
* **Strategies can include chromatography, distillation, centrifuging, and precipitation reactions.**
* **Relevant chemical and physical properties can include melting point, boiling point, conductivity, and density.**

**[Note: HS-PS1-8 is found in Introductory Physics.]** |
| The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*: |
| **Science and Engineering Practices****Developing and Using Models*** Develop a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-PS1-4)
* Use a model to predict the relationships between systems or between components of a system. (HS-PS1-1), (HS-PS1-2), (HS-PS1-10(MA))

**Engaging in Argument from Evidence*** Construct an argument based on evidence. (HS-PS1-3), (HS-PS1-6), (HS-PS1-9(MA))

**Using Mathematics and Computational Thinking*** Use mathematical representations of phenomena to support claims. (HS-PS1-7)

**Constructing Explanations and Designing Solutions*** Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students’ own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (HS-PS1-5)
* Apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena and solve design problems, taking into account unanticipated effects. (HS-PS1-6), (HS-PS1-11(MA))

**Planning and Carrying Out Investigations*** Plan an investigation individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems. Consider possible confounding variables or effects and evaluate the investigation’s design to ensure variables are controlled. (HS-PS1-5)
 | **Disciplinary Core Ideas****PS1.A: Structure and Properties of Matter*** Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons. (HS-PS1-1)
* The periodic table orders elements horizontally by the number of protons in the atom’s nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states. (HS-PS1-1), (HS-PS1-2)
* The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms. (HS-PS1-3), *(Note: This Disciplinary Core Idea is also secondary to HS-PS2-6)*
* Stable forms of matter are those in which the electric and magnetic field energy is minimized. A stable molecule has less energy than the same set of atoms separated; one must provide at least this energy in order to take the molecule apart. (HS-PS1-4)
* Heterogeneous and homogeneous mixtures can be separated into their components using a variety of methods. (HS-PS1-11(MA))

**PS1.B: Chemical Reactions*** Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy. (HS-PS1-4), (HS-PS1-5), *(secondary to HS-PS1-6)*
* In many situations, a dynamic and condition-dependent balance between a reaction and the reverse reaction determines the numbers of all types of molecules present. (HS-PS1-6)
* The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions. (HS-PS1-2), (HS-PS1-7)
* Aqueous acid or base solutions have useful and harmful properties that depend on the molecular characteristics of the acid or base and the concentration of the solution. Acid-base reactions in aqueous solutions can be explained using the Arrhenius and Bronsted-Lowry models. (HS-PS1-9(MA))
* In oxidation-reduction reactions, the movement of electrons can be tracked through the rearrangement of molecules to identify the reducing and oxidizing agents. The transfer of electrons in redox reactions allows for energy transfer that can be useful (e.g., in cellular respiration, batteries). (HS-PS1-10(MA))
* The patterns in the periodic table can be used to predict the products of a chemical reaction and the relative strength of the bonds between atoms. (HS-PS1-2)

**PS2.B: Types of Interactions*** Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects. *(secondary to HS-PS1-1), (secondary to HS-PS1-3),* (Note: This Disciplinary Core Idea is also addressed by HS-PS2-6)
* The dissolving process depends on intermolecular forces; such as dipole-dipole (including hydrogen bonding), ion-dipole, and dispersion; of the solvent and the solute, as well as factors contributing to the kinetic energy of the solution. (HS-PS1-5), (Note: This Disciplinary Core Idea is also addressed by HS-PS2-7(MA))
* Kinetic molecular theory can be used to predict and explain interactions between molecules in solids, liquids and gases. *(secondary to HS-PS1-5), (secondary to HS-PS1-6),* (Note: This Disciplinary Core Idea is also addressed by HS-PS2-8(MA))

**ETS1.C: Optimizing the Design Solution*** Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed. *(secondary to HS-PS1-6), (Note: This Disciplinary Core Idea is also secondary to HS-PS2-3)*
 |
| *ELA/Literacy –***◊WCA.9-10.1** Write arguments focused on *discipline-specific content*. **(◊HS-PS1-3), (◊HS-PS1-11(MA))****RCA-ST.9-10.3** Follow precisely a complex multi-step procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text. **(HS-PS1-6), (HS-PS1-9(MA)),****RCA-ST.9-10.7** Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words. **(HS-PS1-1), (HS-PS1-2), (HS-PS1-4), (HS-PS1-7), (HS-PS1-10(MA))***Mathematics –*  **◊A-CED.A.2** Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. **(HS-PS1-1), (◊HS-PS1-7)****◊A-CED.B.3** Solve linear equations and inequalities in one variable, and give examples showing how extraneous solutions may arise. **(◊HS-PS1-7)****N-Q.A.1** [Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.](http://www.corestandards.org/Math/Content/HSN/Q) **(HS-PS1-2),(HS-PS1-3),(HS-PS1-4),(HS-PS1-5),(HS-PS1-7),(HS-PS1-8)****N-Q.A.2** [Define appropriate quantities for the purpose of descriptive modeling.](http://www.corestandards.org/Math/Content/HSN/Q) **(HS-PS1-4),(HS-PS1-7),(HS-PS1-8)****N-Q.A.3** [Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.](http://www.corestandards.org/Math/Content/HSN/Q) **(HS-PS1-2),(HS-PS1-3),(HS-PS1-4),(HS-PS1-5),(HS-PS1-7),(HS-PS1-8)** |

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| **PS2. Motion and Stability: Forces and Interactions** |
| **HS-PS2-6. Communicate scientific and technical information about the molecular-level structures of polymers, ionic compounds, acids and bases, and metals to justify why these are useful in the functioning of designed materials.\*** **Clarification Statement:** * **Examples could include comparing molecules with simple molecular geometries; analyzing how pharmaceuticals are designed to interact with specific receptors; and considering why electrically conductive materials are often made of metal, household cleaning products often contain ionic compounds to make materials soluble in water, or materials that need to be flexible but durable are made up of polymers.**

**State Assessment Boundary:** * **State assessment will be limited to comparing substances of the same type with one compositional or structural feature different.**

**HS-PS2-7(MA). Construct a model to explain how ions dissolve in polar solvents (particularly water). Analyze and compare solubility and conductivity data to determine the extent to which different ionic species dissolve.** **Clarification Statement:** * **Data for comparison should include different concentrations of solutions with the same ionic species, and similar ionic species dissolved in the same amount of water.**

**HS-PS2-8(MA). Use kinetic molecular theory to compare the strengths of electrostatic forces and the prevalence of interactions that occur between molecules in solids, liquids, and gases. Use the combined gas law to determine changes in pressure, volume, and temperature in gases.****[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.]** |
| The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*: |
| **Science and Engineering Practices****Obtaining, Evaluating, and Communicating Information*** Communicate scientific and technical information (e.g. about the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically). (HS-PS2-6)

**Developing and Using Models*** Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems. (HS-PS2-7(MA))

**Constructing Explanations and Designing Solutions*** Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables. (HS-PS2-8(MA))

**Using Mathematics and Computational Thinking*** Apply techniques of algebra and functions to represent and solve scientific and engineering problems. (HS-PS2-8(MA))
 | **Disciplinary Core Ideas****PS1.A: Structure and Properties of Matter*** The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms. *(secondary to HS-PS2-6),* (Note: This Disciplinary Core Idea is also addressed by HS-PS1-3)

**PS2.B: Types of Interactions*** Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects. (HS-PS2-6), *(Note: This Disciplinary Core Idea is also secondary to HS-PS1-1 and HS-PS1-3)*
* The dissolving process depends on the intermolecular forces; such as dipole-dipole (including hydrogen bonding), ion-dipole, and dispersion; of the solvent and the solute, as well as factors contributing to the kinetic energy of the solution. (HS-PS2-7(MA)), (Note: This Disciplinary Core Idea is also addressed by HS-PS1-5)
* Kinetic molecular theory can be used to predict and explain interactions between molecules in solids, liquids and gases. (HS-PS2-8(MA)), *(Note: This Disciplinary Core Idea is secondary to HS-PS1-5 and HS-PS1-6)*
* The combined gas law relationships contribute to interactions between molecules in gases; changes in pressure, volume, and temperature in gases can be predicted using mathematical models. (HS-PS2-8(MA))
 |
| *ELA/Literacy –***RCA.ST.9-10.1** Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions. **(HS-PS2-6)****RCA.ST.11-12.1** Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. **(HS-PS2-6)****SLCA.9-10.4**Present information, findings, and supporting evidence clearly, concisely, and logically such that listeners can follow the line of reasoning and the organization, development, vocabulary, substance, and style are appropriate to purpose, audience, and task. **(HS-PS2-6), (HS-PS2-8(MA))***Mathematics –*[**N-Q.A.1**](http://www.corestandards.org/Math/Content/HSN/Q)[Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.](http://www.corestandards.org/Math/Content/HSN/Q) **(HS-PS2-6)**[**N-Q.A.2**](http://www.corestandards.org/Math/Content/HSN/Q)[Define appropriate quantities for the purpose of descriptive modeling.](http://www.corestandards.org/Math/Content/HSN/Q) **(HS-PS2-6)**[**N-.A.3**](http://www.corestandards.org/Math/Content/HSN/Q)[Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.](http://www.corestandards.org/Math/Content/HSN/Q) **(HS-PS2-6)****◊A-CED.A.2** Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. **(◊HS-PS2-8(MA))****◊A-CED.A.4** Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. For example, rearrange Ohm’s law V=IR to highlight resistance R. **(◊HS-PS2-8(MA))****◊A-REI.B.3** Solve linear equations and inequalities in one variable involving absolute value. **(◊HS-PS2-8(MA))** |

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| **PS3. Energy**  |
| **HS-PS3-4b. Provide evidence from informational text or available data to illustrate that the transfer of energy during a chemical reaction in a closed system involves changes in energy dispersal (entropy change) and heat content (enthalpy change) while assuming the overall energy in the system is conserved.** **State Assessment Boundary:** * **Calculations involving Gibbs free energy are not expected in state assessment.**

**[Note: HS-PS3-1, HS-PS3-2, HS-PS3-3, HS-PS3-4a, and HS-PS3-5 are found in Introductory Physics.]** |
| The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*: |
| **Science and Engineering Practices****Engaging in Argument from Evidence*** Construct, use, and/or present an oral and written argument or counter-arguments based on data and evidence. (HS-PS1-4b)
 | **Disciplinary Core Ideas****PS3.B: Conservation of Energy and Energy Transfer*** Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. (HS-PS3-4b), (Note: This Disciplinary Core Idea is also addressed by HS-PS3-1 and HS-PS3-4a in Introductory Physics)
* Uncontrolled systems always evolve toward more stable states—that is, toward more uniform energy distribution (e.g., water flows downhill, objects hotter than their surrounding environment cool down). (HS-PS3-4b), (Note: This Disciplinary Core Idea is also addressed by HS-PS3-4a in Introductory Physics)
* Changes in enthalpy can be observed through temperature changes and phase changes. Within a phase, enthalpy can be modeled mathematically with changes in temperature. (HS-PS3-4b), (Note: This Disciplinary Core Idea is also addressed by HS-PS3-4a in Introductory Physics)

**PS3.D: Energy in Chemical Processes and Everyday Life*** Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment. (HS-PS3-4b), (Note: This Disciplinary Core Idea is also addressed by HS-PS3-3 in Introductory Physics)
 |
| *ELA/Literacy –* **◊WCA.9-10.9** Draw evidence from informational texts to support analysis, reflection, and research. **(◊HS-PS3-4b)***Mathematics –***6.NS.C.5** Understand that positive and negative numbers are used together to describe quantities having opposite directions or values (e.g. temperature above/below zero, elevation above/below sea level, credits/debits, positive/negative electric charge); use positive and negative numbers to represent quantities in real-world contexts, explaining the meaning of 0 in each situation. **(HS-PS3-4b)** |

High School: Introductory Physics

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| **PS1. Matter and its Interactions** |
| **HS-PS1-8. Develop a model to illustrate the energy released or absorbed during the processes of fission, fusion, and radioactive decay.** **Clarification Statements:** * **Examples of models include simple qualitative models, such as pictures or diagrams.**
* **Types of radioactive decay include alpha, beta, and gamma.**

**State Assessment Boundary:** * **Quantitative calculations of energy released or absorbed are not expected in state assessment.**

**[Note: HS-PS1-1, HS-PS1-2, HS-PS1-3, HS-PS1-4, HS-PS1-5, HS-PS1-6, HS-PS1-7, HS-PS1-9(MA), HS-PS1-10(MA), and HS-PS1-11(MA) are found in Chemistry.]** |
| The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*: |
| **Science and Engineering Practices****Developing and Using Models*** Develop and use a model based on evidence to illustrate the relationships between components of a system (HS-PS1-8)
 | **Disciplinary Core Ideas****PS1.C: Nuclear Processes*** Nuclear processes, including fusion, fission, and radioactive decays of unstable nuclei, involve release or absorption of energy. The total number of neutrons plus protons does not change in any nuclear process. (HS-PS1-8)
 |
| *ELA/Literacy-***RCA-ST.9-10.7** Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words. **(HS-PS1-8)****SLCA.9-10.4** Present information, findings, and supporting evidence clearly, concisely, and logically such that listeners can follow the line of reasoning and the organization, development, vocabulary, substance, and style are appropriate to purpose, audience, and task. **(HS-PS1-8)***Mathematics –* **F-LE.A.1b** Distinguish between situations that can be modeled with linear functions and with exponential functions: Recognize situations in which one quantity changes at a constant rate per unit interval relative to another. **(HS-PS1-8)****◊F-LE.A.1c** Recognize situations in which a quantity grows or decays by a constant percent rate per unit interval relative to another. **(HS-PS1-8)****S-ID.A.1** [Represent data with plots on the real number line (dot plots, histograms, and box plots).](http://www.corestandards.org/Math/Content/HSS/ID)  **(HS-PS1-8)** |

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| **PS2. Motion and Stability: Forces and Interactions** |
| **HS-PS2-1. Analyze data to support the claim that Newton’s second law of motion is a mathematical model describing change in motion (the acceleration) of objects when acted on by a net force.** **Clarification Statements:** * **Examples of data could include tables or graphs of position or velocity as a function of time for objects subject to a net unbalanced force, such as a falling object, an object rolling down a ramp, and a moving object being pulled by a constant force.**
* **Forces can include contact forces, including friction, and forces acting at a distance, such as gravity and magnetic forces.**

**State Assessment Boundary:** * **Variable forces are not expected in state assessment.**

**HS-PS2-2. Use mathematical representations to show that the total momentum of a system of interacting objects is conserved when there is no net force on the system.** **Clarification Statement:** * **Emphasis is on the qualitative meaning of the conservation of momentum and the quantitative understanding of the conservation of linear momentum in interactions involving elastic and inelastic collisions between two objects in one dimension.**

**HS-PS2-3. Apply scientific principles of motion and momentum to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.\*** **Clarification Statement:** * **Both qualitative evaluations and algebraic manipulations may be used.**

**HS-PS2-4. Use mathematical representations of Newton’s law of gravitation and Coulomb’s law to both qualitatively and quantitatively describe and predict the effects of gravitational and electrostatic forces between objects.** **Clarification Statement:** * **Emphasis is on the relative changes when distance, mass or charge, or both are changed.**

**State Assessment Boundaries:** * **State assessment will be limited to systems with two objects.**
* **Permittivity of free space is not expected in state assessment.**

**HS-PS2-5. Provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current.** **Clarification Statement:** * **Examples of evidence can include movement of a magnetic compass when placed in the vicinity of a current-carrying wire, and a magnet passing through a coil that turns on the light of a Faraday flashlight.**

**State Assessment Boundary:** * **Explanations of motors or generators are not expected in state assessment.**

**HS-PS2-9(MA). Evaluate simple series and parallel circuits to predict changes to voltage, current, or resistance when simple changes are made to a circuit.** **Clarification Statements:** * **Predictions of changes can be represented numerically, graphically, or algebraically using Ohm’s law.**
* **Simple changes to a circuit may include adding a component, changing the resistance of a load, and adding a parallel path, in circuits with batteries and common loads.**
* **Simple circuits can be represented in schematic diagrams.**

**State Assessment Boundary:** * **Use of measurement devices and predictions of changes in power are not expected in state assessment.**

**HS-PS2-10(MA). Use free-body force diagrams, algebraic expressions, and Newton’s laws of motion to predict changes to velocity and acceleration for an object moving in one dimension in various situations.** **Clarification Statements:** * **Predictions of changes in motion can be made numerically, graphically, and algebraically using basic equations for velocity, constant acceleration, and Newton’s first and second laws.**
* **Forces can include contact forces, including friction, and forces acting at a distance, such as gravity and magnetic forces.**

 **[Note: HS-PS2-6, HS-PS2-7(MA), and HS-PS2-8(MA) are found in Chemistry.]** |
| The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*: |
| **Science and Engineering Practices****Analyzing and Interpreting Data*** Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. (HS-PS2-1)

**Using Mathematics and Computational Thinking*** Use mathematical representations of phenomena to describe explanations. (HS-PS2-2),(HS-PS2-4)
* Apply techniques of algebra and functions to represent and solve scientific and engineering problems. (HS-PS2-10)

**Constructing Explanations and Designing Solutions*** Apply scientific ideas to solve a design problem, taking into account possible unanticipated effects. (HS-PS2-3)

**Engaging in Argument from Evidence*** Construct, use, and/or present an oral and written argument or counter-arguments based on data and evidence. (HS-PS2-5)

**Planning and Carrying Out Investigations*** Select appropriate tools to collect, record, analyze, and evaluate data. (HS-PS2-10)
 | **Disciplinary Core Ideas****PS2.A: Forces and Motion*** Newton’s second law accurately predicts changes in the motion of macroscopic objects. (HS-PS2-1), (HS-PS2-10(MA))
* Momentum is defined for a particular frame of reference; it is the mass times the velocity of the object. In any system, total momentum is always conserved. (HS-PS2-2)
* If a system interacts with objects outside itself, the total momentum of the system can change; however, any such change is balanced by changes in the momentum of objects outside the system. (HS-PS2-2), (HS-PS2-3)
* Forces acting on an object can be modeled using free body force diagrams; these diagrams can be used to predict changes in motion for the object. (HS-PS2-1), (HS-PS2-10(MA))

**PS2.B: Types of Interactions*** Newton’s law of universal gravitation and Coulomb’s law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects. (HS-PS2-4)
* Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields. (HS-PS2-4), (HS-PS2-5)
* The relationship between current, voltage, and resistance can be represented using mathematical models related to Ohm’s law. (HS-PS2-9(MA))
* Schematic models of circuits are used to show an authentic circuit in a simplified form, which is useful when analyzing circuits or predicting changes to current, voltage, or resistance when a simple change is made to the circuit. (HS-PS2-9(MA))

**PS3.A: Definitions of Energy*** “Electrical energy” may mean energy stored in a battery or energy transmitted by electrical currents. *(secondary to HS-PS2-5), (secondary to HS-PS2-9(MA))*

**ETS1.A: Defining and Delimiting an Engineering Problem*** Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. *(secondary to HS-PS2-3), (Note: This Disciplinary Core Idea is also secondary to HS-PS3-3)*

**ETS1.C: Optimizing the Design Solution*** Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed. *(secondary to HS-PS2-3),* *(Note: This Disciplinary Core Idea is also secondary to HS-PS1-6)*
 |
| *ELA/Literacy-***SLCA.9-10.4** Present information, findings, and supporting evidence clearly, concisely, and logically such that listeners can follow the line of reasoning and the organization, development, vocabulary, substance, and style are appropriate to purpose, audience, and task. **(HS-PS2-2), (HS-PS2-4)****WCA.9-10.2** Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes. **(HS-PS2-1), (HS-PS2-5), (HS-PS2-9)***Mathematics* ***–*** **N-Q.A.** [Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.](http://www.corestandards.org/Math/Content/HSN/Q)**(HS-PS2-1), (HS-PS2-6)****N-Q.A.2** [Define appropriate quantities for the purpose of descriptive modeling.](http://www.corestandards.org/Math/Content/HSN/Q)  **(HS-PS2-1),(HS-PS2-2),(HS-PS2-4)** [**N-Q.A.3**](http://www.corestandards.org/Math/Content/HSN/Q)[Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.](http://www.corestandards.org/Math/Content/HSN/Q)  **(HS-PS2-1), (HS-PS2-6)** **◊N-VM.A.1** Recognize vector quantities as having both magnitude and direction. Represent vector quantities by directed line segments, and use appropriate symbols for vectors and their magnitudes**. (◊HS-PS2-10)****◊N-VM.A.3** Solve problems involving velocity and other quantities that can be represented by vectors**. (◊HS-PS2-10)****◊A-REI.B.3** Solve linear equations and inequalities in one variable involving absolute value. **(◊HS-PS2-9), (HS-PS2-1)**[**A-SSE.A.1**](http://www.corestandards.org/Math/Content/HSA/SSE)Interpret expressions that represent a quantity in terms of its context**. (HS-PS2-1),(HS-PS2-2),(HS-PS2-4)**[**A-SSE.B.3**](http://www.corestandards.org/Math/Content/HSA/SSE)[Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression**.**](http://www.corestandards.org/Math/Content/HSA/SSE) **(HS-PS2-1)****A-CED.A.1** [Create equations and inequalities in one variable and use them to solve problems.](http://www.corestandards.org/Math/Content/HSA/CED)**(HS-PS2-1)****A-CED.A.2** [Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales.](http://www.corestandards.org/Math/Content/HSA/CED)**(HS-PS2-1)****A-CED.A.4** [Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations.](http://www.corestandards.org/Math/Content/HSA/CED)**(◊HS-PS2-1), (◊HS-PS2-9), (HS-PS2-4)**[**F-IF.C.7**](http://www.corestandards.org/Math/Content/HSF/IF)Graph functions expressed symbolically and show key features of the graph, by in hand in simple cases and using technology for more complicated cases. **(HS-PS2-1)****F-LE.A.1b** Distinguish between situations that can be modeled with linear functions and with exponential functions: Recognize situations in which one quantity changes at a constant rate per unit interval relative to another. **(◊HS-PS2-1),(HS-PS2-2), (HS-PS2-3), (HS-PS2-4), (HS-PS2-9), (HS-PS2-10)****◊F-LE.A.1c** Recognize situations in which a quantity grows or decays by a constant percent rate per unit interval relative to another. **(◊HS-PS2-1)****S-ID.A.1** [Represent data with plots on the real number line (dot plots, histograms, and box plots).](http://www.corestandards.org/Math/Content/HSS/ID) **(HS-PS2-1)** |

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| **PS3. Energy**  |
| **HS-PS3-1. Use algebraic expressions and the principle of energy conservation to calculate the change in energy of one component of a system when the change in energy of the other component(s) of the system, as well as the total energy of the system including any energy entering or leaving the system, is known. Identify any transformations from one form of energy to another, including thermal, kinetic, gravitational, magnetic, or electrical energy, in the system.** **Clarification Statement:** * **Systems should be limited to two or three components and to thermal energy; kinetic energy; or the energies in gravitational, magnetic, or electric fields.**

**HS-PS3-2. Develop and use a model to illustrate that energy at the macroscopic scale can be accounted for as either motions of particles and objects or energy stored in fields.** **Clarification Statements:** * **Examples of phenomena at the macroscopic scale could include evaporation and condensation, the conversion of kinetic energy to thermal energy, the gravitational potential energy stored due to position of an object above the earth, and the stored energy (electrical potential) of a charged object’s position within an electrical field.**
* **Examples of models could include diagrams, drawings, descriptions, and computer simulations.**

**HS-PS3-3. Design and evaluate a device that works within given constraints to convert one form of energy into another form of energy.\*** **Clarification Statements:** * **Emphasis is on both qualitative and quantitative evaluations of devices.**
* **Examples of devices could include Rube Goldberg devices, wind turbines, solar cells, solar ovens, and generators.**
* **Examples of constraints could include use of renewable energy forms and efficiency.**

**State Assessment Boundary:** * **Quantitative evaluations will be limited to total output for a given input in state assessment.**

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

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

**[Note: HS-PS3-4b is found in Chemistry.]**  |
| The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*: |
| **Science and Engineering Practices****Developing and Using Models*** Develop and use a model based on evidenceto illustrate the relationships between systems or between components of a system. (HS-PS3-2), (HS-PS3-5)

**Using Mathematics and Computational Thinking*** Apply techniques of algebra and functions to represent and solve scientific and engineering problems. (HS-PS3-1)

**Constructing Explanations and Designing Solutions*** Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-PS3-3)
 | **Disciplinary Core Ideas****PS3.A: Definitions of Energy*** Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system’s total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms. (HS-PS3-1),(HS-PS3-2)
* At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. *(secondary to HS-PS3-1)* (HS-PS3-2) (HS-PS3-3)
* These relationships are better understood at the microscopic scale, at which all of the different manifestations of energy can be modeled as either motions of particles or energy stored in fields (which mediate interactions between particles). (HS-PS3-2)

**PS3.B: Conservation of Energy and Energy Transfer*** Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system. (HS-PS3-1)
* Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. (HS-PS3-1), (HS-PS3-4a), (Note: This Disciplinary Core Idea is also addressed by HS-PS3-4b in Chemistry)
* Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g. relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior. (HS-PS3-1)
* The availability of energy limits what can occur in any system. (HS-PS3-1)
* Uncontrolled systems always evolve toward more stable states—that is, toward more uniform energy distribution (e.g., water flows downhill, objects hotter than their surrounding environment cool down). (HS-PS3-4a)
* Changes in enthalpy can be observed through temperature changes and phase changes. Within a phase, enthalpy can be modeled mathematically with changes in temperature. (HS-PS3-4a), (Note: This Disciplinary Core Idea is also addressed by HS-PS3-4b in Chemistry)

**PS3.C: Relationship Between Energy and Forces*** When two objects interacting through a field change relative position, the energy stored in the field is changed. (HS-PS3-5)

**PS3.D: Energy in Chemical Processes and Everyday Life*** Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment. (HS-PS3-3), (Note: This Disciplinary Core Idea is also addressed by HS-PS3-4b in Chemistry)

**ETS1.A: Defining and Delimiting an Engineering Problem*** Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. *(secondary to HS-PS3-3), (Note: This Disciplinary Core Idea is also secondary to HS-PS2-3)*
 |
| *ELA/Literacy-***SLCA.9-10.4** Present information, findings, and supporting evidence clearly, concisely, and logically such that listeners can follow the line of reasoning and the organization, development, vocabulary, substance, and style are appropriate to purpose, audience, and task. **(HS-PS3-2), (HS-PS3-5)****WCA.9-10.2**  Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes**. (HS-PS3-4a), (HS-PS3-3)***Mathematics –* **◊8.EE.A.2** Use square root and cube root symbols to represent solutions to equations of the form $x^{2}=p$ and $x^{3}=p$, where p is a positive rational number. Evaluate square roots of small perfect squares and cube roots of small perfect cubes. Know that $√2$ is a rational number. **(◊HS-PS3-1)****◊A-CED.A.2** Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. **(◊HS-PS3-2)****◊A-CED.A.4** Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. **(◊HS-PS3-2), (◊HS-PS3-4a)****◊A-REI.B.3** Solve linear equations and inequalities in one variable involving absolute value. **(◊HS-PS3-2), (◊HS-PS3-4a)****N-Q.A.1** Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. **(HS-PS2-1),(HS-PS2-2),(HS-PS2-4)** |

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| **PS4. Waves and Their Applications in Technologies for Information Transfer** |
| **HS-PS4-1. Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling within various media. Recognize that electromagnetic waves can travel through empty space (without a medium) as compared to mechanical waves that require a medium.** **Clarification Statements:** * **Emphasis is on relationships when waves travel within a medium, and comparisons when a wave travels in different media.**
* **Examples of situations to consider could include electromagnetic radiation traveling in a vacuum and glass, sound waves traveling through air and water, and seismic waves traveling through the Earth.**
* **Relationships include *v =* λ*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.**

**HS-PS4-3. Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described by either a wave model or a particle model, and that for some situations involving resonance, interference, diffraction, refraction, or the photoelectric effect, one model is more useful than the other.** **Clarification Statement:** * **Emphasis is on qualitative reasoning and comparisons of the two models.**

**State Assessment Boundary:** * **Calculations of energy levels or resonant frequencies are not expected in state assessment.**

**HS-PS4-5. Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.\*** **Clarification Statements:** * **Emphasis is on qualitative information and descriptions.**
* **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 and wave interactions with matter include resonance, photoelectric effect, refraction, and constructive and destructive interference.**

**State Assessment Boundary:** * **Band theory is not expected in state assessment.**

**[Note: HS-PS4-2 and HS-PS4-4 from NGSS are not included.]** |
| The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*: |
| **Science and Engineering Practices****Using Mathematics and Computational Thinking*** Use mathematical representations of phenomena or design solutions to describe and/or support claims and/or explanations. (HS-PS4-1)

**Engaging in Argument from Evidence*** Evaluate the claims, evidence, and reasoning behind currently accepted explanations or solutions to determine the merits of arguments. (HS-PS4-3)

**Obtaining, Evaluating, and Communicating Information*** Communicate technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically). (HS-PS4-5)
 | **Disciplinary Core Ideas****PS3.D: Energy in Chemical Processes*** Solar cells are human-made devices that likewise capture the sun’s energy and produce electrical energy. *(secondary to HS-PS4-5)*

**PS4.A: Wave Properties*** The wavelength and frequency of a wave are related to one another by the speed of travel of the wave, which depends on the type of wave and the medium through which it is passing. (HS-PS4-1)
* Information can be digitized (e.g., a picture stored as the values of an array of pixels); in this form, it can be stored reliably in computer memory and sent over long distances as a series of wave pulses. (HS-PS4-5)
* [From the 3–5 grade band endpoints] Waves can add or cancel one another as they cross, depending on their relative phase (i.e., relative position of peaks and troughs of the waves), but they emerge unaffected by each other. (Boundary: The discussion at this grade level is qualitative only; it can be based on the fact that two different sounds can pass a location in different directions without getting mixed up.) (HS-PS4-3)

**PS4.B: Electromagnetic Radiation*** *(Moved from middle school.)* The path that light travels can be traced as straight lines, except at surfaces between different transparent materials (e.g., air and water, air and glass) where the light path bends. *(secondary to HS-PS4-5)*, (Note: This Disciplinary Core Idea is also addressed by 6.MS-PS4-2)
* Electromagnetic radiation (e.g., radio, microwaves, light) can be modeled as a wave of changing electric and magnetic fields or as particles called photons. The wave model is useful for explaining many features of electromagnetic radiation, and the particle model explains other features. (HS-PS4-3)
* Photoelectric materials emit electrons when they absorb light of a high-enough frequency. (HS-PS4-3), (HS-PS4-5)

**PS4.C: Information Technologies and Instrumentation*** Multiple technologies based on the understanding of waves and their interactions with matter are part of everyday experiences in the modern world (e.g., medical imaging, communications, scanners) and in scientific research. They are essential tools for producing, transmitting, and capturing signals and for storing and interpreting the information contained in them. (HS-PS4-5)
 |
| *ELA/Literacy –* **WCA.9-10.9** Draw evidence form informational texts to support analysis, interpretation, reflection, and research. **(HS-PS4-3)****WCA.9-10.2** Write informative/explanatory texts, including narration of historical events, scientific procedures/experiments, or technical processes. **(◊HS-PS4-5)****RST.11-12.1** Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. **(HS-PS4-3)****RST.9-10.8** Assess the extent to which the reasoning and evidence in a text support the author’s claim or a recommendation for solving a scientific or technical problem**. (HS-PS4-3)****RST.11-12.8** Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. **(HS-PS4-1),**  **(HS-PS4-3)***Mathematics –* **◊A-CED.A.2** Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. **(◊HS-PS4-1)****◊A-CED.A.4** Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. **(◊HS-PS4-1)****◊A-REI.B.3** Solve linear equations and inequalities in one variable involving absolute value. **(◊HS-PS4-1)****A-SSE.A.1** Interpret expressions that represent a quantity in terms of its context. **(HS-PS4-1)****A-SSE.B.3** Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression. **(HS-PS4-1)** |

High School: Technology/Engineering

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| **ETS1. Engineering Design** |
| **HS-ETS1-1. Analyze a major global challenge to specify a design problem that can be improved. Determine necessary qualitative and quantitative criteria and constraints for solutions, including any requirements set by society.\*** **Clarification Statement:** * **Examples of societal requirements can include risk mitigation, aesthetics, ethical considerations, and long-term maintenance costs.**

**HS-ETS1-2. Break a complex real-world problem into smaller, more manageable problems that each can be solved using scientific and engineering principles.\*****HS-ETS1-3. Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, aesthetics, and maintenance, as well as social, cultural, and environmental impacts.\*** **HS-ETS1-4. Use a computer simulation to model the impact of a proposed solution to a complex real-world problem that has numerous criteria and constraints on the interactions within and between systems relevant to the problem.\*** **HS-ETS1-5(MA). Plan a prototype or design solution using orthographic projections and isometric drawings, using proper scales and proportions.\*****HS-ETS1-6(MA). Document and present solutions that include specifications, performance results, successes and remaining issues, and limitations.\*** |
| The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*: |
| **Science and Engineering Practices****Asking Questions and Defining Problems*** Analyze complex real-world problems by specifying criteria and constraints for successful solutions. (HS-ETS1-1)

**Using Mathematics and Computational Thinking*** Use mathematical models and/or computer simulations to predict the effects of a design solution on systems and/or the interactions between systems. (HS-ETS1-4)

**Constructing Explanations and Designing Solutions** * Design a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-ETS1-2), (HS-ETS1-5)
* Evaluate a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-ETS1-3)

**Obtaining, Evaluating, and Communicating Information*** Communicate technical information or ideas in multiple formats (including orally, graphically, textually, and mathematically). (HS-ETS1-6(MA))
 | **Disciplinary Core Ideas****ETS1.A: Defining and Delimiting Engineering Problems*** Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. (HS-ETS1-1)
* Humanity faces major global challenges today, such as the need for supplies of clean water and food or for energy sources that minimize pollution, which can be addressed through engineering. These global challenges also may have manifestations in local communities. (HS-ETS1-1)

**ETS1.B: Developing Possible Solutions*** When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. (HS-ETS1-3), (HS-ETS1-5(MA))
* Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs. (HS-ETS1-4)
* Orthographic projections and isometric drawings, especially of prototypes, can convey technical ideas with more accuracy than descriptions. (HS-ETS1-5(MA))

**ETS1.C: Optimizing the Design Solution*** Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed. (HS-ETS1-2), (HS-ETS1-6(MA))
* When presenting solutions to stakeholders, it is important to address how the criteria, constraints, and design process influenced the final solution (HS-ETS1-6(MA))
 |
| *ELA/Literacy –* **SLCA.9-10.4** Present information, findings, and supporting evidence clearly, concisely, and logically such that listeners can follow the line of reasoning and the organization, development, vocabulary, substance and style appropriate to purpose, audience, and task. **(HS-ETS1-1), (HS-ETS1-5(MA)), (HS-ETS1-6(MA)),****RCA-ST.9-10.7** Translate quantitative or technical information expressed in words in a text into visual form (eg., table or chart) and translate information expressed visually or mathematically (e.g., in an equation into words. **(HS-ETS1-2), (HS-ETS1-5), (HS-ETS1-4)****WCA.9-10.1** Write arguments focused on *discipline-specific content*. **(HS-ETS1-3)***Mathematics –* **◊G-MG.A.1** Use geometric shapes, their measures, and their properties to describe objects (e.g. modeling a tree trunk or a human torso as a cylinder. **(◊HS-ETS1-1)****◊S-ID.C.9** Distinguish between correlation and causation. **(◊HS-ETS1-3)****◊A-CED.A.2** Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. **(◊HS-ETS1-4)****◊A-CED.A.3** Represent constraints by equations or inequalities, and by systems of equations and/or inequalities, and interpret solutions as viable or non-viable options in a modeling context. **(◊HS-ETS1-3), (◊HS-ETS1-4)****◊G-SRT.A.1** Verify experimentally the properties of dilations given by a center and scale factor: a) A dilation takes a line not passing through the center of the dilation to a parallel line, and leaves a line passing through the center unchanged. b) The dilation of a line segment is longer or shorter in the ratio given by the scale factor. **(◊HS-ETS1-5(MA))** |

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| **ETS2. Materials, Tools and Manufacturing** |
| **HS-ETS2-1(MA). Determine the best application of manufacturing processes to create parts of desired shape, size, and finish based on available resources and safety.** **Clarification Statement:** * **Examples of processes can include forming (molding of plastics, casting of metals, shaping, rolling, forging, and stamping), machining (cutting and milling), conditioning (thermal, mechanical, and chemical processes), and finishing.**

**State Assessment Boundary:** * **Specific manufacturing machines are not expected in state assessment.**

**HS-ETS2-2(MA). Explain how computers and robots can be used at different stages of a manufacturing system, typically for jobs that are repetitive, very small, or very dangerous.** **Clarification Statement:** * **Examples of stages include design, testing, production, and quality control.**

**HS-ETS2-3(MA). Compare the costs and benefits of custom versus mass production based on qualities of the desired product, the cost of each unit to produce, and the number of units needed.****HS-ETS2-4(MA). Explain how manufacturing processes transform material properties to meet a specified purpose or function. Recognize that new materials can be synthesized through chemical and physical processes that are designed to manipulate material properties to meet a desired performance condition.** **Clarification Statement:** * **Examples of material properties can include resistance to force, density, hardness, and elasticity.**
 |
| The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*: |
| **Science and Engineering Practices** **Analyzing and Interpreting Data*** Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. (HS-ETS2-4(MA))

**Constructing Explanations and Designing Solutions*** Apply scientific reasoning to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion. (HS-ETS2-2(MA)), (HS-ETS2-4(MA))

**Engaging in Argument from Evidence*** Compare and evaluate competing design solutions in light of currently accepted explanations, new evidence, limitations (e.g., trade-offs), constraints, and ethical issues. (HS-ETS2-3(MA))

**Obtaining, Evaluating, and Communicating Information*** Communicate technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically). (HS-ETS2-4(MA))
 | **Disciplinary Core Ideas****ETS2.B: Manufacturing** * Manufacturing processes can transform material properties to meet a need. Particular manufacturing processes are chosen based on the product design, materials used, precision needed, and safety. Computers can help with all of these. (HS-ETS2-1(MA)), (HS-ETS2-2(MA)), (HS-ETS2-3(MA)), (HS-ETS2-4(MA))
 |
| *ELA/Literacy –* **WCA.9-10.7**Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. **(HS-ETS2-1(MA))** **WCA.9-10.8** When conducting research, gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the usefulness of each source in answering the research question; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and following a standard format for citation. **(HS-ETS2-2(MA))****WCA.9-10.9** Draw evidence from informational texts to support analysis, interpretation, reflection, and research. **(HS-ETS2-3(MA)), (HS-ETS2-4(MA))***Mathematics –* **◊A-CED.A.2** Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. **(◊HS-ETS2-3(MA))****◊A-CED.A.3** Represent constraints by equations or inequalities, and by systems of equations and/or inequalities, and interpret solutions as viable or non-viable options in a modeling context. **(◊HS-ETS2-3(MA))****◊A-REI.B.3** Solve linear equations and inequalities in one variable involving absolute value. **(◊HS-ETS2-3(MA))** |

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| **ETS3. Technological Systems** |
| **HS-ETS3-1(MA). Model a technological system in which the output of one subsystem becomes the input to other subsystems.****HS-ETS3-2(MA). Use a model to explain how information transmitted via digital and analog signals travels through the following media: electrical wire, optical fiber, air, and space. Analyze a communication problem and determine the best mode of delivery for the communication(s).****HS-ETS3-3(MA). Explain the importance of considering both live loads and dead loads when constructing structures. Calculate the resultant force(s) for a combination of live loads and dead loads for various situations.** **Clarification Statements:** * **Examples of structures can include buildings, decks, and bridges.**
* **Examples of loads and forces include live load, dead load, total load, tension, sheer, compression, and torsion.**

**HS-ETS3-4(MA). Use a model to illustrate how the forces of tension, compression, torsion, and shear affect the performance of a structure. Analyze situations that involve these forces and justify the selection of materials for the given situation based on their properties.** **Clarification Statements:** * **Examples of structures include bridges, houses, and skyscrapers.**
* **Examples of material properties can include elasticity, plasticity, thermal conductivity, density, and resistance to force.**

**HS-ETS3-5(MA). Analyze how the design of a building is influenced by thermal conditions such as wind, solar angle, and temperature. Give examples of how conduction, convection, and radiation are considered in the selection of materials for buildings and in the design of a heating system.** **HS-ETS3-6(MA). Use informational text to illustrate how a vehicle or device can be modified to produce a change in lift, drag, friction, thrust, and weight.** **Clarification Statements:** * **Examples of vehicles can include cars, boats, airplanes, and rockets.**
* **Considerations of lift require consideration of Bernoulli’s principle.**
 |
| The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*: |
| **Science and Engineering Practices** **Developing and Using Models*** Develop a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-ETS3-1(MA)), (HS-ETS3-2(MA))
* Develop a model (including mathematical and computational) to generate data to support explanations, analyze systems, and/or solve problems. (HS-ETS3-4(MA))

**Constructing Explanations and Designing Solutions*** Apply scientific reasoning to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion. (HS-ETS3-3(MA))

**Obtaining, Evaluating, and Communicating Information*** Communicate technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically). (HS-ETS3-6(MA))
 | **Disciplinary Core Ideas****ETS3.A: Analyzing Technological Systems*** Technological systems are often composed of multiple subsystems, in which the output of one subsystem is the input of another. (HS-ETS3-1(MA))

**ETS3.B: Technological Systems Society Relies On (examples)*** Communications systems can be analog or digital and use various media. Vehicles can be modified for specific purposes and performance characteristics. Structural analysis must account for active and static loads, as well as properties of materials used in their construction. (HS-ETS3-2(MA)), (HS-ETS3-3(MA)), (HS-ETS3-4(MA)), (HS-ETS3-5(MA)), (HS-ETS3-6(MA))
 |
| *ELA/Literacy –* **RCA-ST.9-10.1** Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions. **(HS-ETS3-6(MA))****WCA.9-10.7**Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. **(HS-ETS2-1(MA))** **WCA.9-10.9** Draw evidence from informational texts to support analysis, interpretation, reflection, and research. **(HS-ETS3-6(MA)), (HS-ETS3-5(MA)), (HS-ETS3-3(MA)),****RCA-ST.9-10.7** Translate quantitative or technical information expressed in words in a text into visual form (eg., table or chart) and translate information expressed visually or mathematically (e.g., in an equation into words. **(HS-ETS3-2(MA)), (HS-ETS3-4(MA))***Mathematics –* **◊7.EE.A.3** Solve multi-step real-life and mathematical problems posed with positive and negative rational numbers in any form (whole numbers, fractions, and decimals), using tools strategically. Apply properties of operations to calculate with numbers in any form; convert between forms as appropriate; and assess the reasonableness of answers using mental computation and estimation strategies. **(◊HS-ETS3-3(MA))** |

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| **ETS4. Energy and Power Technologies** |
| **HS-ETS4-1(MA). Research and describe various ways that humans use energy and power systems to harness resources to accomplish tasks effectively and efficiently.** **Clarification Statement:** * **Examples of energy and power systems can include fluid systems such as hydraulics and pneumatics, thermal systems such as heating and cooling, and electrical systems such as electronic devices and residential wiring.**

**HS-ETS4-2(MA). Use a model to explain differences between open fluid systems and closed fluid systems. Determine when it is more or less appropriate to use one type of system instead of the other.** **Clarification Statements:** * **Examples of open systems can include irrigation, forced hot air systems, and air compressors.**
* **Examples of closed systems can include forced hot water systems and hydraulic brakes.**

**HS-ETS4-3(MA). Explain how differences and similarities between hydraulic and pneumatic systems lead to different applications of each in technologies.****HS-ETS4-4(MA). Calculate and describe the ability of a hydraulic system to multiply distance, multiply force, and effect directional change.** **Clarification Statement:** * **Emphasis is on the ratio of piston sizes (cross-sectional area) as represented in Pascal’s law.**

**HS-ETS4-5(MA). Explain how a machine converts energy, through mechanical means, to do work. Collect and analyze data to determine the efficiency of simple and complex machines.** |
| The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*: |
| **Science and Engineering Practices****Developing and Using Models*** Use a model based on evidence to explain the relationships between systems or between components of a system. (HS-ETS4-2(MA))

**Obtaining, Evaluating, and Communicating Information*** Gather information from multiple authoritative sources, assessing the evidence and usefulness of each source. (HS-ETS4-1(MA))
* Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically). (HS-ETS4-1(MA))

**Using Mathematics and Computational Thinking*** Apply techniques of algebra and functions to represent and solve scientific and engineering problems. (HS-ETS4-4(MA))

**Planning and Carrying Out Investigations*** Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems. Consider possible confounding variables or effects and evaluate the investigation’s design to ensure that variables are controlled. (HS-ETS4-5(MA))
 | **Disciplinary Core Ideas****ETS4.A: Using, Transferring, Converting Energy and Power in Technological Systems*** Most technological systems use energy and resources to accomplish desired tasks. People continually work to increase the effectiveness and efficiency of these systems. Technological systems often rely on open or closed fluid systems, particularly hydraulic systems to accomplish tasks requiring large forces (HS-ETS4-1(MA)), (HS-ETS4-5(MA))
* Technological systems often rely on open or closed fluid systems, particularly hydraulic systems to accomplish tasks requiring large forces (HS-ETS4-2(MA)), (HS-ETS4-3(MA)), (HS-ETS4-4(MA))

**ETS4.B: Thermal Systems** * Thermal processes and material properties must be considered in the design of certain technologies, particularly buildings. (HS-ETS4-1(MA)), (HS-ETS4-2(MA))

**ETS4.C: Electrical Systems*** The use of electrical circuits and electricity is critical to most technological systems in society. Electrical systems can be AC or DC, rely on a variety of key components, and are designed for specific voltage, current, and/or power. (HS-ETS4-1(MA)), (HS-ETS4-5(MA))
 |
| *ELA/Literacy –* **◊WCA.9-10.7** Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. **(◊HS-ETS4-1(MA))****RCA-ST.9-10.1** Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions. **(HS-ETS3-6(MA))****WCA.9-10.9** Draw evidence from informational texts to support analysis, interpretation, reflection, and research. **(HS-ETS4-3(MA)), (HS-ETS4-5(MA))****RCA-ST.9-10.7** Translate quantitative or technical information expressed in words in a text into visual form (eg., table or chart) and translate information expressed visually or mathematically (e.g., in an equation into words. **(HS-ETS4-2(MA))***Mathematics –* **◊A-CED.A.4** Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. **(◊HS-ETS4-4(MA))** |