High School Earth and Space Sciences

Students in high school continue to develop their understanding of the three disciplinary core ideas in the Earth and Space Sciences. The high school performance expectations in Earth and Space Science build on the middle school ideas and skills and allow high school students to explain more in-depth phenomena central not only to the earth and space sciences, but to life and physical sciences as well. These performance expectations blend the core ideas with scientific and engineering practices and crosscutting concepts to support students in developing useable knowledge to explain ideas across the science disciplines. While the performance expectations shown in high school earth and space science couple particular practices with specific disciplinary core ideas, instructional decisions should include use of many practices that lead to the performance expectations.

The performance expectations in **ESS1: Earth’s Place in the Universe**, help students formulate an answer to the question: “What is the universe, and what is Earth’s place in it?” The ESS1 Disciplinary Core Idea from the *NRC Framework* is broken down into three sub-ideas: the universe and its stars, Earth and the solar system and the history of planet Earth. Students examine the processes governing the formation, evolution, and workings of the solar system and universe. Some concepts studied are fundamental to science, such as understanding how the matter of our world formed during the Big Bang and within the cores of stars. Others concepts are practical, such as understanding how short-term changes in the behavior of our sun directly affect humans. Engineering and technology play a large role here in obtaining and analyzing the data that support the theories of the formation of the solar system and universe. The crosscutting concepts of patterns, scale, proportion, and quantity, energy and matter, and stability and change are called out as organizing concepts for these disciplinary core ideas. In the ESS1 performance expectations, students are expected to demonstrate proficiency in developing and using models, using mathematical and computational thinking, constructing explanations and designing solutions, engaging in argument, and obtaining, evaluating and communicating information; and to use these practices to demonstrate understanding of the core ideas.

The performance expectations in **ESS2: Earth’s Systems**, help students formulate an answer to the question: “How and why is Earth constantly changing?” The ESS2 Disciplinary Core Idea from the *NRC Framework* is broken down into five sub-ideas: Earth materials and systems, plate tectonics and large-scale system interactions, the roles of water in Earth’s surface processes, weather and climate, and biogeology. For the purpose of the NGSS, biogeology has been addressed within the life science standards. Students develop models and explanations for the ways that feedbacks between different Earth systems control the appearance of Earth’s surface. Central to this is the tension between internal systems, which are largely responsible for creating land at Earth’s surface, and the sun-driven surface systems that tear down the land through weathering and erosion. Students begin to examine the ways that human activities cause feedbacks that create changes to other systems. Students understand the system interactions that control weather and climate, with a major emphasis on the mechanisms and implications of climate change. Students model the flow of energy between different components of the weather system and how this affects chemical cycles such as the carbon cycle. The crosscutting concepts of cause and effect, energy and matter, structure and function and stability and change are called out as organizing concepts for these disciplinary core ideas. In the ESS2 performance expectations, students are expected to demonstrate proficiency in
developing and using models, planning and carrying out investigations, analyzing and interpreting data, and engaging in argument; and to use these practices to demonstrate understanding of the core ideas.

The performance expectations in **ESS3: Earth and Human Activity** help students formulate an answer to the question: “How do Earth’s surface processes and human activities affect each other?” The ESS3 Disciplinary Core Idea from the *NRC Framework* is broken down into four sub-ideas: natural resources, natural hazards, human impact on Earth systems, and global climate change. Students understand the complex and significant interdependencies between humans and the rest of Earth’s systems through the impacts of natural hazards, our dependencies on natural resources, and the significant environmental impacts of human activities. Engineering and technology figure prominently here, as students use mathematical thinking and the analysis of geoscience data to examine and construct solutions to the many challenges facing long-term human sustainability on Earth. The crosscutting concepts of cause and effect, systems and system models, and stability and change are called out as organizing concepts for these disciplinary core ideas. In the ESS3 performance expectations, students are expected to demonstrate proficiency in developing and using analyzing and interpreting data, mathematical and computational thinking, constructing explanations and designing solutions and engaging in argument; and to use these practices to demonstrate understanding of the core ideas.
**HS-ESS1 Earth’s Place in the Universe**

**HS-ESS1-1.** Develop a model based on evidence to illustrate the life span of the sun and the role of nuclear fusion in the sun’s core to release energy that eventually reaches Earth in the form of radiation. [Clarification Statement: Emphasis is on the energy transfer mechanisms that allow energy from nuclear fusion in the sun’s core to reach Earth. Examples of evidence for the model include observations of the masses and lifetimes of other stars, as well as the way that the sun’s radiation varies due to sudden solar flares ("space weather"), the 11-year solar cycle, and non-cyclical variations over centuries.] [Assessment Boundary: A assessment does not include details of the atomic and sub-atomic processes involved with the sun’s nuclear fusion.]

**HS-ESS1-2.** Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the universe. [Clarification Statement: Emphasis is on the astronomical evidence of the red shift of light from 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 (from the spectra of electromagnetic radiation from stars), which matches that predicted by the Big Bang theory (3/4 hydrogen and 1/4 helium).]

**HS-ESS1-3.** Explain how evidence can be abstracted and used to make claims about the way objects, organisms, or events changed over the life cycle of the universe. [Clarification Statement: Emphasis is on the way nucleosynthesis, and therefore the different elements created, varies as a function of the mass of a star and the stage of its lifetime.] [Assessment Boundary: Details of the many different nucleosynthesis pathways for stars of differing masses are not assessed.]

**HS-ESS1-4.** Use mathematical or computational representations to predict the motion of orbiting objects in the solar system. [Clarification Statement: Emphasis is on Newtonian gravitational law governing orbital motions, which apply to human-made satellites as well as planets and moons.] [Assessment Boundary: Mathematical representations for the gravitational attraction of bodies and Kepler’s Laws of orbital motions should not deal with more than two objects, nor involve calculi.]

**HS-ESS1-5.** Evaluate evidence of the past and current movements of continental and oceanic crust and the theory of plate tectonics to explain the ages of crustal rocks. [Clarification Statement: Emphasis is on the ability of plate tectonics to explain the ages of crustal rocks. Examples include evidence of the ages oceanic crust increasing with distance from mid-ocean ridges (a result of plate spreading) and the ages of North American continental crust increasing with distance from a central ancient core (a result of past plate interactions).]

**HS-ESS1-6.** Apply scientific reasoning and evidence from ancient Earth materials, meteorites, and other planetary surfaces to construct an account of Earth’s formation and early history. [Clarification Statement: Emphasis is on using available evidence within the solar system to reconstruct the early history of Earth, which formed along with the rest of the solar system 4.6 billion years ago. Examples of evidence include the absolute ages of ancient materials (obtained by radiometric dating of meteorites, moon rocks, and Earth’s oldest minerals), the sizes and compositions of solar system objects, and the impact cratering record of planetary surfaces.]

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
  - Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds. (HS-ESS1-1)
- Using Mathematical and Computational Thinking
  - Mathematical and computational thinking in 9–12 builds on K–8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponents and logarithms, and computational tools for statistical analysis to analyze, represent, and interpret data. Simple computational simulations are created and used based on mathematical models of basic assumptions. (HS-ESS1-4)
- Constructing Explanations and Designing Solutions
  - Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. (HS-ESS1-5)
- Engaging in Argument from Evidence
  - Engaging in argument from evidence in 9–12 builds on K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science. (HS-ESS1-6)
  - Evaluate evidence behind currently accepted explanations or solutions to determine the merits of arguments. (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 the presence of elemental-features of stars, their movements, and their distances from Earth. (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. (HS-ESS1-3)
- Other than the hydrogen and helium formed at the time of the Big Bang, nuclear fusion within stars produces all atomic nuclei lighter than and including iron, and the process releases electromagnetic energy. Heavier elements are produced when certain massive stars achieve a supernova stage and explode. (HS-ESS1-4)
- 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 collisions with other objects in the solar system. (HS-ESS1-5)

**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)
- Although active geologic processes, such as plate tectonics and erosion, have destroyed or altered most of the very early rock record on Earth, other objects in the solar system, such as lunar rocks, asteroids, and meteorites, have changed little over billions of years. Studying these objects can provide information about Earth’s formation and early history. (HS-ESS1-6)

**ESS1.B: Earth and the Solar System**
- 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. (ESS1.B Grade 8 GBE) (secondary to HS-ESS1, HS-ESS2, and others)

**Crosscutting Concepts**
- Patterns
  - Empirical evidence is needed to identify patterns. (HS-ESS1-5)
- Scale, Proportion, and Quantity
  - The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. (HS-ESS1-1)
- Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth). (HS-ESS1-4)
- Energy and Matter
  - Energy cannot be created or destroyed only moved between one place and another between objects, b y processes, or fields, between systems. (HS-ESS1-2)
- In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved. (HS-ESS1-3)
- Stability and Change
  - Much of science deals with constructing explanations of how things change and how they remain stable. (HS-ESS1-6)

**Connections to Engineering, Technology, and Applications of Science**
- Interdependence of Science, Engineering, and Technology
  - Science and engineering complement each other in the cycle known as research and development (R&D). Many R&D projects may involve scientists, engineers, and others with wide ranges of expertise. (HS-ESS1-2, HS-ESS1-4)

**Connections to Nature of Science**
- Scientific Knowledge Assumes an Order and Consistency in Natural Systems

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

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### HS-ESS1 Earth's Place in the Universe

**Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena**

- A scientific theory is a substantiated explanation of some aspect of the natural world, based on a body of facts that have been repeatedly confirmed through observation and experiment and the science community validates each theory before it is accepted. If new evidence is discovered that the theory does not accommodate, the theory is generally modified.

**Connections to Nature of Science**

**HSS**

**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-ESS1-1), (HS-ESS1-2), (HS-ESS1-3), (HS-ESS1-4), (HS-ESS1-5), (HS-ESS1-6)

**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-ESS1-1), (HS-ESS1-2), (HS-ESS1-3), (HS-ESS1-4), (HS-ESS1-5), (HS-ESS1-6)

**WHST.9-12.1** Write arguments focused on discipline-specific content. (HS-ESS1-1), (HS-ESS1-2), (HS-ESS1-3), (HS-ESS1-4), (HS-ESS1-5), (HS-ESS1-6)

**WHST.9-12.2** Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes. (HS-ESS1-1), (HS-ESS1-2), (HS-ESS1-3), (HS-ESS1-4), (HS-ESS1-5), (HS-ESS1-6)

**SL.11-12.4** Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence, sound valid reasoning, and well-chosen details; use appropriate eye contact, adequate volume, and clear pronunciation. (HS-ESS1-1), (HS-ESS1-2), (HS-ESS1-3), (HS-ESS1-4), (HS-ESS1-5), (HS-ESS1-6)

**Mathematics**

**MP.2** Reason abstractly and quantitatively. (HS-ESS1-1), (HS-ESS1-2), (HS-ESS1-3), (HS-ESS1-4), (HS-ESS1-5), (HS-ESS1-6)

**MP.4** Model with mathematics. (HS-ESS1-1), (HS-ESS1-4)

**HSN-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-ESS1-1), (HS-ESS1-2), (HS-ESS1-3), (HS-ESS1-4), (HS-ESS1-5), (HS-ESS1-6)

**HSN-Q.A.2** Define appropriate quantities for the purpose of descriptive modeling. (HS-ESS1-1), (HS-ESS1-2), (HS-ESS1-3), (HS-ESS1-4), (HS-ESS1-5), (HS-ESS1-6)

**HSN-Q.A.3** Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-ESS1-1), (HS-ESS1-2), (HS-ESS1-3), (HS-ESS1-4), (HS-ESS1-5), (HS-ESS1-6)

**HSA-SSA.A.1** Interpret expressions that represent a quantity in terms of its context. (HS-ESS1-1), (HS-ESS1-2), (HS-ESS1-4)

**HSA-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-ESS1-1), (HS-ESS1-2), (HS-ESS1-4)

**HSA-CED.A.4** Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. (HS-ESS1-1), (HS-ESS1-2), (HS-ESS1-4)

**HSF.IF.B.5** Relate the domain of a function to its graph and, where applicable, to the quantitative relationship it describes. (HS-ESS1-6)

**HSS-ID.B.6** Represent data on two quantitative variables on a scatter plot, and describe how those variables are related. (HS-ESS1-6)
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HS-ESS2 Earth’s Systems

Engaging in Argument from Evidence
Engaging in argument from evidence in 9–12 builds on K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science.

- Construct an oral and written argument or counterarguments based on data and evidence. (HS-ESS2-7)

Connections to Nature of Science

Scientific Knowledge is Based on Empirical Evidence

- Science knowledge is based on empirical evidence. (HS-ESS2-3)
- Science disciplines share common rules of evidence used to evaluate explanations about natural systems. (HS-ESS2-3)
- Science includes the process of coordinating patterns of evidence with current theory. (HS-ESS2-3)
- Science arguments are strengthened by multiple lines of evidence supporting a single explanation. (HS-ESS2-4)

- Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth’s surface and provides a framework for understanding its geologic history. Plate movements are responsible for most continental and ocean-floor features and for the distribution of most rocks and minerals within Earth’s crust. (ESS2.B Grade 8 OBE) (HS-ESS2-1)

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-ESS2-4)
- 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-ESS2-6)

ESS2.E: Biogeology

- The many dynamic and delicate feedbacks between the biosphere and other Earth systems cause a continual co-evolution of Earth’s surface and the life that exists on it. (HS-ESS2-7)

PS4.A: Waves

- Geologists use seismic waves and their reflection at interfaces between layers to probe structures deep in the planet. (secondary to HS-ESS2-3)

Connections to other DCIs in this grade band:
- HS.PS1.A (HS-ESS2-3), (HS-ESS2-6)
- HS.PS1.B (HS-ESS2-3), (HS-ESS2-6)
- HS.PS1.C (HS-ESS2-3), (HS-ESS2-6)
- HS.PS1.D (HS-ESS2-3), (HS-ESS2-6)
- HS.PS2.A (HS-ESS2-3), (HS-ESS2-6)
- HS.PS2.B (HS-ESS2-3), (HS-ESS2-6)
- HS.PS2.C (HS-ESS2-3), (HS-ESS2-6)
- HS.PS2.D (HS-ESS2-3), (HS-ESS2-6)
- HS.PS2.E (HS-ESS2-3), (HS-ESS2-6)
- HS.PS4.A (HS-ESS2-3), (HS-ESS2-6)
- HS.PS4.B (HS-ESS2-3), (HS-ESS2-6)
- HS.PS4.C (HS-ESS2-3), (HS-ESS2-6)
- HS.PS4.D (HS-ESS2-3), (HS-ESS2-6)
- HS.PS4.E (HS-ESS2-3), (HS-ESS2-6)
- HS.PS4.F (HS-ESS2-3), (HS-ESS2-6)
- HS.PS4.G (HS-ESS2-3), (HS-ESS2-6)
- HS.PS4.H (HS-ESS2-3), (HS-ESS2-6)
- HS.PS4.I (HS-ESS2-3), (HS-ESS2-6)
- HS.PS4.J (HS-ESS2-3), (HS-ESS2-6)
- HS.PS4.K (HS-ESS2-3), (HS-ESS2-6)
- HS.PS4.L (HS-ESS2-3), (HS-ESS2-6)
- HS.PS4.M (HS-ESS2-3), (HS-ESS2-6)
- HS.PS4.N (HS-ESS2-3), (HS-ESS2-6)
- HS.PS4.O (HS-ESS2-3), (HS-ESS2-6)
- HS.PS4.P (HS-ESS2-3), (HS-ESS2-6)
- HS.PS4.Q (HS-ESS2-3), (HS-ESS2-6)
- HS.PS4.R (HS-ESS2-3), (HS-ESS2-6)
- HS.PS4.S (HS-ESS2-3), (HS-ESS2-6)
- HS.PS4.T (HS-ESS2-3), (HS-ESS2-6)
- HS.PS4.U (HS-ESS2-3), (HS-ESS2-6)
- HS.PS4.V (HS-ESS2-3), (HS-ESS2-6)
- HS.PS4.W (HS-ESS2-3), (HS-ESS2-6)
- HS.PS4.X (HS-ESS2-3), (HS-ESS2-6)
- HS.PS4.Y (HS-ESS2-3), (HS-ESS2-6)
- HS.PS4.Z (HS-ESS2-3), (HS-ESS2-6)

Articulation of DCIs across grade bands:
- MS.PS1.A (HS-ESS2-3), (HS-ESS2-6)
- MS.PS1.B (HS-ESS2-3), (HS-ESS2-6)
- MS.PS1.C (HS-ESS2-3), (HS-ESS2-6)
- MS.PS1.D (HS-ESS2-3), (HS-ESS2-6)
- MS.PS1.E (HS-ESS2-3), (HS-ESS2-6)
- MS.PS1.F (HS-ESS2-3), (HS-ESS2-6)
- MS.PS1.G (HS-ESS2-3), (HS-ESS2-6)
- MS.PS1.H (HS-ESS2-3), (HS-ESS2-6)
- MS.PS1.I (HS-ESS2-3), (HS-ESS2-6)
- MS.PS1.J (HS-ESS2-3), (HS-ESS2-6)
- MS.PS1.K (HS-ESS2-3), (HS-ESS2-6)
- MS.PS1.L (HS-ESS2-3), (HS-ESS2-6)
- MS.PS1.M (HS-ESS2-3), (HS-ESS2-6)
- MS.PS1.N (HS-ESS2-3), (HS-ESS2-6)
- MS.PS1.O (HS-ESS2-3), (HS-ESS2-6)
- MS.PS1.P (HS-ESS2-3), (HS-ESS2-6)
- MS.PS1.Q (HS-ESS2-3), (HS-ESS2-6)
- MS.PS1.R (HS-ESS2-3), (HS-ESS2-6)
- MS.PS1.S (HS-ESS2-3), (HS-ESS2-6)
- MS.PS1.T (HS-ESS2-3), (HS-ESS2-6)
- MS.PS1.U (HS-ESS2-3), (HS-ESS2-6)
- MS.PS1.V (HS-ESS2-3), (HS-ESS2-6)
- MS.PS1.W (HS-ESS2-3), (HS-ESS2-6)
- MS.PS1.X (HS-ESS2-3), (HS-ESS2-6)
- MS.PS1.Y (HS-ESS2-3), (HS-ESS2-6)
- MS.PS1.Z (HS-ESS2-3), (HS-ESS2-6)

Common Core State Standards Connections

ELA/Literacy –
- 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-ESS2-3)

RST.11-12.2 Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms. (HS-ESS2-3)

WHST.9-12.1, WHST.9-12.2 Write arguments focused on discipline-specific content. (HS-ESS2-7)

WHST.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-ESS2-5)

SL.11-12.5 Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (HS-ESS2-1), (HS-ESS2-3), (HS-ESS2-4)

Mathematics –
- MP.2 Reason abstractly and quantitatively. (HS-ESS2-1), (HS-ESS2-3), (HS-ESS2-4), (HS-ESS2-6)
- MP.3 Model with mathematics. (HS-ESS2-1), (HS-ESS2-3), (HS-ESS2-4), (HS-ESS2-6)
- MP.4 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-ESS2-1), (HS-ESS2-3), (HS-ESS2-4), (HS-ESS2-6)
- HSN-Q.A.1 Define appropriate quantities for the purpose of descriptive modeling. (HS-ESS2-1), (HS-ESS2-3), (HS-ESS2-4), (HS-ESS2-6)
- HSN-Q.A.2 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-ESS2-1), (HS-ESS2-3), (HS-ESS2-4), (HS-ESS2-6)
- HSN-Q.A.3 Choose a level of accuracy appropriate to reporting quantities. (HS-ESS2-1), (HS-ESS2-3), (HS-ESS2-4), (HS-ESS2-6)

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HS-ESS3 Earth and Human Activity

Students who demonstrate understanding can:

**HS-ESS3-1.** Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity. [Clarification Statement: Examples of key natural resources include access to fresh water (such as rivers, lakes, and groundwater), regions of fertile soils such as river deltas, and high concentrations of minerals and fossil fuels. Examples of natural hazards can be from interior processes (such as volcanic eruptions and earthquakes), surface processes (such as tsunamis, mass wasting, soil erosion), and severe weather (such as hurricanes, floods, and droughts). Examples of the results of changes in climate that can affect populations or drive mass migrations include changes to sea level, regional patterns of temperature and precipitation, and the types of crops and livestock that can be raised.]

**HS-ESS3-2.** Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.* [Clarification Statement: Emphasis is on the conservation, recycling, and reuse of resources (such as minerals and metals) where possible, and on minimizing impacts where it is not. Examples include developing best practices for agricultural soil use, mining (for coal, tar sands, and oil shales), and pumping (for petroleum and natural gas). Science knowledge indicates what can happen in natural systems—not what should happen.]

**HS-ESS3-3.** Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity. [Clarification Statement: Examples of factors that affect 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 that affect human sustainability include agricultural efficiency, levels of conservation, and urban planning.] [Assessment Boundary: An assessment of computational simulations is limited to using provided multi-parameter programs or constructing simplified spreadsheet calculations.]

**HS-ESS3-4.** Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.* [Clarification Statement: Examples of data on the impacts of human activities could include the quantities and types of pollutants released, changes to biomass and species diversity, or areal changes in land surface use (such as urban development; agriculture and livestock; or surface mining). Examples for limiting future impacts could range from local efforts (such as reducing, reusing, and recycling resources) to large-scale geoengineering design solutions (such as altering global temperatures by making large changes to the atmosphere or ocean.)]

**HS-ESS3-5.** Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems. [Clarification Statement: Examples of evidence, for both data and climate model outputs, are for climate changes (such as precipitation and temperature) and their associated impacts (such as on sea level, glacial ice volumes, or atmosphere and ocean composition).] [Assessment Boundary: An assessment is limited to one example of a climate case and its associated impacts.]

**HS-ESS3-6.** Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity. [Clarification Statement: Examples of Earth systems to be considered are the hydroosphere, atmosphere, cryosphere, geosphere, and/or biosphere. An example of the far-reaching impacts from a human activity is how an increase in atmospheric carbon dioxide results in an increase in photosynthetic biomass on land and an increase in ocean acidification, with resulting impacts on sea organism health and marine populations.] [Assessment Boundary: An assessment does not include running computational representations but is limited to the published results of scientific computational models.]

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*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

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**Scientific Knowledge is Based on Empirical Evidence**

- New technologies advance scientific knowledge.
- Science investigations use diverse methods and do not rely on science alone, but rely on social and cultural contexts to resolve issues.
- Scientific investigations use diverse methods and do not always use the same set of procedures to obtain data.
- New technologies advance scientific knowledge.

**Scientific Knowledge is Based on Empirical Evidence**

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**Scientific Investigations Use a Variety of Methods**

- 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).
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**Connections to Nature of Science**

Science is a human endeavor.

- Science is a result of human endeavors, imagination, and creativity.
- Science knowledge indicates what can happen in natural systems—not what should happen. The latter involves ethics, values, and human decisions about the use of knowledge.
- Many decisions are not made using science alone, but rely on social and cultural contexts to resolve issues.

**Connections to Other DCIs**


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**ELA/Literacy –**

<table>
<thead>
<tr>
<th>Standard</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RST.11-12.1</td>
<td>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-ESS3-1), (HS-ESS3-2), (HS-ESS3-4), (HS-ESS3-5)</td>
</tr>
<tr>
<td>RST.11-12.2</td>
<td>Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in a simpler but still accurate terms. (HS-ESS3-5)</td>
</tr>
<tr>
<td>RST.11-12.7</td>
<td>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-ESS3-5)</td>
</tr>
<tr>
<td>RST.11-12.8</td>
<td>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-ESS3-2), (HS-ESS3-4)</td>
</tr>
<tr>
<td>WHST.9-12.2</td>
<td>Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-ESS3-1)</td>
</tr>
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</table>

**Mathematics –**

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<thead>
<tr>
<th>Standard</th>
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<tbody>
<tr>
<td>MP.2</td>
<td>Reason abstractly and quantitatively. (HS-ESS3-1), (HS-ESS3-2), (HS-ESS3-3), (HS-ESS3-4), (HS-ESS3-5), (HS-ESS3-6)</td>
</tr>
<tr>
<td>MP.4</td>
<td>Model with mathematics. (HS-ESS3-3), (HS-ESS3-6)</td>
</tr>
<tr>
<td>HSN-Q.A.1</td>
<td>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-ESS3-1), (HS-ESS3-4), (HS-ESS3-5), (HS-ESS3-6)</td>
</tr>
<tr>
<td>HSN-Q.A.2</td>
<td>Define appropriate quantities for the purpose of descriptive modeling. (HS-ESS3-3), (HS-ESS3-4), (HS-ESS3-5), (HS-ESS3-6)</td>
</tr>
<tr>
<td>HSN-Q.A.3</td>
<td>Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-ESS3-1), (HS-ESS3-4), (HS-ESS3-5), (HS-ESS3-6)</td>
</tr>
</tbody>
</table>