

# HS-ESS1 Earth's Place in the Universe

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Students who demonstrate understanding can:	
<b>HS-ESS1-1.</b>	<b>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.</b> [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 ways that the sun's radiation varies due to sudden solar flares ("space weather"), the 11-year sunspot cycle, and non-cyclic variations over centuries.] [Assessment Boundary: Assessment does not include details of the atomic and sub-atomic processes involved with the sun's nuclear fusion.]
<b>HS-ESS1-2.</b>	<b>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.</b> [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).]
<b>HS-ESS1-3.</b>	<b>Communicate scientific ideas about the way stars, over their life cycle, produce elements.</b> [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.]
<b>HS-ESS1-4.</b>	<b>Use mathematical or computational representations to predict the motion of orbiting objects in the solar system.</b> [Clarification Statement: Emphasis is on Newtonian gravitational laws 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 bodies, nor involve calculus.]
<b>HS-ESS1-5.</b>	<b>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.</b> [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 away from a central ancient core (a result of past plate interactions).]
<b>HS-ESS1-6.</b>	<b>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.</b> [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	Disciplinary Core Ideas	Crosscutting Concepts
<p><b>Developing and Using Models</b> Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s).</p> <ul style="list-style-type: none"> <li>Develop a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-ESS1-1)</li> </ul> <p><b>Using Mathematical and Computational Thinking</b> Mathematical and computational thinking in 9–12 builds on K–8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.</p> <ul style="list-style-type: none"> <li>Use mathematical or computational representations of phenomena to describe explanations. (HS-ESS1-4)</li> </ul> <p><b>Constructing Explanations and Designing Solutions</b> 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.</p> <ul style="list-style-type: none"> <li>Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (HS-ESS1-2)</li> <li>Apply scientific reasoning to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion. (MS-ESS1-6)</li> </ul> <p><b>Engaging in Argument from Evidence</b> 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.</p> <ul style="list-style-type: none"> <li>Evaluate evidence behind currently accepted explanations or solutions to determine the merits of arguments. (HS-ESS1-5)</li> </ul> <p><b>Obtaining, Evaluating, and Communicating Information</b> Obtaining, evaluating, and communicating information in 9–12</p>	<p><b>ESS1.A: The Universe and Its Stars</b></p> <ul style="list-style-type: none"> <li>The star called the sun is changing and will burn out over a lifespan of approximately 10 billion years. (HS-ESS1-1)</li> <li>The study of stars' light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth. (HS-ESS1-2),(HS-ESS1-3)</li> <li>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-ESS1-2)</li> <li>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-ESS1-2),(HS-ESS1-3)</li> </ul> <p><b>ESS1.B: Earth and the Solar System</b></p> <ul style="list-style-type: none"> <li>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)</li> </ul> <p><b>ESS1.C: The History of Planet Earth</b></p> <ul style="list-style-type: none"> <li>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)</li> <li>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)</li> </ul> <p><b>ESS2.B: Plate Tectonics and Large-Scale System Interactions</b></p> <ul style="list-style-type: none"> <li>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. (<i>ESS2.B Grade 8 GBE</i>) (<i>secondary to</i></li> </ul>	<p><b>Patterns</b></p> <ul style="list-style-type: none"> <li>Empirical evidence is needed to identify patterns. (HS-ESS1-5)</li> </ul> <p><b>Scale, Proportion, and Quantity</b></p> <ul style="list-style-type: none"> <li>The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. (HS-ESS1-1)</li> <li>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)</li> </ul> <p><b>Energy and Matter</b></p> <ul style="list-style-type: none"> <li>Energy cannot be created or destroyed—only moved between one place and another place, between objects and/or fields, or between systems. (HS-ESS1-2)</li> <li>In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved. (HS-ESS1-3)</li> </ul> <p><b>Stability and Change</b></p> <ul style="list-style-type: none"> <li>Much of science deals with constructing explanations of how things change and how they remain stable. (HS-ESS1-6)</li> </ul> <hr/> <p style="text-align: center;"><b>Connections to Engineering, Technology, and Applications of Science</b></p> <hr/> <p><b>Interdependence of Science, Engineering, and Technology</b></p> <ul style="list-style-type: none"> <li>Science and engineering complement each other in the cycle known as research and development (R&amp;D). Many R&amp;D projects may involve scientists, engineers, and others with wide ranges of expertise. (HS-ESS1-2),(HS-ESS1-4)</li> </ul> <hr/> <p style="text-align: center;"><b>Connections to Nature of Science</b></p> <hr/> <p><b>Scientific Knowledge Assumes an Order and Consistency in Natural Systems</b></p>

\*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

<p>builds on K–8 experiences and progresses to evaluating the validity and reliability of the claims, methods, and designs.</p> <ul style="list-style-type: none"> <li>▪ 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-ESS1-3)</li> </ul> <p style="text-align: center;">-----</p> <p style="text-align: center;"><b>Connections to Nature of Science</b></p> <p><b>Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena</b></p> <ul style="list-style-type: none"> <li>▪ 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 in light of this new evidence. (HS-ESS1-2),(HS-ESS1-6)</li> <li>▪ Models, mechanisms, and explanations collectively serve as tools in the development of a scientific theory. (HS-ESS1-6)</li> </ul>	<p style="text-align: center;"><i>HS-ESS1-5)</i></p> <p><b>PS1.C: Nuclear Processes</b></p> <ul style="list-style-type: none"> <li>▪ 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. (<i>secondary to HS-ESS1-5</i>),(secondary to <i>HS-ESS1-6</i>)</li> </ul> <p><b>PS3.D: Energy in Chemical Processes and Everyday Life</b></p> <ul style="list-style-type: none"> <li>▪ Nuclear Fusion processes in the center of the sun release the energy that ultimately reaches Earth as radiation. (<i>secondary to HS-ESS1-1</i>)</li> </ul> <p><b>PS4.B Electromagnetic Radiation</b></p> <ul style="list-style-type: none"> <li>▪ 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. (<i>secondary to HS-ESS1-2</i>)</li> </ul>	<ul style="list-style-type: none"> <li>▪ Scientific knowledge is based on the assumption that natural laws operate today as they did in the past and they will continue to do so in the future. (HS-ESS1-2)</li> <li>▪ Science assumes the universe is a vast single system in which basic laws are consistent. (HS-ESS1-2)</li> </ul>
<p><i>Connections to other DCIs in this grade-band:</i> <b>HS.PS1.A</b> (HS-ESS1-2),(HS-ESS1-3); <b>HS.PS1.C</b> (HS-ESS1-1),(HS-ESS1-2),(HS-ESS1-3); <b>HS.PS2.A</b> (HS-ESS1-6); <b>HS.PS2.B</b> (HS-ESS1-4),(HS-ESS1-6); <b>HS.PS3.A</b> (HS-ESS1-1),(HS-ESS1-2); <b>HS.PS3.B</b> (HS-ESS1-2),(HS-ESS1-5); <b>HS.PS4.A</b> (HS-ESS1-2); <b>HS.ESS2.A</b> (HS-ESS1-5),(HS-ESS1-6)</p>		
<p><i>Articulation of DCIs across grade-bands:</i> <b>MS.PS1.A</b> (HS-ESS1-1),(HS-ESS1-2),(HS-ESS1-3); <b>MS.PS2.A</b> (HS-ESS1-4); <b>MS.PS2.B</b> (HS-ESS1-4),(HS-ESS1-6); <b>MS.PS4.B</b> (HS-ESS1-1),(HS-ESS1-2); <b>MS.ESS1.A</b> (HS-ESS1-1),(HS-ESS1-2),(HS-ESS1-3),(HS-ESS1-4); <b>MS.ESS1.B</b> (HS-ESS1-1),(HS-ESS1-4),(HS-ESS1-6); <b>MS.ESS1.C</b> (HS-ESS1-5),(HS-ESS1-6); <b>MS.ESS2.A</b> (HS-ESS1-1),(HS-ESS1-5),(HS-ESS1-6); <b>MS.ESS2.B</b> (HS-ESS1-5),(HS-ESS1-6); <b>MS.ESS2.D</b> (HS-ESS1-1)</p>		
<p><i>Common Core State Standards Connections:</i></p> <p><i>ELA/Literacy –</i></p> <p><b>RST.11-12.1</b> 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. (<i>HS-ESS1-1</i>),(<i>HS-ESS1-2</i>),(<i>HS-ESS1-5</i>),(<i>HS-ESS1-6</i>)</p> <p><b>RST.11-12.8</b> 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-ESS1-5),(HS-ESS1-6)</p> <p><b>WHST.9-12.1</b> Write arguments focused on <i>discipline-specific content</i>. (HS-ESS1-6)</p> <p><b>WHST.9-12.2</b> Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-ESS1-2),(<i>HS-ESS1-3</i>),(<i>HS-ESS1-5</i>)</p> <p><b>SL.11-12.4</b> 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. (<i>HS-ESS1-3</i>)</p> <p><i>Mathematics –</i></p> <p><b>MP.2</b> Reason abstractly and quantitatively. (HS-ESS1-1),(HS-ESS1-2),(HS-ESS1-3),(HS-ESS1-4),(HS-ESS1-5),(HS-ESS1-6)</p> <p><b>MP.4</b> Model with mathematics. (HS-ESS1-1),(HS-ESS1-4)</p> <p><b>HSN-Q.A.1</b> 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-ESS1-4),(HS-ESS1-5),(HS-ESS1-6)</p> <p><b>HSN-Q.A.2</b> Define appropriate quantities for the purpose of descriptive modeling. (HS-ESS1-1),(<i>HS-ESS1-2</i>),(HS-ESS1-4),(<i>HS-ESS1-5</i>),(<i>HS-ESS1-6</i>)</p> <p><b>HSN-Q.A.3</b> Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-ESS1-1),(HS-ESS1-2),(HS-ESS1-4),(HS-ESS1-5),(HS-ESS1-6)</p> <p><b>HSA-SSE.A.1</b> Interpret expressions that represent a quantity in terms of its context. (<i>HS-ESS1-1</i>),(<i>HS-ESS1-2</i>),(HS-ESS1-4)</p> <p><b>HSA-CED.A.2</b> Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. (<i>HS-ESS1-1</i>),(<i>HS-ESS1-2</i>),(<i>HS-ESS1-4</i>)</p> <p><b>HSA-CED.A.4</b> Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. (<i>HS-ESS1-1</i>),(<i>HS-ESS1-2</i>),(<i>HS-ESS1-4</i>)</p> <p><b>HSF-IF.B.5</b> Relate the domain of a function to its graph and, where applicable, to the quantitative relationship it describes. (<i>HS-ESS1-6</i>)</p> <p><b>HSS-ID.B.6</b> Represent data on two quantitative variables on a scatter plot, and describe how those variables are related. (<i>HS-ESS1-6</i>)</p>		

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