**Earth Science Curriculum Revision**

**Semester 1:Earth’s Systems**

***How and why is Earth constantly changing?***

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| **HS.Earth’s Systems**  ***How do Earth’s systems interact?*** | | | | | |
| **TOPIC** | **Performance Expectation** | **DCI** | **Science and Engineering Practices** | **Crosscutting Concepts** | **Resources** |
| **Latitude and Longitude**  **Types of Maps**  **Rock Types** | **HS-ESS2-2**  Analyze geoscience data to make the claim that one change to Earth’s surface can create feedbacks that cause changes to other Earth systems. | **ESS2.A: Earth Materials and Systems**  -Earth’s system, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes.  **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. | **Analyzing and Interpreting Data**  Analyzing data in 9-12 builds on K-8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze 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 optional design solution. (HS-ESS2-2) | **Stability and Change**  Feedback (negative or positive) can stabilize or destabilize a system. (HS-ESS2-2) | **Chapters: 2, 4, 5, 6**  [**Variety of searchable activities for Earth Science**](http://www.earthsciweek.org/classroom-activities)  [**The Chocolate Rock Cycle: Geological Society of London**](https://www.geolsoc.org.uk/Education-and-Careers/Resources/Supporting-Materials/Lesson-Plans/The-Chocolate-Rock-Cycle)  [**The Great Ocean Conveyer**](http://www.earthsciweek.org/classroom-activities/great-ocean-conveyor)  [**The Greenhouse Effect**](http://phet.colorado.edu/en/simulation/greenhouse)  [**Fluid Pressure and Flow**](http://phet.colorado.edu/en/simulation/fluid-pressure-and-flow)  [**EarthCaching**](http://www.earthsciweek.org/classroom-activities/earthcaching)  [**Cardboard contour maps**](http://www.geoblox.com)  [**Lat/Long Google Earth**](http://www.aktsunami.com/exercises/atep_GIT_9-12_LatitudeAndLongitudeWithGoogleEarth.pdf) |
| **Composition of the Earth**  **Plate Tectonics** | **HS-ESS2-3**  Develop a model based on evidence of Earth’s interior to describe the cycling of matter by thermal convection. | **ESS2.A: Earth Materials and Systems**  -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 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 the outward flow of energy from Earth’s interior and gravitational movement of denser materials toward the interior.  **ESS2.B: Plate Tectonics and Large-Scale System Interactions**  -The reactive 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.  ***Secondary to ESS2-2***  **PS4.A: Wave Properties**  -Geologists use seismic waves and their reflection at interfaces between layers to probe structures deep in the planet. | **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 world(s).  -Develop a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-ESS2-3) | **Energy and Matter**  Energy drives the cycling of matter within and between systems.  (HS-ESS2-3) | **Chapters: 1, 4, 5, 6, 7, 8, 9, 14, 16, 18, 19, 20, 22**  [**Radioactive Decay Model**](http://www.earthsciweek.org/classroom-activities/dating-popcorn)  [**Plate Tectonics: Earthquakes & Volcanoes Simulation**](https://authoring.concord.org/activities/1089/single_page/8cc27854-2f56-4b13-aadc-27cde1b0e456)  [**Earthquake Machine**](http://www.earthsciweek.org/classroom-activities/earthquake-machine)  [**Plate tectonics lesson plans, class activities.**](http://www.geology.com/teacher/plate-tectonics.shtml)  [**Nevada Mining Association Activities**](http://www.nevadamining.org/issues_policy/activities.php)  [**The Day the Earth Shook**](http://www.pbs.org/wgbh/nova/education/activities/2302_shook.html) |
| **Weathering**  **Erosion and Deposition**  **Soil**  **Surface Water Movement**  **Movement and Storage of Groundwater** | **HS-ESS2-5**  Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes. | **ESS2.C: The Roles of Water in Earth’s Surface**  -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 | **Planning and Carrying Out Investigations**  Planning and carrying out investigations in 9-12 builds on k-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models. | **Structure and Function**  The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials. | **Chapters: 3, 7, 8, 9, 10, 11, 15**  [**Will there be enough fresh water?**](http://concord.org/stem-resources/will-there-be-enough-fresh-water)  [**Slideshow Gallery of Freshwater**](http://climatekids.nasa.gov/freshwater-gallery/)  [**Flooding Simulation**](http://www.stopdisastersgame.org/en/playgame.html)  [**Salts and Solubility**](http://phet.colorado.edu/en/simulation/legacy/soluble-salts)  [**Friction: phet simulation**](http://phet.colorado.edu/en/simulation/friction)  [**Cardboard contour maps**](http://www.geoblox.com)  [**Land & People: Finding a Balance**](http://www.earthsciweek.org/classroom-activities/land-and-people-finding-balance)  [**Weathering of Building Stones**](https://higherlogicdownload.s3.amazonaws.com/GEOSOCIETY/a2a49183-ba2a-469c-9d3b-68daf22c94bd/UploadedImages/TAP%20Photos/Lesson%20Plans/Rocks,%20Minerals%20and%20Mining/NIST_StoneWallActivity_9-12.pdf) |
| **Atmospheric Basics**  **Properties of the Atmosphere**  **The Carbon Cycle** | **HS-ESS2-6**  Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere. | **ESS2.D: Weather and Climate**  -Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen.  -Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate. | **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 world(s).  -Develop a model based on evidence to illustrate the relationships between systems or between components of a system.  (HS-ESS2-6) | **Energy and Matter**  The total amount of energy and matter in closed systems is conserved.  (HS-ESS2-6) | **Chapters: 11, 12, 13, 14.1, 14.2, 22.3**  [**What is the future of the Earth's climate?**](http://authoring.concord.org/sequences/47)  [**Cloud scramble**](http://spaceplace.nasa.gov/cloud-scramble/en/)  [**Ozone Resource**](http://aura.gsfc.nasa.gov/ozone.html) |
| **Biogeochemical Cycles**  **Soil Formation**  **Photosynthetic Life** | **HS-ESS2-7**  Construct an argument based on evidence about the simultaneous co-evolution of Earth’s systems and life on Earth. | **ESS2.D: Weather and Climate**  -Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen.  **ESS2.E: Biogeology**  -The many dynamic and delicate feedbacks between the biosphere and other Earths systems cause a continual co-evolution of Earth’s surface and the life that exists on it. | **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 counter-arguments based on data and evidence.  (HS-ESS2-7) | **Stability and Change**  -Much of science deals with constructing explanations of how things change and how they remain stable.  (HS-ESS2-7) | **Chapters: 1, 11, 12, 13, 14.1, 14.2, 22.3**  [**Slideshow Gallery of Climate & Weather Pictures**](http://climatekids.nasa.gov/weather-and-climate-gallery/)  [**Slideshow Gallery of Carbon Travels**](http://climatekids.nasa.gov/carbon-gallery/)  [**Natural Selection**](http://phet.colorado.edu/en/simulation/legacy/natural-selection) |
| **HS. Human Sustainability** | | | | | |
| **TOPIC** | **Performance Expectation** | **DCI** | **Science and Engineering Practices** | **Crosscutting Concepts** | **Resources** |
| **Natural Resources** | **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. | **ESS3.A: Natural Resource**  -Resource availability has guided the development of human society.  (HS-ESS3-1)  **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) | **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 knowledge, principles, and theories.  -Construct and 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) | **Cause and Effect**  -Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-ESS3-1) | **Ch 24**  [**Videos about natural resources**](http://www.bozemanscience.com/ngs-ess3a-natural-resources)  [**Student Carbon Footprint Calculator**](http://www3.epa.gov/climatechange/students/calc/calculator.html) |
|  | **HS-ESS3-2\***  Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios. | **ESS3.A: Natural Resource**  **-**All forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits. New technology and social regulations can change the balance of these factors.  (HS-ESS3-2)  **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*) | **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.  -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) | Connections to Engineering, Technology and the Application of Science  **Influence of Engineering, Technology, and Science on Society and the Natural World**  -Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks. (HS-ESS3-2)  -Analysis of costs and benefits is a critical aspect of decisions about technology. (HS-ESS3-2)  Connections to Nature of Science  **Science Addresses Questions About the Natural and Material World**  -Science and technology may raise ethical issues for which science, by itself, does not provide answers and solutions. (HS-ESS3-2)  -Scientific knowledge indicates what can happen in natural systems-not what should happen. The latter involves ethics, values, and human decisions about the use the knowledge. (HS-ESS3-2)  -Many decisions are not made using science alone, but rely on social and cultural contexts to resolve issues. (HS-ESS3-2) | **Ch 25**  [**What are our Energy Choices?**](http://concord.org/stem-resources/what-are-our-energy-choices)  [**Know your energy costs.**](http://www.earthsciweek.org/classroom-activities/know-your-energy-costs) |

**Semester 2**

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| **HS.Human Sustainability (continued)** | | | | | |
| **TOPIC** | **Performance Expectation** | **DCI** | **Science and Engineering Practices** | **Crosscutting Concepts** | **Resources** |
| **Human impact**  **on Populations**  **-exponential growth**  **-carrying capacity**  **-environmental limits**  **-Mining**  **-Agriculture**  **-deforestation**  **-Air pollution**  **-Water pollution** | **HS-ESS3-3**  Create a computational simulation to illustrate the relationship among the management of natural resources, the sustainability of human populations, and biodiversity. | [**ESS3.C: Human Impacts on Earth System**](http://www.nap.edu/openbook.php?record_id=13165&page=194)**s**  -[The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources.](http://www.nap.edu/openbook.php?record_id=13165&page=194) | **Using Mathematics 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, 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.  -Create a computational model or simulation of a phenomenon, designed device, process, or system. (HS-ESS3-3) | **Stability and Change**  -Change and rates of change can be quantified and modeled over very short or very long periods of time. Some systems changes are irreversible. (HS-ESS3-3)  Connections to Engineering, Technology, and Applications of Science  **Influence of Engineering, Technology, and Science on Society and the Natural World**  -Modern civilizations depends on major technological systems. (HS-ESS3-3)  New technologies can have deep impacts on society and the environment, including some that were not anticipated. (HS-ESS3-3)  Connections to Nature of Science  **Science is a Human Endeavor**  -Scientific knowledge is a result of human endeavors, imagination, and creativity. (HS-ESS3-3) | Ch 26  [Teaching & Learning for a Sustainable Future](http://www.unesco.org/education/tlsf/mods/theme_b/mod06.html?panel=2#top) |
| **Sustainable practices**  **-reclamation**  **-conservation**  **-renewable resources** | **HS-ESS3-4\***  Evaluate or refine a technological solution that reduces impacts of human activities on natural systems. | [**ESS3.C: Human Impacts on Earth Systems**](http://www.nap.edu/openbook.php?record_id=13165&page=194)  -[Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude ecosystem degradation. (HS-ESS3-4)](http://www.nap.edu/openbook.php?record_id=13165&page=194)  [**ETS1.B: Developing Possible Solutions**](http://www.nap.edu/openbook.php?record_id=13165&page=175)  -[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.](http://www.nap.edu/openbook.php?record_id=13165&page=206)  (*secondary to HS-ESS3-4)* | **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 knowledge, principles, and theories.  -Design 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-ESS3-4) | **Stability and Change**  -Feedback (negative or positive) can stabilize or destabilize a system. (HS-ESS3-4) | Ch 26  [Website offers a search tool of activities that meet this performance expectation](http://geocntr.org/education-resources/classroom-activities/?szbl-query=&szbl-filter=grade_level&szbl-filter-slug=9-12) |
| **Impact of Human Activity**  **-greenhouse effect**  **-global warming** | **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. | [**ESS3.D: Global Climate Change**](http://www.nap.edu/openbook.php?record_id=13165&page=196)  -[Through computer simulations and other studies, important discoveries are still being made about how the ocean, the atmosphere, and the biosphere interact and are modified in response to human activities.](http://www.nap.edu/openbook.php?record_id=13165&page=196)  **ESS2-D: Weather and Climate**  -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 the biosphere. (*secondary to HS-ESS3-6*) | **Using Mathematics 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, 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.  -Use a computational representation of phenomena or design solutions to describe and/or support claims and/or explanations.  (HS-ESS3-6) |  | Ch 14.4  [EPA Global Climate Change Wheel Card](http://www3.epa.gov/climatechange/wheel-card.html)  [Global Climate Change Activities](https://www.ucar.edu/learn/1_4_2.htm)  [The Greenhouse Effect](http://phet.colorado.edu/en/simulation/greenhouse) |

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| **HS. History of Earth** | | | | | |
| **TOPIC** | **Performance Expectation** | **DCI** | **Science and Engineering Practices** | **Crosscutting Concepts** | **Resources** |
|  | **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. | **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 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)*  **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)* | **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.  -Evaluate evidence behind currently accepted explanations or solutions to determine the merits of arguments. (HS-ESS1-5) | **Patterns**  Empirical evidence is needed to identify patterns. (HS-ESS1-5) | Chapter 21  [Plate Tectonics](http://phet.colorado.edu/en/simulation/legacy/plate-tectonics) |
| Earth’s formation  -impact theory  -radioactive dating, decay  -half-life | **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. | **ESS1.C: The History of Planet Earth**  -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)  **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 HS-ESS1-6)* | **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.  -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-ESS1-6)  Connections to Nature of Science  **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 in light of this new evidence.  -Models, mechanisms, and explanations collectively serve as tools in the development of a scientific theory.  (HS-ESS1-6) | **Stability and Change**  Much of science deals with constructing explanations of how things change and how they remain stable. (HS-ESS1-6) | Ch 27.2, 28.4  Unraveling Earth’s Early History (NGSS)  [Radioactive Dating Game](http://phet.colorado.edu/en/simulation/legacy/radioactive-dating-game)  [Evolution of Life Activities](http://www.earthlearningidea.com/English/Evolution_of_Life.html)  [USGS Geologic Time Scale background and fact sheets](http://www.usgs.gov/science/science.php?term=1745&type=theme)  [A Relative Age Dating Activity](https://higherlogicdownload.s3.amazonaws.com/GEOSOCIETY/a2a49183-ba2a-469c-9d3b-68daf22c94bd/UploadedImages/TAP%20Photos/Lesson%20Plans/Geology%20&%20Geologic%20Time/Relative_Age_7-14.pdf) |
| Plate Tectonics | **HS-ESS2-1**  Develop a model to illustrate how Earth’s internal and surface processes operate at different spatial and temporal scales to form continental and ocean-floor features. | **ESS2.A: Earth Materials and Systems**  -Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes.  **ESS2.B: Plate Tectonics and Large-Scale Systems Interactions**  -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. | **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 world(s).  -Develop a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-ESS2-1) | **Stability and Change**  Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible. (HS-ESS2-1) | Chapter 1.1, 4.1, 4.2, 5.1, 5.2, 6, 7, 8, 9.1, 9.2, 14.3, 14.4, 16, 18, 19.1, 19.2  [Glaciers](http://phet.colorado.edu/en/simulation/glaciers) |

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| **HS.Weather and Climate** | | | | | |
| **TOPIC** | **Performance Expectation** | **DCI** | **Science and Engineering Practices** | **Crosscutting Concepts** | **Resources** |
| Weather &  Climate | **HS-ESS2-4**  Use a model to describe how variations in the flow of energy into and out of Earth’s system result in changes in climate. | **ESS2.4: Earth Materials and Systems**  -The geologic 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 timescales from sudden (e.g., volcanic ash clouds) to intermediate (ice ages) to very long-term tectonic cycles.  **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 re-radiation into space. (HS-ESS2-4)  -Changes in the atmosphere due to human activity have increased the levels of carbon dioxide concentrations and thus affect climate.  (HS-ESS2-4)  **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 Earth. These phenomena cause a cycle of ice ages and other gradual climate changes.  (*secondary to HS-ESS2-4)* | **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 world(s).  -Use a model to provide mechanistic accounts of phenomena.  (HS-ESS2-4) | **Cause and Effect**  -Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.  (HS-ESS2-4) | Chapter 11, 12, 13, 14  [The Greenhouse Effect](http://phet.colorado.edu/en/simulation/greenhouse) |
| Global Climate  Change  &  Human Impacts on Earth Systems | **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’s systems. | **ESS3.D: Global Climate Change**  -Through 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) | **Analyzing and Interpreting Data**  Analyzing data in 9-12 builds on K-8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data.  -Analyze data using computational models in order to make valid and reliable scientific claims.  (HS-ESS3-5)  Connections to Nature of Science  **Scientific Investigations Use a Variety of Methods**  -Scientific investigations use diverse methods and do not always use the same set of procedures to obtain data.  -New technologies advance scientific knowledge.  (HS-ESS3-5)  **Scientific Knowledge Is Based on Empirical Evidence**  -Scientific knowledge is based on empirical evidence.  -Science arguments are strengthened by multiple lines of evidence supporting a single explanation.  (HS-ESS3-5) | **Stability and Change**  Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible. (HS-ESS3-5) | Chapter 14  [Will the Air be Clean Enough to Breathe?](http://concord.org/stem-resources/will-air-be-clean-enough-breathe) |
| Biogeology | **HS-ESS2-7**  Construct an argument based on evidence about the simultaneous co-evolution of Earth’s systems and life on Earth’s. | **ESS2.D: Weather and Climate**  -Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen.  (HS-ESS2-7)  **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) | **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 counter-arguments based on data and evidence.  (HS-ESS2-7) | **Stability and Change**  -Much of science deals with constructing explanations of how things change and how they remain stable.  (HS-ESS2-7) | Chapters 1, 22, 23  [What craters on the teach us about Earth: two videos included](http://www.universetoday.com/99365/what-craters-on-the-moon-can-teach-us-about-earth/) |

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| **HS.Space Systems** | | | | | |
| **TOPIC** | **Performance Expectation** | **DCI** | **Science and Engineering Practices** | **Crosscutting Concepts** | **Resources** |
| The Solar System  -interstellar clouds  -eccentricity  -Kepler’s laws of planetary motion  -retrograde motion | **HS-ESS1-4**  Use mathematical or computational representations to predict the motion of orbiting objects in the solar system. | **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) | **Using Mathematics 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, 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.  -Use mathematical or computational representations of phenomena to describe explanations.  (HS-ESS1-4) | **Scale, Proportion, and Quantity**  -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)  Connection to Engineering, Technology, and Application 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-ESS1-4) | Chapter 28  [My Solar System](http://phet.colorado.edu/en/simulation/legacy/my-solar-system)  [Gravity and Orbits](http://phet.colorado.edu/en/simulation/gravity-and-orbits)  [Kepler's Planetary Motion Lab](https://washoeschools-my.sharepoint.com/personal/mpedwards_washoeschools_net/_layouts/15/guestaccess.aspx?guestaccesstoken=kTzXxpoUHnHSgpV%2fEAQob5E8QUccgRS4%2fAR%2fqPeRZBM%3d&docid=084f090e37f5347b5aaa6298b0dcd7fc6) |
| Galaxies, Stars, Universe  -radiation  -electromagnetic spectrum  -telescopes  space exploration  -nuclear fusion | **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. | **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.  **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 ESS1-1)* | **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 world(s).  -Develop a model based on evidence to illustrate the relationships between systems or between components of a system.  (HS-ESS1-1) | **Scale, Proportion, and Quantity**  -The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs.  (HS-ESS1-1) | Chapters 29-30  Chapter 27.1  [Isotopes and Atomic Mass](http://phet.colorado.edu/en/simulation/legacy/isotopes-and-atomic-mass) |
| Galaxies, Stars, Universe  -Variable stars  -light spectrum  -Doppler effect  -CMB | **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. | **ESS1.A: The Universe and Its Stars**  -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.  -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) | **Constructing Explanations and Designing Solutions**  Constructing explanations and designing solution 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.  -Construct 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 operation today as they did in the past and will continue to do so in the future. (HS-ESS1-2)  Connections to Nature of Science  **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 in light of this new evidence.  (HS-ESS1-2) | **Energy and Matter**  -Energy cannot be created or destroyed-it only moved between one place and another place, between objects and/or fields, or between systems.  (HS-ESS1-2)  Connection 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)  Connections to Nature of Science  **Scientific Knowledge Assumes an Order and Consistency in Natural Systems**  -Scientific knowledge is based on the assumption that natural laws operate today as they did in the past and will continue to do so in the future.  -science assumes the universe is a vast single system in which basic laws are consistent.  (HS-ESS1-2) | Chapter 30  [Blackbody Spectrum](http://phet.colorado.edu/en/simulation/blackbody-spectrum)  [Wave Interference](http://phet.colorado.edu/en/simulation/wave-interference)  [Spectrum lab](http://www.trschools.com/staff/g/cgirtain/Weblabs/spectrolab.htm) |
| Galaxies, Stars, Universe  -absorption spectrum  -H-R diagram  -Doppler shifts  -parallax  -magnitude  -luminosity  -mass effect on stellar evolution | **HS-ESS1-3**  Communicate scientific ideas about the way stars, over their life cycle, produce elements. | **ESS1.A: The Universe and Its Stars**  -The study of stars’ light spectra and brightness is used to identify compositional elements of the stars, their movements, and their distances from Earth.  -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. | **Obtaining, Evaluating, and Communicating Information**  Obtaining, evaluating, and communicating information in 9-12 builds on K-8 experiences and progresses to evaluating the validity and reliability of the claims, methods, and designs.  -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) | **Energy**  -In nuclear processes, atoms are not conserved, but the total number protons plus neutrons is conserved.  (HS-ESS1-3) | Chapter 29, 30  [Parallax lab](http://blossoms.mit.edu/sites/default/files/video/download/Parallax-Activity.pdf) |
|  |  | (HS-ESS1-3) |  |  |  |

**\****This performance expectation integrates traditional science content with engineering through a practice or disciplinary core idea.*

**Other Resources:**

**EarthLab**

[**http://serc.carleton.edu/earthlabs/index.html**](http://serc.carleton.edu/earthlabs/index.html)

**Life Cycle of Stars Activity**

[**www.communicatingastronomy.org/cap2010/.../star\_cycle\_balloons.doc**](http://www.communicatingastronomy.org/cap2010/.../star_cycle_balloons.doc)

**Resource Packet for Earth Science. Contains a wide range of resources.**

[**http://newyorkscienceteacher.com/sci/files/2011/esrt2011.pdf**](http://newyorkscienceteacher.com/sci/files/2011/esrt2011.pdf)

**Subscribe to get daily articles related to Earth Science**

[**www.sciencedaily.com**](http://www.sciencedaily.com)

## **A Collection of Classroom Activities and Lesson Plans**

[**http://geology.com**](http://geology.com)

**Center for Geoscience and Society**

[**http://geocntr.org**](http://geocntr.org)

[**You Tube Earth's Interior Song set to Uptown Funk**](https://www.youtube.com/watch?v=lulLsmTlB50)

[**You Tube Earth's Interior Rap to Black and Yellow**](https://www.youtube.com/watch?v=RiHRI_Z2Kgs)

[You Tube Plate Tectonics Alfred Wegener](https://www.youtube.com/watch?v=T1-cES1Ekto&list=PLunm0r3Z9wSaLZu7lvQPyJdhNpZwEuOvU)

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