Science Pacing Guide
Earth Science

Time Frame: September – October
Unit 1: Space Systems

Science & Engineering Practices	Crosscutting Concepts	Literacy Standards	Mathematics Standards
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) **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, 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) **Constructing Explanations and Designing Solutions** Constructing explanations and designing solutions in 9–12 builds on K–8 experiences	**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 place, between objects and/or fields, or 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) **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	**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) **WHST.9-12.2** Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-ESS1-2),(HS-ESS1-3) **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-ESS1-3)	**MP.2** Reason abstractly and quantitatively. (HS-ESS1-1), (HS-ESS1-2), (HS-ESS1-3), (HS-ESS1-4) **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-ESS1-4) **HSN-Q.A.2** Define appropriate quantities for the purpose of descriptive modeling. (HS-ESS1-1), *(HS-ESS1-2)*, (HS-ESS1-4) **HSN-Q.A.3** Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-ESS1-1), (HS-ESS1-2), (HS-ESS1-4) **HSA-SSE.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

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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, 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) **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) **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	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** 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) Science assumes the universe is a vast single system in which basic laws are consistent. (HS-ESS1-2)		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)

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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)			

Next Generation Science Standards	Disciplinary Core Ideas	Essential Questions	Assessments	Vocabulary	Resources
Students who demonstrate understanding can: **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 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 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.]*	**ESS1.A: The Universe and Its Stars** The star called the sun is changing and will burn out over a lifespan of approximately 10 billion years. (HS-ESS1-1) The study of stars' light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth. (HS-ESS1-2), (HS-ESS1-3) 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	What is the universe, and what goes on in stars? What are the predictable patterns caused by Earth's movement in the solar system? How does nuclear fusion produce energy in the sun? How have nuclear fusion and other processes in the stars led to the formation of other chemical elements?	**<u>Before</u>:** KWL about the universe and its stars Students will journal a definition of the big bang theory and attempt to support their definition Students will label the relative speeds of objects of varying masses traveling in an elliptical path Pretest (This will be the same as the posttest) **<u>During</u>:** Students will develop a model that illustrates the life span of the sun	Absolute magnitude Apparent magnitude Astronomical unit Big Bang theory Binary star Black hole Chromosphere Comet Constellation Corona Cosmic background radiation Cosmology Eccentricity Electromagnetic spectrum Ellipse Fission Fusion Hertzsprung-Russell diagram Luminosity Main sequence	Outstanding - This site has an interactive 3-D space travel, in which the students control the space craft and travel throughout the universe. This site also provides information on each of the planets, the sun, and comets. This site also provides lots of information on new scientific discoveries such as worm holes, and multi-dimensional space. There is also a section on the origin of space, and its controversies, and a section devoted to teachers and students. To experience the virtual space tour you must have shockwave 8.5 plug-in installed on your computer, or you can download it from the site. http://www.bbc.co.uk/science/space/ The Birth and Formation of Galaxies http://www.solarviews.com/eng/galaxyformation.htm

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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** Communicate scientific ideas about the way stars, over their life cycle, produce elements. [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*	the universe. (HS-ESS1-2) Other than the hydrogen and helium formed at the time of the Big Bang, nuclear fusion within stars produces all atomic nuclei lighter than and including iron, and the process releases electromagnetic energy. Heavier elements are produced when certain massive stars achieve a supernova stage and explode. (HS-ESS1-2),(HS-ESS1-3) **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) **PS3.D: Energy in Chemical Processes and Everyday Life** Nuclear Fusion processes in the center of the sun		based on data from lifespans of other stars and the ways the sun's radiation varies due to solar flares Students will research the big bang theory and collect evidence that supports the theory Students will use the process of nuclear synthesis to discover how stars create different elements throughout their lifecycles based on their masses **After**: Students revisit KWL to identify any misconceptions they came with and add what they learned Students will create a presentation (poster, PPT, video, lecture) that uses red shift light and interstellar gas abundance evidence to support the big bang theory	Meteor shower Nebula Neutron star Parallax Parsec Photosphere Planetesimal Prominence Proton star Pulsar Retrograde motion Scarp Solar flare Solar wind Super nova Terrestrial plant	The Life Cycle of Stars, Information and Activity Book - Solar System, Galaxy and Universe (V.4.HS.1&3) This site contains a booklet with information about stars (formation, energy, classification, black holes, and more). There are many student activity ideas in the booklet and it is suggested that the booklet be used in conjunction with the Imagine the Universe website or CD-ROM http://imagine.gsfc.nasa.gov/docs/teachers/lifecycles/Imagine2.pdf

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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 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.*]	release the energy that ultimately reaches Earth as radiation. *(secondary to HS-ESS1-1)* **PS4.B: Electromagnetic Radiation** Atoms of each element emit and absorb characteristic frequencies of light. These characteristics allow identification of the presence of an element, even in microscopic quantities. *(secondary to HS-ESS1-2)*		Students will complete a scale model of the Earth's orbit showing Kepler's first law. Students will design a satellite and describe its mass, orbit, and speed around the Earth using Kepler's Laws of orbital motion. Students will create an "Armageddon movie trailer" That describes the death of our sun. Posttest		

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Time Frame: October – November
Unit 2: History of Earth

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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) **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) **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.	**Patterns** Empirical evidence is needed to identify patterns. (HS-ESS1-5) **Stability and Change** Much of science deals with constructing explanations of how things change and how they remain stable. (HS-ESS1-6) 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)	**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-ESS1-5), (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-ESS1-5), (HS-ESS1-6) **WHST.9-12.1** Write arguments focused on *discipline-specific content.* (HS-ESS1-6) **WHST.9-12.2** Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-ESS1-2), (HS-ESS1-5) **SL.11-12.5** Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance	**MP.2** Reason abstractly and quantitatively. (HS-ESS1-5), (HS-ESS1-6), (HS-ESS2-1) **MP.4** Model with mathematics. (HS-ESS2-1) **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-ESS1-5), (HS-ESS1-6), (HS-ESS2-1) **HSN-Q.A.2** Define appropriate quantities for the purpose of descriptive modeling. *(HS-ESS1-5),(HS-ESS1-6)*,(HS-ESS2-1) **HSN-Q.A.3** Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-ESS1-5), (HS-ESS1-6), (HS-ESS2-1) **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)

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• Evaluate evidence behind currently accepted explanations or solutions to determine the merits of arguments. (HS-ESS1-5) **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-ESS1-6) Models, mechanisms, and explanations collectively serve as tools in the development of a scientific theory. (HS-ESS1-6)		understanding of findings, reasoning, and evidence and to add interest. (HS-ESS2-1)	**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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Students who demonstrate understanding can: **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	**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	How do people reconstruct and date events in Earth's planetary history? How do chemical, physical, and biological processes interact to shape Earth? How do these	**<u>Before</u>:** Students will use the continental "puzzle pieces" to draw motion arrows showing the movement of the continents and predicting the time span that movement occurred. Students will create a	Acid Atomic number Basaltic rock Base Bedding Bowen's reaction series Cementation Chemical bond Chemical reaction Clastic Clastic	Layers of the Earth A science lesson on the layers of the earth. http://www.instructorweb.com/lesson/earthlayers.asp Geologic Time Scale I Students will research the geologic time scale. They will... Identify the four eras. Indicate the time span of each era. Classify major events of each era http://www.geology.wisc.edu/~mu

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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).] **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.] **HS-ESS2-1** Develop a model	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) **ESS2.A: Earth Materials and Systems** Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. (HS-ESS2-1), *(Note: This Disciplinary Core Idea is also addressed by HS-ESS2-2.)* **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. *(ESS2.B Grade 8 GBE) (secondary to HS-ESS1-5)*, (HS-ESS2-	processes shape Earth? Why do the continents move? What are the major causes and effects of radioactive decay and how can it be used to reconstruct the Earth's history?	timeline that shows the age of the universe, our sun, solar system, Earth, and our moon. Students will use response cards to answer questions about the formation processes of structures on the Earth and weathering and erosion. Pretest (This will be the same as the posttest) **<u>During</u>:** Students will analyze the ages and locations of various rock samples to explain the movement of the continental plates. Students will look at radiometric dating of Earth's oldest minerals, meteorites, and the moon and make corrections to their timelines Students will make a mini planet model using play-doh, sand,	sedimentary rock Cleavage Compound Contact metamorphism Covalent bond Cross-bedding Crystal Electron Element Evaporate Extrusive rock Foliated Fractional crystallization Fracture Gem Graded bedding Granitic rock Hardness Hydrothermal metamorphism Igneous rock Intrusive rock Ion Isotope Kimberlite Lava Lithification Luster Mass number Matter Mineral Neutron Nonfoliated Nucleus Ore	seum/hughes/GeoTimeScale1.html <u>Plate Tectonics - Geosphere (V.1.HS.2)</u> This site describes the different plate tectonics of earth's outermost layer. It describes the 3 types of boundaries. There are several problems presented for students to solve. There is a Problem Solving icon at the bottom of the page that outlines a problem solving process to assist the students. http://www.cotf.edu/ete/modules/msese/earthsysflr/plates1.html <u>Plate Tectonic Reconstruction Service - Geosphere (V.1.HS.2)</u> This model is used to create maps of different stages of continental drift and the plate tectonic theory. By changing the time scale on the data chart, a new map of the location of the continents is brought up. http://www.odsn.de/odsn/services/paleomap/paleomap.html <u>Mountain Maker, Earth Shaker - Geosphere (V.1.HS.2)</u> A description of plate tectonics and an illustrative exercise are the main activities of this site. Shockwave plugin is required and may be downloaded from this site http://www.pbs.org/wgbh/aso/tryit/tectonics/

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to illustrate how Earth's internal and surface processes operate at different spatial and temporal scales to form continental and ocean-floor features. [Clarification Statement: Emphasis is on how the appearance of land features (such as mountains, valleys, and plateaus) and sea-floor features (such as trenches, ridges, and seamounts) are a result of both constructive forces (such as volcanism, tectonic uplift, and orogeny) and destructive mechanisms (such as weathering, mass wasting, and coastal erosion).] [*Assessment Boundary: Assessment does not include memorization of the details of the formation of specific geographic features of Earth's surface.*]	1) 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 GBE)* (HS-ESS2-1) **PS1.C: Nuclear Processes** Spontaneous radioactive decays follow a characteristic exponential decay law. Nuclear lifetimes allow radiometric dating to be used to determine the ages of rocks and other materials. *(secondary to HS-ESS1-5),(secondary to HS-ESS1-6)*		rocks, water, and other various materials to demonstrate orogeny, weathering and erosion, new land formations. **<u>After</u>:** Students will use the ages of oceanic and continental crusts to create a seafloor spreading model showing movement and ages Students will write a "rock autobiography" that follows the rocks life through the big bang to present day. Post-test	Partial melting Pegmatite Porosity Porphyritic texture Proton Regional metamorphism Rock cycle Sediment Silicate Solution Specific gravity Streak Tetrahedron Texture Vesicular texture	<u>Plate Tectonic Reconstruction Service - Geosphere (V.1.HS.2)</u> This model is used to create maps of different stages of continental drift and the plate tectonic theory. By changing the time scale on the data chart, a new map of the location of the continents is brought up. <u>http://www.odsn.de/odsn/services/paleomap/paleomap.html</u> <u>CIESE On Line Classroom Projects - Musical Plates - Geosphere (V.1.HS.2)</u> A study of Earthquakes and Plate Tectonics Project. This is an on-line project for students. They are given a scenario where they have to pinpoint recent earthquakes, determine whether or not certain parts of the earth experience more earthquakes than others, determine what is causing the earthquakes, organize the information into a report for the President of the United States. Student reports can be submitted to be published on-line, if accepted. There are hyperlinks where students can access data for their reports. There is also a Teacher Area and an On-Line Help. <u>http://www.k12science.org/curriculum/musicalplates3/en/</u> <u>Earthquakes - Geosphere (V.1.HS.2)</u>

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					This site provides great factual and graphical information concerning earthquakes. Good animated demonstrations. http://www.thetech.org/exhibits/online/topics/31g.html Geology: Plate Tectonics - Geosphere (V.1.HS.2) Very basic discussion of plate tectonics. Has some nice animations, but they take a long time to download. http://www.ucmp.berkeley.edu/geology/tectonics.html Regents Prep Earth Science - Geosphere (V.1.HS.1,2&3) This site has a variety of Earth Science resources appropriate for use by students and teachers. http://regentsprep.org/Regents/earthsci/earthsci.cfm Savage Earth Animations - Geosphere (V.1.HS.2) This site has very good animations of several geologic processes that occur on the earth. All animations have written text to provide further information. http://www.pbs.org/wnet/savageearth/ This Dynamic Earth-USGS - Geosphere (V.1.HS.2) This is an informational website

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					about plate tectonics. It provides some illustrations and maps that may be useful in presentations. http://pubs.usgs.gov/gip/dynamic/dynamic.html Understanding Plate Motions - Geosphere (V.1.HS.2) General information about plate tectonics, describing various plates, boundaries and motions. http://pubs.usgs.gov/gip/dynamic/understanding.html USGS – Geosphere (V.1.HS.1,2,3&4) Includes information about volcanoes, earthquakes, and plate tectonics. Includes activities, models, and much, much more. http://www.usgs.gov/education/learnweb/ice.html Volcano World - Geosphere (V.1.HS.2) Provides information about every volcano in the world. When it last erupted, etc. http://volcano.und.nodak.edu/ Radioactive Half-Life This site discusses carbon dating and how half-life information is used. http://www.ndt-ed.org/EducationResources/HighSchool/Radiography/halflife2.htm Radiocarbon Web-info Site This site has information of C-14

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					dating. http://www.c14dating.com/k12.html DEQ, Geology in Michigan - Geosphere (V.1.HS.1,2&3) New Presentations, classroom materials, and maps of Michigan's geology past and present. Once in this site make sure to go to the "For students and Teachers" link which contains games, lessons, diagrams, pictures, and multimedia. http://www.michigan.gov/deq/0,1607,7-135-3311_3582---,00.html Web Geologic Time Machine - Geosphere (V.1.MS.4) This interactive page could be used by teachers and students to see examples of rock types and fossil evidence for the various time periods. It is very well organized and researched. Perhaps a teacher could devise a set of questions for students to answer as they proceed through the various time periods. http://www.ucmp.berkeley.edu/help/timeform.html

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Time Frame: December – January
Unit 3: Earth's Systems

Science & Engineering Practices	Crosscutting Concepts	Literacy Standards	Mathematics Standards
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), (HS-ESS2-6) **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. • Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. (HS-ESS2-5) **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	**Energy and Matter** The total amount of energy and matter in closed systems is conserved. (HS-ESS2-6) Energy drives the cycling of matter within and between systems. (HS-ESS2-3) **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. (HS-ESS2-5) **Stability and Change** Much of science deals with constructing explanations of how things change and how they remain stable. (HS-ESS2-7) Feedback (negative or positive) can stabilize or destabilize a system. (HS-ESS2-2) **Connections to Engineering, Technology, and Applications of Science** **Interdependence of Science, Engineering, and Technology**	**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-ESS2-2),(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-ESS2-2) **WHST.9-12.1** 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,	**MP.2** Reason abstractly and quantitatively. (HS-ESS2-2), (HS-ESS2-3), (HS-ESS2-6) **MP.4** Model with mathematics. (HS-ESS2-3), (HS-ESS2-6) **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-ESS2-2), (HS-ESS2-3), (HS-ESS2-6) **HSN.Q.A.2** Define appropriate quantities for the purpose of descriptive modeling. (HS-ESS2-3), (HS-ESS2-6) **HSN.Q.A.3** Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-ESS2-2), (HS-ESS2-3), (HS-ESS2-5), (HS-ESS2-6)

Science & Engineering Practices	Crosscutting Concepts	Literacy Standards	Mathematics Standards
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 optimal design solution. (HS-ESS2-2) **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. • Construct an oral and written argument or counter-arguments 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 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-ESS2-3) **Influence of Engineering, Technology, and Science on Society and the Natural World** New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology. (HS-ESS2-2)	graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (HS-ESS2-3)	

Next Generation Science Standards	Core Ideas	Essential Questions	Assessments	Vocabulary	Resources
Students who demonstrate understanding can: **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. [Clarification Statement: Examples should include climate feedbacks, such as how an increase in greenhouse gases causes a rise in global temperatures that melts glacial ice, which reduces the amount of sunlight reflected from Earth's surface, increasing surface temperatures and further reducing the amount of ice. Examples could also be taken from other system interactions, such as how the loss of ground vegetation causes an increase in water runoff and soil erosion; how dammed rivers increase groundwater recharge, decrease sediment transport, and increase coastal erosion; or how the loss of wetlands causes a decrease in local humidity that further reduces the wetland extent.] **HS-ESS2-3** Develop a model based on evidence of Earth's	**ESS2.A: Earth Materials and Systems** Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. (HS-ESS2-2) Evidence from deep probes and seismic waves, reconstructions of historical changes in Earth's surface and its magnetic field, and an understanding of physical and chemical processes lead to a model of Earth with a hot but solid inner core, a liquid outer core, a solid mantle core, a solid mantle and crust. Motions of the mantle and its plates occur primarily through thermal convection, which involves the cycling of matter due to the outward flow of energy from Earth's interior and gravitational movement of denser materials toward the interior. (HS-ESS2-3)	What are the chemical, physical, and biological processes that interact to shape Earth? How do these processes shape Earth? How do scientists know that Earth has discernable layers with distinctive properties? What are the Earth's principal sources of internal and external energy? How does radioactive decay generate heat within the Earth's crust and mantle and what effect does that have on the processes that shape our planet? In what ways are the unique properties of	**<u>Before</u>:** Students write a prediction chain-reaction paper that describes the consequences of global temperature increase Students will draw and label layers of the Earth based on prior knowledge and describe the depths and materials Students participate in a think-pair-share to predict the reasons for the movements of the tectonic plates Students create a brainstorm web as a class for the word "carbon" Pretest (This will be the same as the posttest) **<u>During</u>:** Students with create an Earth Systems in a bottle project that shows how a change in one chamber (terrestrial, aquatic, atmospheric, biologic	Abiotic components of ecosystems Adaptive capacity Advection Atmosphere Atmosphere Atmospheric change Basin shape Biogeochemical cycles Biosphere Boundary Buoyancy Carbon Carbon cycle Carbon dioxide Carbon dioxide reservoir Climate change Climate change models Climate system Climates Climatic zones Conduction Continental Convection Coral bleaching Coriolis effect Currents Deep ocean currents Earth's external energy sources Earth's internal energy sources	<u>Climate Diagnostic Center - Atmosphere & Weather (V.3.HS.1)</u> This site provides climate data, maps, graphs, and links to additional climate sites. <u>http://www.cdc.noaa.gov/USclimate/</u> <u>Great Lakes Climate Change Assessment - Atmosphere & Weather (V.3.HS.1)</u> A report from the University of Michigan about the changing climate in the Great Lakes. It is downloadable by chapters as a .pdf file. It contains chapters on Climate Change and Lake-Effect Snow, Climate Change and River Flows, Water Resources, Water Ecology, Historic Overview and Current Situations. The report can also be ordered by mail. <u>http://www.geo.msu.edu/glra/assessment/assessment.html</u> <u>Climate Prediction Center - Atmosphere & Weather (V.3.HS.3)</u> This is an interactive weather site with long term precipitation trends, drought analysis, ozone depletion rate and weekly weather patterns for North America <u>http://www.cpc.ncep.noaa.gov/index.html</u>

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Next Generation Science Standards	Core Ideas	Essential Questions	Assessments	Vocabulary	Resources
interior to describe the cycling of matter by thermal convection. [Clarification Statement: Emphasis is on both a one-dimensional model of Earth, with radial layers determined by density, and a three-dimensional model, which is controlled by mantle convection and the resulting plate tectonics. Examples of evidence include maps of Earth's three-dimensional structure obtained from seismic waves, records of the rate of change of Earth's magnetic field (as constraints on convection in the outer core), and identification of the composition of Earth's layers from high-pressure laboratory experiments.] **HS-ESS2-5** Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes. [Clarification Statement: Emphasis is on mechanical and chemical investigations with water and a variety of solid materials to provide the evidence for connections between the hydrologic cycle and system interactions commonly known as the rock cycle. Examples of	**ESS2.B: Plate Tectonics and Large-Scale System Interactions** The radioactive decay of unstable isotopes continually generates new energy within Earth's crust and mantle, providing the primary source of the heat that drives mantle convection. Plate tectonics can be viewed as the surface expression of mantle convection. (HS-ESS2-3) **ESS2.C: The Roles of Water in Earth's Surface Processes** The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics. These properties include water's exceptional capacity to absorb, store, and release large amounts of energy, transmit sunlight, expand upon freezing,	water responsible for shaping the Earth's surface and impacting the weather? In what was are fossils useful in reconstructing Earth's geologic history and atmospheric history?	etc.) has an effect on the other systems. Students will collect data during a seismic wave lab that shows how waves travel at different speeds through different mediums. Students explore the movement of heat by participating in a convection lab Students will develop a three dimensional model that shows how convection currents in the outer core are responsible for the movement of the plate tectonics. Students will plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes Students draw a picture that includes quantities of carbon found throughout all of the Earth's spheres	El Nino-Southern Oscillation (ENSO) Emissions Estuarine impacts Evaporation External energy sources Fossil fuels Fossils Geologic record Geomorphology Global atmospheric circulation Greenhouse effect Greenhouse gases Harvesting of resources Heat reservoir (oceans, large lakes) Heat transfer of ocean currents Human industrialization Hydrosphere Ice core Interactions of Earth's systems Limestone Maritime climates Methane Natural mechanisms Nitrous oxide Ocean currents Ocean layers Ocean-atmospheric	National Weather Service - Detroit/Pontiac -Michigan Forecast Center - Atmosphere & Weather (V.3.HS.3) The Weather World 2010 Project - Meteorology - Atmosphere & Weather (V.3.HS.1, 2 & 3) This site is a great weather resource, including explanations, animations, student activity sheets, and teacher answer guides. http://ww2010.atmos.uiuc.edu/(Gh)/guides/mtr/home.rxml Geomysteries - Geosphere (V.1.MS.2) This is an outstanding interactive web site. It has excellent pictures, video, and animation of several rocks, their properties, and how igneous, metamorphic, and sedimentary rocks are formed, complete with an interactive geologic timeline. In addition, it also has a question answer section which briefly asks students to respond, to check their understanding of the material. Three major mysteries must be solved by students: Mystery of the Floating Rock (lava), Broken Necklace (fossils), and Golden Cube (Pyrite vs. Gold). Under the mystery of the Golden Cube students will discover why crystals have different shapes and that minerals can be classified

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Next Generation Science Standards	Core Ideas	Essential Questions	Assessments	Vocabulary	Resources
mechanical investigations include stream transportation and deposition using a stream table, erosion using variations in soil moisture content, or frost wedging by the expansion of water as it freezes. Examples of chemical investigations include chemical weathering and recrystallization (by testing the solubility of different materials) or melt generation (by examining how water lowers the melting temperature of most solids).] **HS-ESS2-6** Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere. [Clarification Statement: Emphasis is on modeling biogeochemical cycles that include the cycling of carbon through the ocean, atmosphere, soil, and biosphere (including humans), providing the foundation for living organisms.] **HS-ESS2-7** Construct an argument based on evidence about the simultaneous coevolution of Earth's systems and life on Earth. [Clarification Statement:	dissolve and transport materials, and lower the viscosities and melting points of rocks. (HS-ESS2-5) **ESS2.D: Weather and Climate** The foundation for Earth's global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's re-radiation into space. (HS-ESS2-2) Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen. (HS-ESS2-6),(HS-ESS2-7) Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect		**<u>After</u>:** Students analyze data collected during the Earth's system project and synthesize their results in a formal lab report Students present their findings of their water investigations in an oral presentation Students create a story "My life as a carbon atom" that follows the carbon throughout the spheres and describes quantities and functions in each sphere. Construct an argument based on evidence about the simultaneous coevolution of Earth's systems and life on Earth. Posttest	interactions Organic matter Ozone Polar ice caps Precipitation Prevailing winds Properties of waves Radiation Regional climates Release of energy Salinity Seawater density Shoreline impacts Striations Thermal energy Thermohaline circulation Trapping mechanisms Unequal heating Unequal heating of air Unequal heating of land masses Unequal heating of oceans Varves Volcanic eruptions water density Water vapor	according to their hardness, color, density, cleavage and fracture. Students can also see fast facts or check out where they could go for a field trip. Several links for state geological survey units are provided. http://www.childrensmuseum.org/geomysteries/index2.html <u>The Rock Cycle - Geosphere (V.1.MS.3)</u> The basics on the rock cycle. http://www.moorlandschool.co.uk/earth/rockcycle.htm

Next Generation Science Standards	Core Ideas	Essential Questions	Assessments	Vocabulary	Resources
Emphasis is on the dynamic causes, effects, and feedbacks between the biosphere and Earth's other systems, whereby geoscience factors control the evolution of life, which in turn continuously alters Earth's surface. Examples of include how photosynthetic life altered the atmosphere through the production of oxygen, which in turn increased weathering rates and allowed for the evolution of animal life; how microbial life on land increased the formation of soil, which in turn allowed for the evolution of land plants; or how the evolution of corals created reefs that altered patterns of erosion and deposition along coastlines and provided habitats for the evolution of new life forms.] [*Assessment Boundary: Assessment does not include a comprehensive understanding of the mechanisms of how the biosphere interacts with all of Earth's other systems.*]	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)				

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Science Pacing Guide
Earth Science

Time Frame: February – April
Unit 4: Weather and Climate

Science & Engineering Practices	Crosscutting Concepts	Literacy Standards	Mathematics Standards
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) **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** Science investigations use diverse methods and do not always use the same set of procedures to obtain data. (HS-ESS3-5) New technologies advance scientific knowledge. (HS-ESS3-5) **Scientific Knowledge is Based on Empirical Evidence** Science knowledge is based on empirical	**Cause and Effect** Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-ESS2-4) **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)	**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-ESS3-5) **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-ESS3-5) **RST.11-12.7** Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. (HS-ESS3-5) **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-ESS2-4)	**MP.2** Reason abstractly and quantitatively. (HS-ESS2-4), (HS-ESS3-5) **MP.4** Model with mathematics. (HS-ESS2-4) **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-ESS2-4), (HS-ESS3-5) **HSN.Q.A.2** Define appropriate quantities for the purpose of descriptive modeling. (HS-ESS2-4), (HS-ESS3-5) **HSN.Q.A.3** Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-ESS2-4), (HS-ESS3-5)

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Science & Engineering Practices	Crosscutting Concepts	Literacy Standards	Mathematics Standards
evidence. (HS-ESS3-5) Science arguments are strengthened by multiple lines of evidence supporting a single explanation. (HS-ESS2-4),(HS-ESS3-5)			

Next Generation Science Standards	Core Ideas	Essential Questions	Assessments	Vocabulary	Resources
Students who demonstrate understanding can: **HS-ESS2-4** Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate. [Clarification Statement: Examples of the causes of climate change differ by timescale, over 1-10 years: large volcanic eruption, ocean circulation; 10-100s of years: changes in human activity, ocean circulation, solar output; 10-100s of thousands of years: changes to Earth's orbit and the orientation of its axis; and 10-100s of millions of years: long-term changes in atmospheric composition.] [*Assessment Boundary: Assessment of the results of changes in climate is limited to changes in surface temperatures, precipitation patterns, glacial ice volumes, sea levels, and biosphere*	**ESS1.B: Earth and the Solar System** Cyclical changes in the shape of Earth's orbit around the sun, together with changes in the tilt of the planet's axis of rotation, both occurring over hundreds of thousands of years, have altered the intensity and distribution of sunlight falling on the earth. These phenomena cause a cycle of ice ages and other gradual climate changes. *(secondary to HS-ESS2-4)* **ESS2.A: Earth Materials and Systems** The geological record shows that changes to global and regional climate can be caused by interactions among changes in the sun's energy output or Earth's orbit, tectonic events, ocean circulation, volcanic	What are the main sources of energy to the climate system? How is the climate affected by greenhouse gases? What natural mechanisms could result in significant changes in climate? What are the consequences of warmer oceans? How does the current melting of polar ice caps impact the climate system? What geological evidence that implies that	**<u>Before</u>:** Pretest (This will be the same as the posttest) Students will complete an "ABC graffiti" for weather and climate Students will brainstorm the locations and effects and causes of severe weather **<u>During</u>:** Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate. Students will research and report	<u>State vocabulary</u> Adiabatic cooling Advection Air density Air masses Blizzards Clouds Conduction Convection Convergence Downbursts Drought Dry lines External energy Sources Flooding Frontal boundaries Frontal wedging Fronts Hail Heavy rain Hurricanes Lightning Mitigation Precipitation Radiation Seasonal variations Severe weather	<u>Meteorology - Atmosphere & Weather (V.3.HS.1,2&3)</u> The Online Meteorology Guide is a collection of web-based instructional modules that use multimedia technology and the dynamic capabilities of the web. These resources incorporate text, colorful diagrams, animations, computer simulations, audio and video to introduce fundamental concepts in the atmospheric sciences. Selected pages link to (or will soon link to) relevant classroom activities and current weather products to reinforce topics discussed in the modules and allow the user to apply what has been learned to real-time weather data. <u>http://ww2010.atmos.uiuc.edu/(Gh)/guides/mtr/home.rxml</u> <u>The Weather World 2010 Project - Meteorology - Atmosphere & Weather (V.3.HS.1,2&3)</u> This site is a great weather

Next Generation Science Standards	Core Ideas	Essential Questions	Assessments	Vocabulary	Resources
distribution.] **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: Assessment is limited to one example of a climate change and its associated impacts.*]	activity, glaciers, vegetation, and human activities. These changes can occur on a variety of time scales from sudden (e.g., volcanic ash clouds) to intermediate (ice ages) to very long-term tectonic cycles. (HS-ESS2-4) **ESS2.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) Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate. (HS-ESS2-6), (HS-ESS2-4) **ESS3.D: Global Climate Change** Though the magnitudes of human impacts are greater than they have ever been, so too are human abilities to model, predict, and	climates were significantly colder at times in the geologic record?	on weather and climate from a particular time and place from the past and use geologic and atmospheric evidence to explain the reasons for the weather and climate. **<u>After</u>:** Students will make a "public service commercial" that uses geoscience data to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems Posttest	Thermal energy Thunderstorms Tornadoes Ultraviolet radiation Waves Wind shear <u>Additional vocabulary</u> Convection current Pressure Unequal heating of air Unequal heating of land masses unequal heating of oceans	resource, including explanations, animations, student activity sheets, and teacher answer guides. http://ww2010.atmos.uiuc.edu/(Gh)/home.rxml

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Next Generation Science Standards	Core Ideas	Essential Questions	Assessments	Vocabulary	Resources
	manage current and future impacts. (HS-ESS3-5)				

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Science Pacing Guide
Earth Science

Time Frame: April – June
Unit 5: Human Sustainability

Science & Engineering Practices	Crosscutting Concepts	Literacy Standards	Mathematics Standards
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) • Use a computational representation of phenomena or design solutions to describe and/or support claims and/or explanations. (HS-ESS3-6) **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	**Cause and Effect** Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-ESS3-1) **Systems and System Models** When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models. (HS-ESS3-6) **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-ESS3-3) Feedback (negative or positive) can stabilize or destabilize a system. (HS-ESS3-4) **Connections to Engineering, Technology, and Applications of Science** **Influence of Science, Engineering, and Technology on Society and the Natural World** Modern civilization depends on major	**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-ESS3-1), (HS-ESS3-2), (HS-ESS3-4) **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-ESS3-2), (HS-ESS3-4) **WHST.9-12.2** Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-ESS3-1)	**MP.2** Reason abstractly and quantitatively. (HS-ESS3-1), (HS-ESS3-2), (HS-ESS3-3), (HS-ESS3-4), (HS-ESS3-6) **MP.4** Model with mathematics. (HS-ESS3-3), (HS-ESS3-6) **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-ESS3-1), (HS-ESS3-4), (HS-ESS3-6) **HSN.Q.A.2** Define appropriate quantities for the purpose of descriptive modeling. (HS-ESS3-1), (HS-ESS3-4), (HS-ESS3-6) **HSN.Q.A.3** Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-ESS3-1), (HS-ESS3-4), (HS-ESS3-6)

Science & Engineering Practices	Crosscutting Concepts	Literacy Standards	Mathematics Standards
knowledge, 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 operate today as they did in the past and will continue to do so in the future. (HS-ESS3-1) • 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) **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 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	technological systems. (HS-ESS3-1),(HS-ESS3-3) 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),(HS-ESS3-4) New technologies can have deep impacts on society and the environment, including some that were not anticipated. (HS-ESS3-3) Analysis of costs and benefits is a critical aspect of decisions about technology. (HS-ESS3-2) **Connections to Nature of Science** **Science is a Human Endeavor** Science is a result of human endeavors, imagination, and creativity. (HS-ESS3-3) **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) 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. (HS-		

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Science & Engineering Practices	Crosscutting Concepts	Literacy Standards	Mathematics Standards
considerations). (HS-ESS3-2)	ESS3-2) Many decisions are not made using science alone, but rely on social and cultural contexts to resolve issues. (HS-ESS3-2)		

Next Generation Science Standards	Core Ideas	Essential Questions	Assessments	Vocabulary	Resources
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 and 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	**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 biosphere. *(secondary to HS-ESS3-6)* **ESS3.A: Natural Resources** Resource availability has guided the development of human society. (HS-ESS3-1) All forms of energy production and other	How does energy exist in the Earth system? What impact do elements and compounds have on the biosphere and human health? What impact do humans have on the Earth Systems? What are the differences in the kinds of and the use of both renewable and nonrenewable sources of energy? How do elements exist in different compounds and states as they	**Before**: Students answer “thumbs-up thumbs-down” questions Students will complete a KWL chart for human sustainability Pretest (This will be the same as the posttest) **During**: Students will revisit their KWL and add what they learned about human sustainability. Students will research multiple design solutions for developing, managing, and utilizing energy and	Aggregate Bedrock Biomass fuel Cogeneration Desalination Desertification Energy efficiency Fossil fuel Fuel Geothermal energy Hydrocarbon Hydroelectric power Hydrogen bond Natural resource Nonrenewable resource Nuclear fission Ore Peat Photovoltaic cell Renewable resource Sustainable energy Sustainable yield	Nitrogen Cycles Project http://www.sws.uiuc.edu/nitro/biogen.asp U.S. Global Change Research Program Each year a report, (Our Changing Planet) is published by this program. The latest year's version is downloadable from this site. The report is about 75 pages but it can be printed off all at once or in sections. The report includes how the changing geosphere affects the atmosphere and weather. There are six focus areas on the site; Atmospheric Composition, Changes in Ecosystems, Global Carbon Cycle, Human Dimensions, Climate Variability and Change, and Global Water Cycle. Information on El Nino with daily graphs of the temperature of the Pacific Ocean is included Highlights section. http://www.usgcrp.gov/usgcrp/ProgramElements/carbon.htm

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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	resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors. (HS-ESS3-2) **ESS3.B: Natural Hazards** Natural hazards and other geologic events have shaped the course of human history; [they] have significantly altered the sizes of human populations and have driven human migrations. (HS-ESS3-1) **ESS3.C: Human Impacts on Earth Systems** The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources. (HS-ESS3-3) Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude ecosystem degradation. (HS-ESS3-4) **ESS3.D: Global Climate**	move to different reservoirs? What forms of carbon exist and how are they beneficial or harmful to humans? Some chemical forms may be beneficial for life, but in large quantities they are poisonous. How is this possible? What are some of the positive and negative unintended consciences of technology?	mineral resources based on cost-benefit ratios. Students be civil engineers that design a city based on evaluations or refining of a technological solution that reduces impacts of human activities on natural systems **<u>After</u>:** Students will create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity. Students will debate for or against energy resources, certain agricultural soil use, mining, and pumping. Civil engineering design will be modeled and	Tailings	[Garbage, How can my community reduce waste? - Geosphere (V.1.HS.3&4)](http://www.learner.org/exhibits/garbage/intro.html) This interactive site allows students to apply their knowledge of recycling in reducing wastes. The site shows costs involved to recycle and the benefits. http://www.learner.org/exhibits/garbage/intro.html [Dumptown Game - Geosphere (V.1.HS.4)](http://www.epa.gov/recyclecity/gameintro.htm) This is a game where students are allowed to try different methods to recycle and then see the effects on Dumptown. There are other activities on this site and suggestions on how teachers can use the game in the classroom. http://www.epa.gov/recyclecity/gameintro.htm

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Next Generation Science Standards	Core Ideas	Essential Questions	Assessments	Vocabulary	Resources
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: Assessment for 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 for 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	**Change** 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. (HS-ESS3-6) **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),(secondary HS-ESS3-4)*		presented Posttest		

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temperatures by making large changes to the atmosphere or ocean).] **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 hydrosphere, 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: Assessment does not include running computational representations but is limited to using the published results of scientific computational models.*]					