# High School Earth and Space Science

**Instructional Focus:**

- Describe the Scientific Method in solving a problem or question.
- Demonstrate the scientific method by identifying the relationship between a manipulated/independent variable and a responding/dependent variable.
- Given a data set, develop an appropriate, correctly labeled data table and graph.
- Using graphs and data tables; identify trends and analyze these trends to support conclusions.
- Write conclusions that are logical and supported by evidence.
- Solve a problem or question, of your own design, applying the various steps of the scientific method.

| Objective | Examples |
|---|---|
| ***Star Life Cycle***<br>Students will:<br>• Differentiate between the different types of stars, including our sun, found on the Hertz sprung-Russell diagram.<br>• Compare and contrast the evolution of stars of different masses.<br>• Explain the formation of elements that results from nuclear fusion occurring within stars or supernova explosions. | • Emphasis is on the energy transfer mechanisms that allow energy from nuclear fusion in the sun's core to reach Earth.<br>• 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. |

**Standards**

**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. **HS.ESS1-3.** Communicate scientific ideas about the way stars, over their life cycle, produce elements. **HS.ESS1.A.** Earth and its solar system are part of the Milky Way galaxy, which is one of many galaxies in the universe. **MSBSD.PS3.D.** Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment.

| Objective | Examples |
|---|---|
| ***Big Bang Theory***<br>Students will:<br>• Describe the evidence that supports the big bang theory and the expansion of the universe including the red shift of light from distant galaxies and the cosmic background microwave radiation. | • 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). |

**Standards**

**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. **HS.ESS1.A.** Earth and its solar system are part of the Milky Way galaxy, which is one of many galaxies in the universe.

| Objective | Examples |
|---|---|
| ***Formation of the Solar System***<br>Students will:<br>• Understand and discuss the nebular theory concerning the formation of solar systems.<br>• Describe the motions of the various kinds of objects in our solar system. (e.g., planets, satellites, comets and asteroids)<br>• Explain that Kepler's laws determine the orbits of those objects and know that Kepler's laws are a direct consequence of Newton's Law of Universal.<br>• Gravitation together with his laws of motion. | • Emphasis is on Newtonian gravitational laws governing orbital motions, which apply to human-made satellites as well as planets and moons.<br>• 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. |

**Standards**

**HS.ESS1-4.** Use mathematical or computational representations to predict the motion of orbiting objects in the solar system. **HS.ESS1.B.** The solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them. The solar system appears to have formed from a disk of dust and gas, drawn together by gravity.

| Objective | Examples |
|---|---|
| ***Aurora***<br>Students will:<br>• Explain that excited particles in matter lead to the formation of aurora borealis. | |
| **Standards** | |
| Describe the Phenomena of the Aurora | |
| **Objective** | **Examples** |
| ***Plate Tectonics***<br>Students will:<br>• Understand and discuss the development of plate tectonic theory including continental drift and seafloor spreading.<br>• Describe how radioactive decay is used to determine the ages of rocks and other minerals.<br>• Explain that the origin of geologic features and processes result from plate tectonics including earthquakes, volcanoes, trenches and mountain ranges. | • Emphasis is on the ability of plate tectonics to explain the ages of crustal rocks.<br>• 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 decreasing with distance away from a central ancient core (a result of past plate interactions). |
| **Standards** | |
| **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. **HS.ESS1.C** 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.ESS2.B.** Plate tech tonics 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. **MSBSD.PS1.C.** 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. | |
| **Objective** | **Examples** |
| ***Geologic Process***<br>Students will:<br>• Identify that geologic processes have destroyed early rock record on Earth, other objects in the solar system, (lunar rocks, asteroids, and meteorites) can provide information about Earth's formation and early history.<br>• Discuss current theories for the formation of Earth's moon. | • 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.<br>• 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. |
| **Standards** | |
| **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 and history. **HS.ESS1.C.** Although active geological 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. | |
| **Objective** | **Examples** |
| ***The Earth's Structure***<br>Students will:<br>• Explain the differentiation of the structure of Earth's layers into a core, mantle, and crust compare types of plate boundaries.<br>• Describe how seismic waves can be used to study and gather data regarding earthquakes. | • 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.<br>• 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. |
| **Standards** | |
| **HS.ESS2-3.** Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection. **HS.ESS2.A** All Earth processes are the result of energy flowing and matter cycling within and among the planet's systems. This energy is derived from the sun and Earth's hot interior. The energy that flows and matter that cycles produce chemical and physical changes in Earth's materials and living organisms. **MSBSD.PS4.A** The wavelength and frequency of a wave are related to one another by the speed of travel of the wave, which depends on the type of wave and the medium through which it is passing. | |

| Objective | Examples |
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| ***Hydrology***<br>Students will:<br>• Describe the relationships among evaporation, precipitation, ground water, surface water, and glacial systems in the water cycle.<br>• Examine the effects of changes to the water cycle on earth's surface including freeze/thaw, permafrost, glaciation, salinity and sea level rise.<br>• Analyze the dynamic interaction of erosion and deposition and propose solutions to local problems. (Coastal erosion, Matanuska River)<br>• Analyze surface features of Earth in order to identify geologic processes (including weathering, erosion, deposition, and glaciation) that are likely to have been responsible for their formation.<br>• Discuss the effect of human interactions with the water cycle. | • 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.<br>• Examples of 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.<br>• 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). |

**Standards**

**HS.ESS2-5.** Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes. **HS.ESS2.C.** The abundance of liquid water on Earth's surface and it unique combination of physical and chemical properties are central to the planet's dynamics. These properties include water's exceptional capacity to absorb, store, a d release large amounts of energy, transmit sunlight, expand upon freeing, dissolve and transport materials, and lower the viscosities and melting points of rocks.

| Objective | Examples |
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| ***Carbon Cycle and Climate Change***<br>Students will:<br>• Summarize the changes in Earth's atmosphere over geologic time (including the importance of photosynthesizing organisms to the atmosphere).<br>• Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.<br>• Describe how geographic influences and human actions contribute to global climate.<br>• Describe the factors that contribute to the greenhouse effect.<br>• Give examples of how Earth's dynamic systems can cause feedback effects that can increase or decrease the original changed.<br>• Identify how changes in global temperature and ocean acidity can alter the distribution of living organisms. | • 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.<br>• 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.<br>• 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.<br>• 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). |

**Standards**

**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. **HS.ESS2-6.** Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere. **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. **HS.ESS3-6. HS.ESS2.A** Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. **HS.ESS2.D** 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.** Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate. **HS.ETS1-1.** Analyze a major global challenge to specify qualitative and quantitative criteria and constraints that account for societal needs and wants.

| Objective | Examples |
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| ***Co-Evolution of Earth and Life***<br>Students will:<br>• Describe that dynamic feedbacks between the biosphere and other Earth systems cause a continual co-evolution of Earth's surface and the life that exists on it.<br>• Discuss examples of the interrelatedness of geologic and biologic changes throughout the history of Earth. | • 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.<br>• 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. |
| **Standards** | |
| **HS.ESS2-7.** Construct an argument based on evidence about the simultaneous coevolution of Earth's systems and life on Earth. **HS.ESS2.D** Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen. **HS.ESS2.E** 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. | |
| **Objective** | **Examples** |
| ***Natural Resources***<br>Students will:<br>• Compare renewable and non- renewable resources.<br>• Describe the impact of human use of both renewable and non-renewable resources.<br>• Identify how resource availability has guided the development of human society.<br>• Discuss how the dynamic nature of Earth has influenced human activities. | • 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.<br>• 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).<br>• Examples of the results of changes in climate that can affect populations or drive mass migrations include changes to sea level, regional patterns of temperature and precipitation, and the types of crops and livestock that can be raised.<br>• 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.<br>• 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. |
| **Standards** | |
| **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. **HS.ESS3-2.** Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios. **HS.ESS3.A** Resource availability has guided the development of human society. **HS. ESS3.B** 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.ETS1.B.** | |

| Objective | Examples |
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| ***Human Impact***<br>Students will:<br>• Describe how the sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources.<br>• Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.<br>• Use a computer model to evaluate the sustainability of human activities. | • Examples of factors that affect the management of natural resources include costs of resource extraction and waste management, per-capita consumption, and the development of new technologies.<br>• Examples of factors that affect human sustainability include agricultural efficiency, levels of conservation, and urban planning.<br>• 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).<br>• Examples for limiting future impacts could range from local efforts (such as reducing, reusing, and recycling resources) to large-scale geoengineering design solutions (such as altering global temperatures by making large changes to the atmosphere or ocean). |

| Standards |
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| **HS.ESS3-3.** Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity. **HS.ESS3-4.** Evaluate or refine a technological solution that reduces impacts of human activities on natural systems. **HS.ESS3.C.** The sustainability of human societies and the biodiversity that supports them requires responsible management of natural migrations. |

| Objective | Examples |
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| Students will:<br>• Analyze the criteria and constraints that may satisfy any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them.<br>• Understand that humanity faces major global challenges today, such as the need for supplies of clean water and food or for energy sources that minimize pollution, which can be addressed through engineering. These global challenges also may have manifestations in local communities.<br>• Design a concept map that outlines the influencing factors in a global resource challenge. | |

| Standards |
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| **HS.ETS1-1.** Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants. **HS.ETS1.A** Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. Humanity faces major global challenges today, such as the need for supplies of clean water and food or for energy sources that minimize engineering. These global challenges also may have manifestations in local communities. |

| Objective | Examples |
|---|---|
| Students will:<br>• Develop a criteria that may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed.<br>• List pros and cons for a real-world solution to a complex problem.<br>• Evaluate the costs and benefits of a solution to a complex problem. | |

| Standards | |
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| **HS.ETS1-2.** Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering. **HS.ETS1.C** Criteria may need to be broken down into simpler ones that can be approached systemically, and decisions about the priority of certain criteria over others (trade-offs) may be needed. | |
| **Objective** | **Examples** |
| Students will:<br>• Evaluate a solution, 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. | |
| **Standards** | |
| **HS.ETS1-3.** Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts. **HS.ETS1.B** 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. | |
| **Objective** | **Examples** |
| Students will:<br>• Develop both physical models and computers that can be used in various ways to aid in the engineering design process.<br>• Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs. | |
| **Standards** | |
| **HS.ETS1-4.** Use a computer simulation to model the impact of proposed solutions to a complex real- world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem. **HS.ETS1.B** Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs. | |