



SPACE AND PLANETARY SCIENCE 11-12

Approved by KSD Board of Education: (2019)

Course Description:

The study of the sky and planets builds on our innate sense of curiosity and wonder about the universe we live in from the near and relatively new to the very distant and old. The roots of Astronomy and Planetary Sciences lie in the observations made by our distant ancestors who first noticed and then used patterns that exist all around us. Over millennia, humans have used the process of science to understand the underlying causes of these patterns – and each new understanding led to more questions and deeper study. The experiences in this class will enable students to understand the interdependent relationships we have with the natural world and connect us with the experiences of and knowledge learned by those who have come before us.

Grade Level: 11th-12th Grade

Unit Scope and Sequence

Unit 1: Patterns in the Sky

Unit 2: The Cosmic Distance Ladder (Part 1)

Unit 3: Solar Systems, Gravity, & Orbits

Unit 4: Light, the Electromagnetic Spectrum, and Telescopes

Unit 5: The Sun

Unit 6: The Stars

Unit 7: Cosmology

Unit 8: Planetary Science: Abiotic Causes of Change

Unit 9: Planetary Systems & Cycles

Unit 10: The Interconnectedness of Life & the Planets

Course Enduring Understandings:

- The study of events and objects that can be observed and studied with the naked eye will lead to an understanding of our place in the universe and the physical laws that govern systems and interactions.
- Light reaches us from objects from across the entire universe. We can determine the properties and cycles of stars and build evidence-based models of the beginning, past, and future characteristics of the universe.
- By studying the Earth and other planets and moons we can understand their properties, structures, and how they change over time. Humans have a unique impact on our planet and can respond to challenges and opportunities.

Course Essential Questions:

- How do the physical laws observed in the universe help us understand our place within it and the systems that govern our planet?
- In what ways does the study of light from distant stars contribute to our understanding of the universe's history and future?
- What are the key ways in which human activities influence Earth's systems, and how can we address the challenges and opportunities this presents?

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Unit 1: Patterns in the Sky

During this unit, students will study ground and sky coordinate systems. They will also explore patterns in the stars, moon, sun and planets.

Unit Essential Learning Targets	
<i>Enduring Understandings</i>	<i>Essential Questions</i>
• Patterns exist in the positions and motions of objects in the sky. • These can be patterns can be identified through observation and data collection and used to make predictions about future events. • Human recognition and use of these patterns established a way of thinking about the world that led to the development of science as a process.	• How can we identify and analyze patterns in the positions and motions of celestial objects to make predictions about future astronomical events? • In what ways has the recognition of patterns in the natural world shaped the development of scientific thought and inquiry?
<i>Students must know:</i>	<i>Students must be able to:</i>
• latitude/longitude identification • Altitude, Azimuth, Zenith identification • Equator • Tropics of Cancer & Capricorn • Arctic & Antarctic Circle • (Identify) the phases of the moon • Solar & Lunar Eclipses	• Qualitatively describe the changes in path the sun follows across the sky in St. Louis in different seasons. • Construct a model explaining the changing visibility of stars in the night sky. • Construct a model explaining the phases of the moon and the relative locations of the Earth, moon, & sun. • Construct a model explaining the sun's path across the sky and the resulting daylight, surface temperature, & seasonal conditions. Use the model to predict changes over time. • Predict sun & star position when given latitude, longitude, and time.

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Unit 1: Patterns in the Sky

Missouri Learning Standards

Priority Standard: Develop and use a model of the Earth-sun-moon system to explain the cyclic patterns of lunar phases and eclipses of the sun and moon. [Clarification Statement: Examples of models can be physical, graphical, or conceptual and should emphasize relative positions and distances.] (6-8.ESS1.A.1)

Priority Standard: Develop and use a model of the Earth-sun system to explain the cyclical pattern of seasons, which includes the Earth's tilt and directional angle of sunlight on different areas of Earth across the year. [Clarification Statement: Examples of models can be physical, graphical, or conceptual.] (6-8.ESS1.A.2)

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Unit 2: The Cosmic Distance Ladder (Part 1)

During this unit, students will study the size of the Earth, sun and moon. They will also explore distances with relation to the sun, moon, Earth and stars.

Unit Essential Learning Targets	
<i>Enduring Understandings</i>	<i>Essential Questions</i>
Combining a knowledge of Earth, moon, sun and star patterns with mathematical and proportional reasoning enables us to indirectly measure the sizes of and distance to astronomical objects.	- How can we apply mathematical concepts and proportional reasoning to understand the relationships between the Earth, moon, sun, and stars? - In what ways do patterns in the movements of celestial bodies help us indirectly measure their sizes and distances?
<i>Students must know:</i>	<i>Students must be able to:</i>
Parallax phenomenon & its limitations	- Construct a diagram that shows the relative sizes of and distances between the Earth, moon, and sun. - Use the phenomena of parallax to make quantitative calculations of distance. - Evaluate the methods used by early astronomers to measure sizes of and distances to the Earth, moon, and sun in order to identify potential sources of error and ways that measurements could be made more accurate.

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Unit 2: The Cosmic Distance Ladder (Part 1)

Missouri Learning Standards

Priority Standard: Apply geometric methods to solve design mathematical modeling problems (G.MG.A.3).

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Unit 3: Solar Systems, Gravity, & Orbits

In this unit, students will study models of the Earth and sun including orbits, and gravity. Further, they will apply Kepler's Laws of Planetary Motion and Newton's Law of Gravitation.

Unit Essential Learning Targets	
<i>Enduring Understandings</i>	<i>Essential Questions</i>
The self-correcting nature of science and our ability to build on the discoveries of previous generations led to an accurate and complete model of our solar system and an understanding of orbits and gravity.	In what ways do the discoveries of previous generations influence current scientific models and our current understanding of orbits and gravity?
<i>Students must know:</i>	<i>Students must be able to:</i>
- Kepler's Three Laws of Planetary Motion - Newton's Law of Gravitation - Geocentric Model of the Solar System - Heliocentric Model of the Solar System	- Construct, use, and/or present an oral and written argument or counter-arguments based on data and evidence for either model of the Solar System. - Combine Kepler's Laws and Newton's Law of Gravitation to predict the motion of orbiting objects (moons, planets, and human-made satellites) in the solar system and around other stars.

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Unit 3: Solar Systems, Gravity, & Orbits

Missouri Learning Standards

Priority Standard: Create and analyze a graph to use as evidence to support the claim that gravitational interactions depend on the mass of interacting objects. [Clarification Statement: Examples of evidence for arguments could include data generated from simulations or digital tools; and charts displaying mass, strength of interaction, distance from the Sun, and orbital periods of objects within the solar system.] (6-8.PS2.B.2)

Priority Standard: Use mathematical representations of Newton's Law of Gravitation to describe and predict the gravitational forces between objects. [Clarification Statement: Emphasis is on both quantitative and conceptual descriptions of gravitational fields.] (9-12.PS2.B.1)

Priority Standard: Develop and use a model to describe the role of gravity in the motions within galaxies and the solar system. [Clarification Statement: Emphasis for the model is on gravity as the force that holds together the solar system and Milky Way galaxy and controls orbital motions within them. Examples of models can be physical or conceptual.] (6-8.ESS1.A.3)

Priority Standard: 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] (NGSS HS-ESS1-4)

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Unit 4: Light, the Electromagnetic Spectrum & Telescopes

Students will explore the characteristics of waves and of light as it relates to the composition of materials, motion, temperature, and distance. They will also explore the relationship between light and telescopes; telescope views across the electromagnetic spectrum will be studied.

Unit Essential Learning Targets	
<i>Enduring Understandings</i>	<i>Essential Questions</i>
From our vantage point on Earth we are able to observe and analyze only the light that comes to us from distant astronomical objects. Our ability to collect and analyze this light has enabled us to access a great deal of information hidden within it and construct an understanding of objects and phenomena that are very distance or old.	How does the analysis of light from distant astronomical objects enhance our understanding of the universe's history and the characteristics of these objects?
<i>Students must know:</i>	<i>Students must be able to:</i>
- Electromagnetic spectrum - Wavelength - Frequency - Doppler Effect (redshift and blueshift) - Reflection - Refraction - Convex lens - Concave lens	- Explain why different elements have different emission and absorption spectra. - Explain the relationship between the color of light emitted by an object and its temperature. - Explain qualitatively the relationship between the apparent brightness of a light source and its distance. - Calculate or measure wave speed, frequency, and wavelength. - Conduct an experiment to collect evidence that supports the claim that light exhibits wave properties. - Determine the elements present in a sample by the spectrum of light it emits or absorbs. - Quantitatively and quantitatively use the Doppler Effect determine the speed and direction of an object. - Arrange curved mirrors and lenses to create a telescope. - Summarize ideal telescope locations and barriers to using telescopes.

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Unit 4: Light, the Electromagnetic Spectrum & Telescopes

Missouri Learning Standards

Priority Standard: Use mathematical representations to describe a simple model for waves that includes how the amplitude of a wave is related to the energy in a wave. [Clarification Statement: Emphasis is on describing waves with both qualitative and quantitative thinking.] (6-8.PS4.A.1)

Priority Standard: Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials. [Clarification Statement: Emphasis is on both light and mechanical waves. Examples of models could include drawings, simulations, and written descriptions.] (6-8.PS4.A.2)

Supporting Standard:

- **Priority Standard: Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter. [Clarification Statement: Emphasis is on the idea that photons associated with different frequencies of light have different energies, and the damage to living tissue from electromagnetic radiation depends on the energy of the radiation. Examples of published materials could include trade books, magazines, web resources, videos, and other passages that may reflect bias. Assessment Boundary: Assessment is limited to qualitative descriptions.] (9-12.PS4.B.2)**

Priority Standard: Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media. [Clarification Statement: Examples of data could include electromagnetic radiation traveling in a vacuum and glass, sound waves traveling through air and water, and seismic waves traveling through the Earth. Assessment Boundary: Assessment is limited to algebraic relationships and describing those relationships qualitatively.] (9-12.PS4.A.1)

Priority Standard: Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other. [Clarification Statement: Emphasis is on how the experimental evidence supports the claim and how a theory is generally modified in light of new evidence. Examples of a phenomenon could include resonance, interference, diffraction, and photoelectric effect. Assessment Boundary: Assessment does not include using quantum theory.] (9-12.PS4.A.2)

Priority Standard: Communicate technical information about how electromagnetic radiation interacts with matter. [Clarification Statement: Examples could include solar cells capturing light and converting it to electricity; medical imaging; and communications technology. Assessment Boundary: Assessments are limited to qualitative information. Assessments do not include band theory.] (9-12.PS4.B.1)

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Unit 5: The Sun

Students will study the structure and function of the sun. They will also explore solar surface structure activity as well as Earth and space weather.

Unit Essential Learning Targets	
<i>Enduring Understandings</i>	<i>Essential Questions</i>
• The sun is a dynamic object, with internal structures and processes, history and future. • The activity on the sun impacts conditions, life and human-constructed infrastructure on Earth.	• What internal processes and structures of the sun contribute to its dynamic nature, and how do these factors influence its behavior over time? • In what ways does solar activity affect Earth's environment, life, and human-made infrastructure, and how can we prepare for these impacts?
<i>Students must know:</i>	<i>Students must be able to:</i>
• Hydrogen • Helium • Sunspots • Solar flares • Solar wind • Coronal mass ejections • Electromagnetic induction • Magnetic field • Gravitational pressure • Thermal pressure	• Construct a model of the sun showing the internal layers and use the model to make qualitative predictions of how changes in the sun's properties (mass, radius, chemical composition...) would effect its life cycle and energy transfer. • Explain the changes that will occur in the sun over time that will result in fusion processes no longer being sustained • Construct a model of the sun in its current state (as a balance between gravitational and thermal pressure) and use this model to illustrate its life span and future evolution • Use historical and current data to describe impact of solar conditions and activity on Earth. • Explain how the Earth's magnetic field provides protection from solar activity. • Evaluate or refine a solution that reduces the impact of solar activity on technology and/or infrastructure. • Predict, when provided with data, the level of impact a given solar event will have on the Earth.

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Unit 5: The Sun

Missouri Learning Standards

Priority Standard: 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").] [Assessment Boundary: Assessment does not include details of the atomic and sub-atomic processes involved with the sun's nuclear fusion.] (9-12.ESS1.A.1)

Priority Standard: Use symbolic representations to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay. [Clarification Statement: Emphasis is on simple qualitative models, such as pictures or diagrams, and on the scale of energy released in nuclear processes relative to other kinds of transformations. Assessment Boundary: Assessment does not include quantitative calculation of energy released. Assessment is limited to alpha, beta, and gamma radioactive decays.] (9-12.PS1.C.1)

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Unit 6: The Stars

Students will explore the characteristics and classification of stars as well as the life cycle of stars.

Unit Essential Learning Targets	
<i>Enduring Understandings</i>	<i>Essential Questions</i>
Stars have patterns in their properties that can be analyzed from the light they emit, allowing us to classify them, predict how they will change over time, and discover how aging and dying stars create new elements.	How can the analysis of light emitted by stars help us classify them, understand their life cycles, and uncover the processes through which aging and dying stars produce new elements?
<i>Students must know:</i>	<i>Students must be able to:</i>
- Binary stars - Stellar mass - Luminosity - Fusion processes	- Describe using mathematical concepts the relationship between a star's radius, temperature, mass, and luminosity to answer quantitative questions. - Analyze a binary star system to determine the orbital properties and star masses. - Describe how the balance of gravitational and thermal pressure change over the life cycle of a star and how these changes impact the star's characteristics. - Construct an HR diagram that graphically organizes stars by luminosity and temperature and use the HR diagram and characteristics of stars to organize them into groups (main sequence, giants, supergiants, red dwarfs, white dwarfs). - Demonstrate the effect that a star's mass has on the path it will follow through the HR diagram from formation to death.

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Unit 6: The Stars

Missouri Learning Standards

Priority Standard: 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 pathways for stars of differing masses are not assessed.] (9-12.ESS1.A.3)

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Unit 7: Cosmology

Students will study the history and scale of the universe, the Big Bang Theory, and the relationship between relativity, spacetime, and gravity.

Unit Essential Learning Targets	
<i>Enduring Understandings</i>	<i>Essential Questions</i>
- Scientific discoveries made since the end of the 19th century have led to new understandings of the early universe and the nature of space and time. - Many of the understandings of the early universe are incomplete and are the focus of research in astronomy today.	- How have scientific discoveries since the late 19th century transformed our understanding of the early universe and the fundamental concepts of space and time? - What are the current gaps in our understanding of the early universe, and what ongoing research in astronomy is being conducted to address these uncertainties?
<i>Students must know:</i>	<i>Students must be able to:</i>
- The Big Bang - Hubble Classification System - Dark matter - Dark energy	- Predict the impact a change in the characteristics and/or conditions of the early universe would have on its evolution and present characteristics. - 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. - Summarize and analyze evidence collected over the past 100 years that has or might lead to adjustments in Big Bang theory(i.e. dark matter and dark energy) - Describe the predictions made by Einstein's explanation of gravity and the experimental evidence that was collected in the 20th and 21st centuries that supported this explanation. - Apply an understanding of gravity to explain the formation of galaxies, stars, solar systems, and planets. - Construct and use an evidence-based model to illustrate the chronological-scale of the history of the universe from the Big Bang to the evolution of humans.

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Unit 7: Cosmology

Missouri Learning Standards

Priority Standard: 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). (9-12.ESS1.A.2)

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Unit 8: Planetary Science: Abiotic Causes of Change

Students will study the abiotic properties of the Earth: materials, interior structures and processes, surface features and processes, and geological history.

Unit Essential Learning Targets	
<i>Enduring Understandings</i>	<i>Essential Questions</i>
Planets are dynamic objects. By studying planets' internal and external structures we can develop an understanding of the processes that cause them to change over time and draw conclusions about their past and future conditions.	How do the internal and external structures of planets inform our understanding of their dynamic processes and enable us to predict their past and future changes?
<i>Students must know:</i>	<i>Students must be able to:</i>
- Igneous rock - Metamorphic rock - Sedimentary rock - Rock cycle - Tectonic plate boundaries - Theory of Plate Tectonics - Radiometric dating - Stratigraphy - Inclusions	- Analyze data from an unknown region on Earth or other terrestrial planet or moon to draw conclusions about the object's geologic history and internal structure. - Use a rock identification key to identify given rock samples. - Conduct an investigation to show the mechanical and chemical affects water has on Earth's surface materials. - Apply scientific methods for determining relative ages (principles of stratigraphy) and numeric age (radiometric dating) of the Earth - Apply scientific reasoning and evidence from ancient earth materials, meteorites, and other planetary surfaces to determine the age of the Earth and construct an account of the Earth's formation and early history.

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Unit 8: Planetary Science: Abiotic Causes of Change

Missouri Learning Standards

Priority Standard: Evaluate evidence of the past and current movements of continental and oceanic crust, the theory of plate tectonics, and relative densities of oceanic and continental rocks to explain why continental rocks are generally much older than rocks of the ocean floor. [Clarification Statement: Examples include the ages of 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).] (9-12.ESS1.C.1)

Priority Standard: 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.] (9-12.ESS.C.2)

Priority Standard: Develop a model to illustrate how Earth's interior and surface processes (constructive and destructive) 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).] (9-12.ESS2.A.1)

Priority Standard: Develop a model based on evidence of Earth's 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.] (9-12.ESS2.A.3)

Priority Standard: 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 mechanical investigations include stream transportation and deposition using a stream table, erosion using variations in soil moisture content, or ice 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).] (9-12.ESS2.C.1)

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Unit 9: Planetary Systems and Cycles

Students will explore Earth's systems including the atmosphere, hydrosphere, and weather and climate. Additionally, students will study the properties of water.

Unit Essential Learning Targets	
<i>Enduring Understandings</i>	<i>Essential Questions</i>
The processes that occur on, in, and around the earth are all interconnected in planet-wide systems and cycles. Understanding the components of and connections between these systems leads to the development of models of how the Earth has changed in the past and continues to change today.	- How do the interconnected processes and cycles on, in, and around Earth influence one another and shape the planet's overall system? - In what ways can we model the interactions within Earth's systems to better understand its past changes and predict future changes?
<i>Students must know:</i>	<i>Students must be able to:</i>
- Carbon cycle - Hydrosphere - Atmosphere - Geosphere - Biosphere - epi-, meso-, bathy-, abysso-, hadal-pelagic zones	- Analyze the characteristics of another terrestrial planet to make an evidence-based argument for why its current conditions are different than those on Earth. - Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere. - Use a model to predict how a change in a component or condition of the carbon cycle can affect other parts of the cycle. - Use geoscience data* to support a claim about the climate of a particular region [*such as latitude, terrain, proximity to water, proximity to prevailing atmospheric and ocean currents] - Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate. - Conduct an investigation about the properties of water including its capacity to absorb, store, and release large amounts of energy, its density in solid and liquid states, and its mechanical effects on Earth's materials.

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Unit 9: Planetary Systems and Cycles

Missouri Learning Standards

Priority Standard: Analyze geoscientific data to make the claim that one change to Earth's surface can create changes to other Earth systems. (9-12.ESS2.A.2)

Priority Standard: 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.] (9-12.ESS2.D.1)

Priority Standard: Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate. (9-12.ESS2.A.4)

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Unit 10: The Interconnectedness of Life and the Planets

Students will study the relationship between Earth and life. They will explore the special case of humans including challenges and opportunities.

Unit Essential Learning Targets	
<i>Enduring Understandings</i>	<i>Essential Questions</i>
• The life that exists on the Earth is an active component in planet-wide systems and cycles. • The Earth has shaped life and life has shaped the Earth. • The impact of humans on Earth is unique both in terms of its scale and the time rates at which it occurs. • It is essential that we understand the role humans play in Earth's systems and that the decisions we can make in this role can be positive or negative.	• How do the interactions between living organisms and Earth's systems illustrate the interconnectedness of life and the environment? • What are the unique ways in which human activities impact Earth's systems, and how can understanding this influence guide our decisions for a sustainable future?
<i>Students must know:</i>	<i>Students must be able to:</i>
• Biodiversity •	• Analyze geoscientific 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 Do one of the following: • Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on economic, social, and environmental cost-benefit ratios • Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity. • Evaluate or refine a technological solution that reduces impacts of human activities on natural systems in order to restore stability and or biodiversity of the ecosystem as well as prevent their reoccurrences.

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Unit 10: The Interconnectedness of Life and the Planets

Missouri Learning Standards

Priority Standard: Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity. [Clarification Statement: Examples of factors that affect the management of natural resources include costs of resource extraction and waste management, per-capita consumption, and the development of new technologies. Examples of factors that affect human sustainability include agricultural efficiency, levels of conservation, and urban planning.] (9-12.ESS3.C.1).

Priority Standard: Construct an argument based on evidence about the simultaneous coevolution of Earth's systems and life on Earth. [Clarification Statement: 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 coevolution 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 new life.] (9-12.ESS2.E.1).

Priority Standard: Analyze geoscientific 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).] (9-12.ESS3.D.1).

Supporting Standards:

- 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, 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. 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.] (9-12.ESS3.A.1).
- Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on economic, social, and environmental 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 shale), and pumping (for petroleum and natural gas). Science knowledge indicates what can happen in natural systems—not what should happen.] (9-12.ESS3.A.2).
- Evaluate or refine a technological solution that reduces impacts of human activities on natural systems in order to restore stability and or biodiversity of the ecosystem as well as prevent their reoccurrences. [Clarification Statement: Examples of human activities could include forest fires, acid rain, flooding, urban development, pollution, deforestation, and introduction of an invasive species.] (9-12.ESS3.C.2).
- Predict how human activity affects the relationships between Earth systems in both positive and negative ways. [Clarification Statement: Examples of Earth systems to be considered are the hydrosphere, atmosphere, cryosphere, geosphere, and/or biosphere. (9-12.ESS3.D.2).