## Prepared Graduates:

9. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding the universe and Earth's place in it.

## Grade Level Expectation:

1. All stars, including the sun, undergo stellar evolution, and the study of stars' light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth.

### Evidence Outcomes

*Students Can:*

a. 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-ESS1-1) *(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.) (Boundary Statement: Does not include details of the atomic and sub-atomic processes involved with the sun's nuclear fusion.)*

b. Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the universe. (HS-ESS1-2) *(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].)*

c. Communicate scientific ideas about the way stars, over their life cycle, produce elements. (HS-ESS1-3) *(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.) (Boundary Statement: Details of the many different nucleosynthesis pathways for stars of differing masses are not assessed.)*

### Academic Context and Connections

*Colorado Essential Skills and Science and Engineering Practices:*

1. Develop a model based on evidence to illustrate the relationships between systems or between components of a system. (Developing and Using Models) (Personal: Initiative/Self-direction)
2. 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. (Constructing Explanations and Designing Solutions) (Professional: Resilience/Perseverance).
3. 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.) (Obtaining, Evaluating, and Communicating Information) (Professional: Information literacy)

4. Connections to Nature of Science: Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena. A scientific theory is a substantiated explanation of some aspect of the natural world, based on a body of facts that have been repeatedly confirmed through observation and experiment and the science community validates each theory before it is accepted. If new evidence is discovered that the theory does not accommodate, the theory is generally modified in light of this new evidence. Models, mechanisms, and explanations collectively serve as tools in the development of a scientific theory.

*Elaboration on the GLE:*

1. Students can answer the question: What is the universe and what goes on in stars?
2. ESS1:A The Universe and Its Stars: The star called the sun is changing and will burn out over a life span of approximately 10 billion years. The sun is just one of more than 200 billion stars in the Milky Way galaxy, and the Milky Way is just one of hundreds of billions of galaxies in the universe. The study of stars' light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth. The Big Bang theory is supported by observations of distant galaxies receding from our own, of the measured composition of stars and non-stellar gases, and of the maps of spectra of the primordial radiation (cosmic microwave background) that still fills the universe. Other than the hydrogen and helium formed at the time of the Big Bang, nuclear fusion within stars produces all atomic nuclei lighter than and including iron, and the process releases electromagnetic energy. Heavier elements are produced when certain massive stars achieve a supernova stage and explode.

*Cross Cutting Concepts:*

1. Scale, Proportion, and Quantity: The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs.
2. 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. In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved.
3. 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. Science assumes the universe is a vast single system in which basic laws are consistent.

## Prepared Graduates:

9. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding the universe and Earth's place in it.

## Grade Level Expectation:

2. Explanations of and predictions about the motions of orbiting objects are described by the laws of physics.

### Evidence Outcomes

*Students Can:*

a. Use mathematical or computational representations to predict the motion of orbiting objects in the solar system. (HS-ESS1-4) *(Clarification Statement: Emphasis is on Newtonian gravitational laws governing orbital motions, which apply to human-made satellites as well as planets and moons.) (Boundary Statement: 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.)*

### Academic Context and Connections

*Colorado Essential Skills and Science and Engineering Practices:*

1. Use mathematical or computational representations of phenomena to describe explanations. (Using Mathematical and Computational Thinking) (Entrepreneurial: Critical thinking/Problem solving)

*Elaboration on the GLE:*

1. Students can answer the question: What are the predictable patterns caused by Earth's movement in the solar system?
2. 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. Cyclical changes in the shape of Earth's orbit around the sun, together with changes in the orientation of the planet's axis of rotation, both occurring over tens to hundreds of thousands of years, have altered the intensity and distribution of sunlight falling on Earth. These phenomena cause cycles of ice ages and other gradual climate changes.

*Cross Cutting Concepts:*

1. Scale, Proportion and Quantity: Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth).

## Prepared Graduates:

9. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding the universe and Earth's place in it.

## Grade Level Expectation:

3. The rock record resulting from tectonic and other geoscience processes as well as objects from the solar system can provide evidence of Earth's early history and the relative ages of major geologic formations.

### Evidence Outcomes

*Students Can:*

a. 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-ESS1-5) *(Clarification Statement: Emphasis is on the ability of plate tectonics to explain the ages of crustal rocks. Examples include evidence of the ages oceanic crust increasing with distance from mid-ocean ridges, a result of plate spreading, and the ages of North American continental crust decreasing with distance away from a central ancient core of the continental plate, a result of past plate interactions.)*

b. Apply scientific reasoning and evidence from ancient Earth materials, meteorites, and other planetary surfaces to construct an account of Earth's formation and early history. (HS-ESS1-6) *(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.)*

### Academic Context and Connections

*Colorado Essential Skills and Science and Engineering Practices:*

1. Evaluate evidence behind currently accepted explanations or solutions to determine the merits of arguments. (Engaging in Argument from Evidence) (Personal: Initiative/Self-direction)
2. Apply scientific reasoning to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion. (Constructing Explanations and Designing Solutions) (Entrepreneurial: Creativity/Innovation)
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 observation and experiment and the science community validates each theory before it is accepted. If new evidence is discovered that the theory does not accommodate, the theory is generally modified in light of this new evidence. Models, mechanisms, and explanations collectively serve as tools in the development of a scientific theory.

*Elaboration on the GLE:*

1. Students can answer the question: How do people reconstruct and date events in Earth's planetary history?
2. ESS1:C The History of Planet Earth: Continental rocks, which can be older than 4 billion years, are generally much older than rocks on the ocean floor, which are less than 200 million years old. 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.

*Cross Cutting Concepts:*

1. Patterns: Empirical evidence is needed to identify patterns.
2. Stability and Change: Much of science deals with constructing explanations of how things change and how they remain stable.

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## Prepared Graduates:

10. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how and why Earth is constantly changing.

## Grade Level Expectation:

4. Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes, and these effects occur on different time scales, from sudden (e.g., volcanic ash clouds) to intermediate (ice ages) to very long-term tectonic cycles.

### Evidence Outcomes

*Students Can:*

a. Develop a model to illustrate how Earth's internal and surface processes operate at different spatial and temporal scales to form continental and ocean-floor features. (HS-ESS2-1) *(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].) (Boundary Statement: Does not include memorization of the details of the formation of specific geographic features of Earth's surface.)*

b. 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-ESS2-2) *(Clarification Statement: Examples should include climate feedback, 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.)*

c. Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection. (HS-ESS2-3) *(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.)*

d. 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-ESS2-4) *(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.) (Boundary Statement: Results of changes in climate is limited to changes in surface temperatures, precipitation patterns, glacial ice volumes, sea levels, and biosphere distribution.)*

## Academic Context and Connections

*Colorado Essential Skills and Science and Engineering Practices:*

1. Develop a model based on evidence to illustrate the relationships between systems or between components of a system. Use a model to provide mechanistic accounts of phenomena. (Developing and Using Models) (Personal: Initiative/Self-direction)
2. 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. (Analyzing and Interpreting Data) (Entrepreneurial: Critical thinking/Problem solving)
3. Connections to Nature of Science: Scientific Knowledge is Based on Empirical Evidence. Science knowledge is based on empirical evidence. Science disciplines share common rules of evidence used to evaluate explanations about natural systems. Science includes the process of coordinating patterns of evidence with current theory.

*Elaboration on the GLE:*

1. Students can answer the question: How do Earth's major systems interact?
2. ESS2:A Earth's Materials and Systems: Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. 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 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.

*Cross Cutting Concepts:*

1. Stability and Change: Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible. Feedback (negative or positive) can stabilize or destabilize a system.
2. Energy and Matter: Energy drives the cycling of matter within and between systems.
3. Cause and Effect: Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

## Prepared Graduates:

10. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how and why Earth is constantly changing.

## Grade Level Expectation:

5. Plate tectonics can be viewed as the surface expression of mantle convection, which is driven by heat from radioactive decay within Earth's crust and mantle.

### Evidence Outcomes

*Students Can:*

a. Develop a model to illustrate how Earth's internal and surface processes operate at different spatial and temporal scales to form continental and ocean-floor features. (HS-ESS2-1) *(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].) (Boundary Statement: Does not include memorization of the details of the formation of specific geographic features of Earth's surface.)*
b. Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection. (HS-ESS2-3) *(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.)*

### Academic Context and Connections

*Colorado Essential Skills and Science and Engineering Practices:*

1. Develop a model based on evidence to illustrate the relationships between systems or between components of a system. (Developing and Using Models) (Civic/Interpersonal: Collaboration/Teamwork)

*Elaboration on the GLE:*

1. Students can answer the question: Why do the continents move, and what causes earthquakes and volcanoes?
2. ESS2:B Plate Tectonics and Large Scale Interactions: Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth's surface and provides a framework for understanding its geologic history. Plate movements are responsible for most continental and ocean-floor features and for the distribution of most rocks and minerals within Earth's crust. 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.

*Cross Cutting Concepts:*

1. Stability and Change: Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible.
2. Energy and Matter: Energy drives the cycling of matter within and between systems.
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 involve scientists, engineers, and others with wide ranges of expertise.
4. 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.

## Prepared Graduates:

10. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how and why Earth is constantly changing.

## Grade Level Expectation:

6. The planet's dynamics are greatly influenced by water's unique chemical and physical properties.

### Evidence Outcomes

*Students Can:*

a. Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes. (HS-ESS2-5) *(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 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.)*

### Academic Context and Connections

*Colorado Essential Skills and Science and Engineering Practices:*

1. 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. (Planning and Carrying Out Investigations) (Entrepreneurial: Inquiry/Analysis)

*Elaboration on the GLE:*

1. Students can answer the question: How do the properties and movements of water shape Earth's surface and affects its systems?
2. 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, dissolve and transport materials, and lower the viscosities and melting points of rocks.

*Cross Cutting Concepts:*

1. 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.

## Prepared Graduates:

10. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how and why Earth is constantly changing.

## Grade Level Expectation:

7. The role of radiation from the sun and its interactions with the atmosphere, ocean, and land are the foundation for the global climate system. Global climate models are used to predict future changes, including changes influenced by human behavior and natural factors.

### Evidence Outcomes

*Students Can:*

a. 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-ESS2-2) *(Clarification Statement: Examples should include climate feedback, 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.)*

b. 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-ESS2-4) *(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.) (Boundary Statement: Results of changes in climate is limited to changes in surface temperatures, precipitation patterns, glacial ice volumes, sea levels, and biosphere distribution.)*

c. Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere. (HS-ESS2-6) *(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.)*

d. Construct an argument based on evidence about the simultaneous co-evolution of Earth's systems and life on Earth. (HS-ESS2-7) *(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 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.) (Boundary Statement: Does not include a comprehensive understanding of the mechanisms of how the biosphere interacts with all of Earth's other systems.)*

## Academic Context and Connections

*Colorado Essential Skills and Science and Engineering Practices:*

1. 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. (Analyzing and Interpreting Data) (Entrepreneurial: Critical thinking/Problem solving)
2. Use a model to provide mechanistic accounts of phenomena and develop a model based on evidence to illustrate the relationships between systems or between components of a system. (Developing and Using Models) (Personal: Initiative/Self-direction)
3. Construct an oral and written argument or counter-arguments based on data and evidence. (Engaging in Argument from Evidence) (Civic/Interpersonal: Collaboration/Teamwork)
4. Connections to Nature of Science: Scientific Knowledge is Based on Empirical Evidence.Science arguments are strengthened by multiple lines of evidence supporting a single explanation.

*Elaboration on the GLE:*

1. Students can answer the question: What regulates weather and climate?
2. 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. Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen. Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate. 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

*Cross Cutting Concepts:*

1. Stability and Change: Feedback (negative or positive) can stabilize or destabilize a system. Much of science deals with constructing explanations of how things change and how they remain stable.
2. Cause and Effect: Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.
3. Energy and Matter: The total amount of energy and matter in closed systems is conserved.

## Prepared Graduates:

10. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how and why Earth is constantly changing.

## Grade Level Expectation:

8. The biosphere and Earth's other systems have many interconnections that cause a continual co-evolution of Earth's surface and life on it.

### Evidence Outcomes

*Students Can:*

a. Construct an argument based on evidence about the simultaneous co-evolution of Earth's systems and life on Earth. (HS-ESS2-7) *(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 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.) (Boundary Statement: Does not include a comprehensive understanding of the mechanisms of how the biosphere interacts with all of Earth's other systems.)*

### Academic Context and Connections

*Colorado Essential Skills and Science and Engineering Practices:*

1. Construct an oral and written argument or counter-arguments based on data and evidence. (Engaging in Argument from Evidence) (Professional: Information technologies/Communications)

*Elaboration on the GLE:*

1. Students can answer the question: How do living organisms alter Earth's processes and structures?
2. 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.

*Cross Cutting Concepts:*

1. Stability and Change: Much of science deals with constructing explanations of how things change and how they remain stable.

## Prepared Graduates:

11. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how human activities and the Earth's surface processes interact.

## Grade Level Expectation:

9. Resource availability has guided the development of human society and use of natural resources has associated costs, risks, and benefits.

### Evidence Outcomes

*Students Can:*

a. 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-ESS3-1) *(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 changes to sea level, regional patterns of temperature and precipitation, and the types of crops and livestock that can be raised.)*

b. Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios. (HS-ESS3-2) *(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.)*

### Academic Context and Connections

*Colorado Essential Skills and Science and Engineering Practices:*

1. 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. (Constructing Explanations and Designing Solutions) (Civic/Interpersonal: Civic engagement)
2. Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and logical arguments regarding relevant factors (e.g., economic, societal, environmental, ethical considerations). (Engaging in Argument from Evidence) (Personal: Initiative/Self-direction)

*Elaboration on the GLE:*

1. Students can answer the question: How do humans depend on Earth's resources?
2. ESS3:A Natural Resources: Resource availability has guided the development of human society. All forms of energy production and other 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.

*Cross Cutting Concepts:*

1. Cause and Effect: Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.
2. Connections to Nature of Science: Science Addresses Questions About the Natural and Material World. Science and technology may raise ethical issues for which science, by itself, does not provide answers and solutions. 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. Many decisions are not made using science alone, but rely on social and cultural contexts to resolve issues.

## Prepared Graduates:

11. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how human activities and the Earth's surface processes interact.

## Grade Level Expectation:

10. Natural hazards and other geological events have shaped the course of human history at local, regional, and global scales.

### Evidence Outcomes

*Students Can:*

a. 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-ESS3-1) *(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 changes to sea level, regional patterns of temperature and precipitation, and the types of crops and livestock that can be raised.)*

### Academic Context and Connections

*Colorado Essential Skills and Science and Engineering Practices:*

1. 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. (Constructing Explanations and Designing Solutions) (Entrepreneurial: Critical thinking/Problem solving)

*Elaboration on the GLE:*

1. Students can answer the question: How do natural hazards affect individuals and societies?
2. ESS3:B Natural Hazards: Natural hazards and other geologic events have shaped the course of human history, and have significantly altered the sizes of human populations and have driven human migrations.

*Cross Cutting Concepts:*

1. Cause and Effect: Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

## Prepared Graduates:

11. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how human activities and the Earth's surface processes interact.

## Grade Level Expectation:

11. Sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources, including the development of technologies.

### Evidence Outcomes

*Students Can:*

a. Create a computational simulation to illustrate the relationships among the management of natural resources, the sustainability of human populations, and biodiversity. (HS-ESS3-3) *(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.) (Boundary Statement: Computational simulation is limited to using provided multi-parameter programs or constructing simplified spreadsheet calculations.)*
b. Evaluate or refine a technological solution that reduces impacts of human activities on natural systems. (HS-ESS3-4) *(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 temperatures by making large changes to the atmosphere or ocean].)*

### Academic Context and Connections

*Colorado Essential Skills and Science and Engineering Practices:*

1. Create a computational model or simulation of a phenomenon, designed device, process, or system. (Using Mathematics and Computational Thinking) (Entrepreneurial: Critical thinking/Problem solving)
2. Design or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade-off considerations. (Constructing Explanations and Designing Solutions) (Civic/Interpersonal: Global/Cultural awareness)

*Elaboration on the GLE:*

1. Students can answer the question: How do humans change the planet?
2. ESS3:C Human Impacts on Earth's Systems: The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources. Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude ecosystem degradation.

*Cross Cutting Concepts:*

1. Stability and Change: Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible. Feedback (negative or positive) can stabilize or destabilize a system.
2. Connections to Nature of Science: Science is a Human Endeavor. Science is a result of human endeavors, imagination, and creativity.

## Prepared Graduates:

11. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how human activities and the Earth's surface processes interact.

## Grade Level Expectation:

12. Global climate models used to predict future climate change continue to improve our understanding of the impact of human activities on the global climate system.

### Evidence Outcomes

*Students Can:*

a. Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth's systems. (HS-ESS3-5) *(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].) (Boundary Statement: Limited to one example of a climate change and its associated impacts.)*
b. Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity. (HS-ESS3-6) *(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.) (Boundary Statement: Does not include running computational representations but is limited to using the published results of scientific computational models.)*

### Academic Context and Connections

*Colorado Essential Skills and Science and Engineering Practices:*

1. Analyze data using computational models in order to make valid and reliable scientific claims. (Analyzing and Interpreting Data) (Entrepreneurial: Critical thinking/Problem solving)
2. Use a computational representation of phenomena or design solutions to describe and/or support claims and/or explanations. (Using Mathematics and Computational Thinking) (Professional: Information/Communication technologies)
3. 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. New technologies advance scientific knowledge.
4. Scientific Knowledge is Based on Empirical Evidence: Science arguments are strengthened by multiple lines of evidence supporting a single explanation.

*Elaboration on the GLE:*

1. Students can answer the question: How do people model and predict the effects of human activities on Earth's climate?
2. ESS3:D Global Climate Change: Though the magnitudes of humans' impacts are greater than they have ever been, so too are humans' abilities to model, predict, and manage current and future impacts. 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, as well as to changes in human activities.

*Cross Cutting Concepts:*

1. Stability and Change: Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible.
2. 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.