Earth and Space Sciences

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HS-ESS1 Earth's Place in the Universe HS-ESS1

1-1 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-ESS1-1

1-2 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-ESS1-2

1-3 Communicate scientific ideas about the way stars, over their life cycle, produce elements HS-ESS1-3

1-4 Use mathematical or computational representations to predict the motion of orbiting objects in the solar system. HS-ESS1-4

1-5 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-ESS1-5

1-6 Apply scientific reasoning and evidence from ancient Earth materials, meteorites, and other planetary surfaces to construct an account of Earth's formation and early history. HS-ESS1-6

HS-ESS2 Earth's Systems HS-ESS2

2-1 Develop a model to illustrate how Earth's internal and surface processes operate at different spatial and temporal scales to form continental and ocean-floor features. [HS-ESS2-1

2-2 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-ESS2-2

2-3 Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection. HS-ESS2-3

2-4 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-ESS2-4

2-5 Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes. HS-ESS2-5

2-6 Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere. HS-ESS2-6

2-7 Construct an argument based on evidence about the simultaneous coevolution of Earth's systems and life on Earth. HS-ESS2-7

HS-ESS3 Earth and Human Activity HS-ESS3

3-1 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-ESS3-1

3-2 Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios. HS-ESS3-2

3-3 Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity. HS-ESS3-3

3-4 Evaluate or refine a technological solution that reduces impacts of human activities on natural systems. HS-ESS3-4

3-5 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-ESS3-5

3-6 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

DCI Disciplinary Core Ideas DCI

ESS1.A ESS1.A : The Universe and Its Stars ESS1.A

- a The star called the sun is changing and will burn out ov er a lifespan of approximately 10 billion y ears. ESS1.A(A)
- b The study of stars' light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth. ESS1.A(B)
- c 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. ESS1.A(C)
- d O ther than the hy drogen 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 . Heav ier elements are produced when certain massiv e stars achiev e a supernov a stage and explode. ESS1.A(D)

ESS1.B Earth and the Solar System ESS1.B

- a Kepler's laws describe common features of the motions of orbiting objects, including their elliptical paths around the sun. O rbits may change due to the grav itational effects from, or collisions with, other objects in the solar sy stem. ESS1.B(A)
- b Cyclical changes in the shape of Earth's orbit around the sun, together with changes in the tilt of the planet's axis of rotation, both occurring over hundreds of thousands of years, have altered the intensity and distribution of sunlight falling on the earth. These phenomena cause a cycle of ice ages and other gradual climate changes ESS1.B(B)

ESS1.C The History of Planet Earth ESS1.C

- a C ontinental rocks, which can be older than 4 billion y ears, are generally much older than the rocks of the ocean floor, which are less than 200 million y ears old. ESS1.C(A)
- b A lthough activ e geologic processes, such as plate tectonics and erosion, hav e destroy ed or altered most of the v ery early rock record on Earth, other objects in the solar sy stem, such as lunar rocks, asteroids, and meteorites, hav e changed little ov er billions of y ears. Study ing these objects can prov ide information about Earth's formation and early history . ESS1.C(B)

ESS2.A Earth Materials and Systems ESS2.A

- a Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. ESS2.A(A)
- b 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 ESS2.A(B)

c The geological record shows that changes to global and regional climate can be caused by interactions among changes in the sun's energy output or Earth's orbit, tectonic events, ocean circulation, volcanic activity, glaciers, vegetation, and human activities. These changes can occur on a variety of time scales from sudden (e.g., volcanic ash clouds) to intermediate (ice ages) to very long-term tectonic cycles. ESS2.A(C)

ESS2.B Plate Tectonics and Large-Scale System Interactions ESS2.B

a Plate tectonics is the unify ing theory that explains the past and current mov ements of the rocks at Earth's surface and prov ides a framework for understanding its geologic history . ESS2.B(A)

b 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. ESS2.B(B)

c 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. ESS2.B(C)

ESS2.C The Roles of Water in Earth's Surface Processes ESS2.C

a 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. ESS2.C(A)

ESS2.D Weather and Climate ESS2.D

a 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. ESS2.D(A)

b Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen. ESS2.D(B)

c Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate. ESS2.D(C)

d C urrent models predict that, although future regional climate changes will be complex and v aried, av erage 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 y ear and by the way s in which these gases are absorbed by the ocean and biosphere. ESS2.D(D)

ESS2.E Biogeology ESS2.E

a 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. ESS2.E(A)

ESS3.A Natural Resources ESS3.A

a Resource av ailability has guided the dev elopment of human society . ESS3.A(A)

b A ll forms of energy production and other resource extraction hav e associated economic, social, env ironmental, and geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors ESS3.A(B)

ESS3.B Natural Hazards ESS3.B

a Natural hazards and other geologic ev ents hav e shaped the course of human history ; [they] hav e significantly altered the sizes of human populations and hav e driv en human migrations. ESS3.B(A)

ESS3.C Human Impacts on Earth Systems ESS3.C

a The sustainability of human societies and the biodiv ersity that supports them requires responsible management of natural resources. ESS3.C(A)

a Scientists and engineers can make major contributions by dev eloping technologies that produce less pollution and waste and that preclude ecosy stem degradation. ESS3.C(B)

ESS3.D Global Climate Change ESS3.D

a Though the magnitudes of human impacts are greater than they hav e ev er been, so too are human abilities to model, predict, and manage current and future impacts. ESS3.D(A)

b Through computer simulations and other studies, important discov eries are still being made about how the ocean, the atmosphere, and the biosphere interact and are modified in response to human activ ities. ESS3.D(B)

PS1.C Nuclear Processes PS1.C

a Spontaneous radioactiv e decay s follow a characteristic exponential decay law. Nuclear lifetimes allow radiometric dating to be used to determine the ages of rocks and other materials. PS1.C(A)

PS3.D Energy in Chemical Processes and Everyday Life PS3.D

a Nuclear Fusion processes in the center of the sun release the energy that ultimately reaches Earth as radiation. PS3.D(A)

PS4.A Wave Properties PS4.A

a Geologists use seismic waves and their reflection at interfaces between layers to probe structures deep in the planet PS4.A(A)

PS4.B Electromagnetic Radiation PS4.B

a A toms of each element emit and absorb characteristic frequencies of light. These characteristics allow identification of the presence of an element, ev en in microscopic quantities. PS4.B(A)

Crosscutting Concepts CCC

1 Cause and Effect CCC1

a Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. CCC1A

2 Energy and Matter CCC2

a Energy cannot be created or destroy ed– only mov ed between one place and another place, between objects and/or fields, or between sy stems CCC2A

b In nuclear processes, atoms are not conserv ed, but the total number of protons plus neutrons is conserv ed CCC2B

c The total amount of energy and matter in closed systems is conserved. CCC2C

d Energy drives the cycling of matter within and between systems. CCC2D

3 Patterns CCC3

a Empirical ev idence is needed to identify patterns CCC3A

4 Scale, Proportion, and Quantity CCC4

a The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. CCC4A

b A lgebraic thinking is used to examine scientific data and predict the effect of a change in one v ariable on another (e.g., linear growth v s. exponential growth). CCC4B

5 Stability and Change CCC5

a Much of science deals with constructing explanations of how things change and how they remain stable. CCC5A

b Much of science deals with constructing explanations of how things change and how they remain stable. CCC5B

c Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible. CCC5C

d Feedback (negative or positive) can stabilize or destabilize a system. CCC5D

6 Structure and Function CCC6

a 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. CCC6A

7 Systems and System Models CCC7

a When inv estigating or describing a sy stem, the boundaries and initial conditions of the sy stem need to be defined and their inputs and outputs analy zed and described using models. CCC7A