High School Life Earth Science

Essential Standards Extended Guide

HIGH SCHOOL EARTH SCIENCE

Background information about this document:

In response to requests from schools and districts for guidance on essential standards, committees of educators from around Idaho collaborated in the summer of 2024 to categorize Science standards into two groups:

1. **Essential standards** are explicitly taught, assessed multiple times, and receive targeted interventions for students who have not yet reached proficiency.
2. **Supporting standards** are taught to reinforce essential standards and may or may not be formally assessed.

This guidance helps LEAs prioritize the most critical standards, recognizing that not all standards are of equal importance. This document serves as a resource—not a mandate—to assist local efforts. Importantly, this work did not remove or revise any of the adopted Idaho Content Standards and is intended to refocus time and effort.

The committees developed instructional grouping models to demonstrate how standards can be combined into focused units. However, this is just one approach, and other combinations are possible. Educators can use this guide to begin developing scope and sequence for their instructional time and district-specific courses. It also provides a useful starting point for creating formative and summative assessments aligned with the standards.

Guiding Information: Instructional groups are organized in a sequential manner that starts with the entire universe/solar system and then slowly focuses in on the earth's place in the space and time of the universe/solar system and then gives focus on geoscience processes and atmospheric processes and then finishes with an emphasis on the impact that humans have on these systems.

Instructional Grouping 1: Astronomy

Essential Standards **Standards are to be explicitly taught, assessed more than once, and intervened upon in this cluster of standards.**	Supporting Standards and Content **Taught to support the learning of essential standards and may or may not be formally assessed.**
HS-ESS-1.2 Students who demonstrate understanding can: Construct an explanation of the current model of the origin of the universe based on astronomical evidence of light spectra, motion of distant galaxies, and composition of matter 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. (HS-ESS-1.2, HS-ESS-1.3) Origin theories are supported by evidence such as 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 event, nuclear fusion within stars produces all atomic nuclei lighter than and including iron, and the process releases electromagnetic energy. Heavier elements are produced when certain massive stars achieve a supernova stage and explode. (HS-ESS-1.2, HS-ESS-1.3) Atoms of each element emit and absorb characteristic frequencies of light. These characteristics allow identification of the presence of an element, even in microscopic quantities. (HS-ESS-1.2)
HS-ESS-1.4 Use mathematical or computational representations to predict the motion of orbiting objects in the solar system.	Kepler's laws describe common features of the motions of orbiting objects, including their elliptical paths around the Sun. Orbits may change due to the gravitational effects from, or collisions with, other objects in the solar system. (HS-ESS-1.4)
	Supporting Standard: HS-ESS-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.
	Supporting Standard: HS-ESS-1.3 Students who demonstrate understanding can: Communicate scientific ideas about the way stars, over their life cycle, transform elements.

Further explanation:

1. Emphasis is on the astronomical evidence of the redshift of light from galaxies as an indication that the universe is currently expanding, the cosmic microwave background as the remnant radiation from the event, 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 scientific model (3/4 hydrogen and 1/4 helium).
2. Emphasis is on Newtonian gravitational laws governing orbital motions, which apply to human-made satellites as well as planets and moons.

Assessment limits:

1. 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.

Instructional Grouping 2: Earth History

Essential Standards **Standards are to be explicitly taught, assessed more than once, and intervened upon in this cluster of standards.**	**Supporting Standards and Content** **Taught to support the learning of essential standards and may or may not be formally assessed.**
HS-ESS-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.	Although active geologic 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. (HS-ESS-1.6) Spontaneous radioactive decay follows a characteristic exponential decay law. Nuclear lifetimes allow radiometric dating to be used to determine the ages of rocks and other materials. (HS-ESS-1.5, HS-ESS-1.6)
HS-ESS-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.	The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms. (HS-PSC-1.3, HS-PSC-1.5) Attraction and repulsion between electric charges at the atomic scale explain the structure, properties (physical and chemical), and transformations of matter, as well as the contact forces between material objects. (HS-PSC-1.3, HS-PSC-1.5, HS-PSP-1.6)
HS-ESS-2.7 Construct an argument based on evidence about the simultaneous coevolution of Earth's systems and life on Earth.	Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen. (HS-ESS-2.6, HS-ESS-2.7) 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-HS-7)

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	Supporting Standard: HS-ESS-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.

Further explanation:

1. Emphasis is on the ability of plate tectonics to explain the ages of crustal rocks. Examples include evidence of 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 decreasing with distance away from a central ancient core (a result of past plate interactions).
2. 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. 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.
3. 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.

Assessment limits:

1. Assessment does not include a comprehensive understanding of the mechanisms of how the biosphere interacts with all of Earth's other systems.

Instructional Grouping 3: Geoscience Processes

Essential Standards **Standards are to be explicitly taught, assessed more than once, and intervened upon in this cluster of standards.**	Supporting Standards and Content **Taught to support the learning of essential standards and may or may not be formally assessed.**
HS-ESS-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.	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. (HS-ESS-2.3) The radioactive decay of unstable isotopes continually generates new energy within Earth's crust and mantle, providing the primary source of the heat that drives mantle convection. Plate tectonics can be viewed as the surface expression of mantle convection. (HS-ESS-2.3) Geologists use seismic waves and their reflection at interfaces between layers to probe structures deep in the planet. (HS-ESS-2.3)
HS-ESS-2.3 Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection.	All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins, which carry out most of the work of cells. (HS-LS-1.1, HS-LS-3.1) Each chromosome consists of a single very long DNA molecule, and each gene on the chromosome is a particular segment of that DNA. The instructions for forming species' characteristics are carried in DNA. All cells in an organism have the same genetic content, but the genes used (expressed) by the cell may be regulated in different ways. Not all DNA codes for a

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	protein; some segments of DNA are involved in regulatory or structural functions, and some have no as-yet known function. (HS-LS-3.1)
HS-LS-3.2 Make and defend a claim based on evidence that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors.	In sexual reproduction, chromosomes can sometimes swap sections during the process of meiosis, thereby creating new genetic combinations and thus more genetic variation. Although DNA replication is tightly regulated and remarkably accurate, errors do occur and result in mutations, which are also a source of genetic variation. Environmental factors can also cause mutations in genes, and viable mutations are inherited. (HS-LS-3.2) Environmental factors also affect expression of traits, and hence affect the probability of occurrences of traits in a population. Thus, the variation and distribution of traits observed depends on both genetic and environmental factors. (HS-LS-3.2, HS-LS-3.3)
HS-LS-3.3 Apply concepts of probability and statistical analysis to explain the variation and distribution of expressed traits in a population.	Environmental factors also affect expression of traits, and hence affect the probability of occurrences of traits in a population. Thus, the variation and distribution of traits observed depends on both genetic and environmental factors. (HS-LS-3.2, HS-LS-3.3)
	Supporting Standard: HS-ESS-2.5 Students who demonstrate understanding can: Plan and conduct an investigation of how the chemical and physical properties of water contribute to the mechanical and chemical mechanisms that affect Earth materials and surface processes.

Further explanation:

1. Examples of system interactions include how melting ice exposes darker land, which increases temperatures and causes more ice to melt; 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.

2. 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.

Instructional Grouping 4: Atmospheric Science

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HS-ESS-2.4 Use a model to describe how variations in the flow of energy into and out of Earth's systems result in variations in climate.	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 variations. (HS-ESS-2.4) 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 (e.g., ice ages) to very long-term tectonic cycles. (HS-ESS-2.4) The foundation for Earth's global climate systems is the electromagnetic radiation from the Sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's re-radiation into space. (HS-ESS-2.2, HS-ESS-2.4) Changes in carbon dioxide concentrations in the atmosphere affect climate. (HS-ESS-2.6, HSESS-2.4)
HS-ESS-2.6 Students who demonstrate understanding can: Develop a model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.	Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen. (HS-ESS-2.6, HS-ESS-2.7) Changes in carbon dioxide concentrations in the atmosphere affect climate. (HS-ESS-2.4, HSESS-2.6)
HS-ESS-3.5 Students who demonstrate understanding can: Analyze geoscience data and the results from global climate models to make an evidence-based	Human abilities to model, predict, and manage current and future effects on Earth's systems are improving with advancing technologies. (HS-ESS-3.5)

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explanation of how climate variability can affect Earth’s systems on a global and regional scale.	

Further explanation:

1. Examples of the causes of variations in climate 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.
2. 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.
3. Examples of evidence, for both data and climate model outputs, are for climate variations (such as precipitation and temperature) and their associated effects (such as on sea level, glacial ice volumes, or atmosphere and ocean composition).

Assessment limits:

1. Assessment of the results of changes in climate is limited to changes in surface temperatures, precipitation patterns, glacial ice volumes, sea levels, and biosphere distribution.
2. Assessment is limited to one example of a climate variation and its associated effect.

Instructional Grouping 5: Humans and the Environment

Essential Standards **Standards are to be explicitly taught, assessed more than once, and intervened upon in this cluster of standards.**	**Supporting Standards and Content** **Taught to support the learning of essential standards and may or may not be formally assessed.**
HS-ESS-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.	All forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical benefits, costs and risks. New technologies and social regulations can change the balance of these factors. (HS-ESS-3.2) When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental factors. (HS-ESS-3.2, HS-ESS-3.4) Emphasis is on the conservation, recycling, and reuse of resources (such as minerals and metals) and on minimizing impacts. Examples include developing best practices for agricultural soil use, mining (for coal, tar sands, and oil shales), and pumping (for petroleum and natural gas).
HS-ESS-3.3 Illustrate relationships among management of natural resources, the sustainability of human populations, and biodiversity.	The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources. (HS-ESS-3.3)
HS-ESS-3.5 Analyze geoscience data and the results from global climate models to make an evidence-based explanation of how climate variability can affect Earth's systems on a global and regional scale.	Human abilities to model, predict, and manage current and future effects on Earth's systems are improving with advancing technologies. (HS-ESS-3.5) Natural hazards and other geologic events have shaped the course of human history. They have altered the sizes of human populations and have driven human migrations. (HS-ESS-3.1)
HS-ESS-3.4 Students who demonstrate understanding can: Evaluate or refine a scientific or technological solution that mitigates or enhances human influences on natural systems.	Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude ecosystem degradation. (HS-ESS-3.4) When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and

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	aesthetics, and to consider social, cultural, and environmental factors. (HS-ESS-3.2, HS-ESS-3.4)
	Supporting Standard: HS-ESS-3.6 Students who demonstrate understanding can: Communicate how relationships among Earth systems are being influenced by human activity

Further explanation:

1. 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.
2. Emphasis is on the conservation, recycling, and reuse of resources (such as minerals and metals) and on minimizing impacts. Examples include developing best practices for agricultural soil use, mining (for coal, tar sands, and oil shales), and pumping (for petroleum and natural gas).
3. 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.
4. Examples of data on the influences of human activities could include the quantities and types of pollutants released, changes to biomass and species diversity, or changes in land surface use (such as for urban development, agriculture and livestock, or surface mining). Examples of human contributions could range from local efforts (such as reducing, reusing, and recycling resources) to large-scale geoengineering design solutions (such as cloud seeding).