Earth & Space: High School

HS. History of the Earth

A Performance Expectations HS.ESS1.HE

1. 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
2. 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
3. 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

B Science and Engineering Practices HS.HE.SEP

1. Developing and Using Models HS.HE.SEP.1
   a. Develop a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-ESS2-1) HS.HE.SEP.1A
2. Constructing Explanations and Designing Solutions HS.HE.SEP.2
   a. Apply scientific reasoning to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion. (HS-ESS1-6) HS.HE.SEP.2A
3. Engaging in Argument from Evidence HS.HE.SEP.3
   a. Evaluate evidence behind currently accepted explanations or solutions to determine the merits of arguments. (HS-ESS1- 5) HS.HE.SEP.3A
4. Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena HS.HE.SEP.4
   a. 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. (HS-ESS1- 6) HS.HE.SEP.4A
   b. Models, mechanisms, and explanations collectively serve as tools in the development of a scientific theory. (HS-ESS1-6) HS.HE.SEP.4B

Disciplinary Core Ideas HS.HE.DCI

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1 ESS1.C: The History of Planet Earth HS.HE.DCI.ESS1.C

a Continental rocks, which can be older than 4 billion years, are generally much older than the rocks of the ocean floor, which are less than 200 million years old. (HS-ESS1-5) HS.HE.DCI.ESS1.C.1

b 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-ESS1-6) HS.HE.DCI.ESS1.C.2

2 ESS2.A: Earth Materials and Systems HS.HE.DCI.ESS2.A

a Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. (HS-ESS2-1) (Note: This Disciplinary Core Idea is also addressed by HS-ESS2-2) HS.HE.DCI.ESS2.A.1

3 ESS2.B: Plate Tectonics and Large-Scale System Interactions HS.HE.DCI.ESS2.B

a 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. (ESS2.B Grade 8 GBE) (secondary to HS-ESS1-5),(HS-ESS2-1) HS.HE.DCI.ESS2.B.1

b 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 Grade 8 GBE) (HS-ESS2-1) HS.HE.DCI.ESS2.B.2

4 PS1.C: Nuclear Processes HS.HE.DCI.PS1.C

a (NYSED) Spontaneous radioactive decay follows a characteristic exponential decay law allowing an element's half-life to be used for radiometric dating of rocks and other materials. (secondary to HS-ESS1- 5),(secondary to HS-ESS1-6) HS.HE.DCI.PS1.C.1

D Crosscutting Concepts HS.HE.CC

1 Patterns HS.HE.CC.1

a Empirical evidence is needed to identify patterns. (HS-ESS1-5) HS.HE.CC.1A

2 Stability and Change HS.HE.CC.2

a Much of science deals with constructing explanations of how things change and how they remain stable. (HS-ESS1-6) HS.HE.CC.2A

b Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible. (HSESS2-1) HS.HE.CC.2B DEPTH

HS. Earth's Systems

A Performance Expectations HS.ESS2.ES

1 Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to Earth's systems. HS.ESS2.2

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

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

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

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

B Science and Engineering Practices HS.ES.SEP

1 Developing and Using Models HS.ES.SEP.1

a Develop a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-ESS2-3),(HS-ESS2-6) HS.ES.SEP.1A

2 Planning and Carrying Out Investigations HS.ES.SEP.2

a 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. (HS-ESS2-5) HS.ES.SEP.2A

3 Analyzing and Interpreting Data HS.ES.SEP.3

a 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. (HS-ESS2-2) HS.ES.SEP.3A

4 Engaging in Argument from Evidence HS.ES.SEP.4

a Construct an oral and written argument or counterarguments based on data and evidence. (HS-ESS2-7) HS.ES.SEP.4A

5 Scientific Knowledge is Based on Empirical Evidence HS.ES.SEP.5

a Science knowledge is based on empirical evidence. (HSESS2-3) HS.ES.SEP.5A

b Science disciplines share common rules of evidence used to evaluate explanations about natural systems. (HS-ESS2-3) Science includes the process of coordinating patterns of evidence with current theory. (HS-ESS2-3) HS.ES.SEP.5B

C Disciplinary Core Ideas HS.ES.DCI

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1. ESS2.A: Earth Materials and Systems HS.ES.DCI.ESS2.A
    a. Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes (HS-ESS2-2) HS.ES.DCI.ESS2.A.1
    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. (HS-ESS2-3) HS.ES.DCI.ESS2.A.2
2. ESS2.B: Plate Tectonics and Large-Scale System Interactions HS.ES.DCI.ESS2.B
    a. (NYSED) Residual heat from Earth's formation and the radioactive decay of unstable isotopes in Earth's interior continually generate energy that is absorbed by Earth's mantle and crust, driving mantle convection. Plate tectonics can be viewed as the surface expression of mantle convection. (HS-ESS2-3) HS.ES.DCI.ESS2.B.1
    b. (NYSED) Minerals are the building blocks of igneous, metamorphic, and sedimentary rocks and can be identified using physical and chemical characteristics. These rock types are evidence of stages of constant recycling of Earth material by surface processes and convection currents in the mantle. (HS-ESS2-3) HS.ES.DCI.ESS2.B.2
3. ESS2.C: The Roles of Water in Earth's Surface Processes HS.ES.DCI.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. (HS-ESS2-5) HS.ES.DCI.ESS2.C.1
4. ESS2.D: Weather and Climate HS.ES.DCI.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. (HS-ESS2-2) HS.ES.DCI.ESS2.D.1
    b. Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen. (HS-ESS2-6),(HS-ESS2-7) HS.ES.DCI.ESS2.D.2
    c. Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate. (HS-ESS2-6) HS.ES.DCI.ESS2.D.3
5. ESS2.E: Biogeology HS.ES.DCI.ESS2.E
    a. The many dynamic and delicate feedbacks between the biosphere and other Earth systems cause a continual coevolution of Earth's surface and the life that exists on it. (HS-ESS2-7) HS.ES.DCI.ESS2.E.1

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6 PS4.A: Wave Properties HS.ES.DCI.PS4.A

a Geologists use seismic waves and their reflection at interfaces between layers to probe structures deep in the planet. (secondary to HS-ESS2-3) HS.ES.DCI.PS4.A.1

D Crosscutting Concepts HS.ES.CC

1 Energy and Matter HS.ES.CC.1

a The total amount of energy and matter in closed systems is conserved. (HSESS2-6) HS.ES.CC.1A

b Energy drives the cycling of matter within and between systems. (HS-ESS2-3) HS.ES.CC.1B

2 Structure and Function HS.ES.CC.2

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. (HS-ESS2-5) HS.ES.CC.2A

3 Stability and Change HS.ES.CC.3

a Much of science deals with constructing explanations of how things change and how they remain stable. (HS-ESS2-7) HS.ES.CC.3A

b Feedback (negative or positive) can stabilize or destabilize a system. (HSESS2-2) HS.ES.CC.3B

4 Interdependence of Science, Engineering, and Technology HS.ES.CC.4

a 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. (HS-ESS2-3) HS.ES.CC.4A

5 Influence of Engineering, Technology, and Science on Society and the Natural World HS.ES.CC.5

a 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. (HS-ESS2-2) HS.ES.CC.5A DEPTH

HS. Space Systems

A Performance Expectations HS.ESS1.SS

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

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

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

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

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5 Construct an explanation using evidence to support the claim that the phases of the moon, eclipses, tides and seasons change cyclically. HS.ESS1.7

B Science and Engineering Practices HS.SS.SEP

1 Developing and Using Models HS.SS.SEP.1

a Develop a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-ESS1-1) HS.SS.SEP.1A

2 Using Mathematics and Computational Thinking HS.SS.SEP.2

a Use mathematical or computational representations of phenomena to describe explanations. (HS-ESS1-4) HS.SS.SEP.2A

3 Constructing Explanations and Designing Solutions HS.SS.SEP.3

a 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. (HS-ESS1-2),(HS-ESS1-7) HS.SS.SEP.3A

4 Obtaining, Evaluating, and Communicating Information HS.SS.SEP.4

a 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). (HS-ESS1-3) HS.SS.SEP.4A

5 Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena HS.SS.SEP.5

a 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. (HS-ESS1-2) HS.SS.SEP.5A

C Disciplinary Core Ideas HS.SS.DCI

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1 ESS1.A: The Universe and Its Stars HS.SS.DCI.ESS1.A

a The star called the sun is changing and will burn out over a lifespan of approximately 10 billion years. (HS-ESS1-1) HS.SS.DCI.ESS1.A.1

b The study of stars' light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth. (HS-ESS1-2), (HS-ESS1-3) HS.SS.DCI.ESS1.A.2

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. (HS-ESS1- 2) HS.SS.DCI.ESS1.A.3

d 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. (HS-ESS1-2),(HSESS1-3) HS.SS.DCI.ESS1.A.4

2 ESS1.B: Earth and the Solar System HS.SS.DCI.ESS1.B

a 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-ESS1-4) HS.SS.DCI.ESS1.B.1

b (NYSED) Earth and celestial phenomena can be described by principles of relative motion and perspective. (HS-ESS1-7) HS.SS.DCI.ESS1.B.2

3 PS3.D: Energy in Chemical Processes and Everyday Life HS.SS.DCI.PS3.D

a Nuclear Fusion processes in the center of the sun release the energy that ultimately reaches Earth as radiation. (secondary to HS-ESS1-1) HS.SS.DCI.PS3.D.1

4 PS4.B: Electromagnetic Radiation HS.SS.DCI.PS4.B

a 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. (secondarytoHS-ESS1-2) HS.SS.DCI.PS4.B.1

D Crosscutting Concepts HS.SS.CC

1 Patterns HS.SS.CC.1

a Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS-ESS1-7) HS.SS.CC.1A

2 Scale, Proportion, and Quantity HS.SS.CC.2

a The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. (HS-ESS1-1) HS.SS.CC.2A

b 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). (HS-ESS1-4) HS.SS.CC.2B

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3 Energy and Matter HS.SS.CC.3

a Energy cannot be created or destroyed– only moved between one place and another place, between objects and/or fields, or between systems. (HS-ESS1-2) HS.SS.CC.3A

b In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved. (HS-ESS1-3) HS.SS.CC.3B

4 Interdependence of Science, Engineering, and Technology HS.SS.CC.4

a 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. (HS-ESS1- 2),(HS-ESS1-4) HS.SS.CC.4A

5 Scientific Knowledge Assumes an Order and Consistency in Natural Systems HS.SS.CC.5

a 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. (HS-ESS1-2) HS.SS.CC.5A

b Science assumes the universe is a vast single system in which basic laws are consistent. (HS-ESS1-2) HS.SS.CC.5B DEPTH

HS. Weather and Climate

A Performance Expectations HS.ESS2.WC

1 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 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 Evaluate data and communicate information to explain how the movement and interactions of air masses result in changes in weather conditions. HS.ESS2.8

B Science and Engineering Practices HS.WC.SEP

1 Developing and Using Models HS.WC.SEP.1

a Use a model to provide mechanistic accounts of phenomena. (HS-ESS2-4) HS.WC.SEP.1A

2 Analyzing and Interpreting Data HS.WC.SEP.2

a Analyze data using tools, technologies and/or models (e.g., computational or mathematical) in order to make valid and reliable scientific claims or determine optimal design solution. (HS-ESS3-5) HS.WC.SEP.2A

3 Obtaining, Evaluating, and Communicating Information HS.WC.SEP.3

a 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). (HS-ESS2-8) HS.WC.SEP.3A

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4 Scientific Investigations Use a Variety of Methods HS.WC.SEP.4

a Science investigations use diverse methods and do not always use the same set of procedures to obtain data. (HSESS3-5) HS.WC.SEP.4A

b New technologies advance scientific knowledge. (HS-ESS3- 5) HS.WC.SEP.4B

5 Scientific Knowledge is Based on Empirical Evidence HS.WC.SEP.5

a Science knowledge is based on empirical evidence. (HSESS3-5) HS.WC.SEP.5A

b Science arguments are strengthened by multiple lines of evidence supporting a single explanation. (HS-ESS2-4), (HSESS3-5) HS.WC.SEP.5B

C Disciplinary Core Ideas HS.WC.DCI

1 ESS1.B: Earth and the Solar System HS.WC.DCI.ESS1.B

a 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. (secondary to HS-ESS2-4) HS.WC.DCI.ESS1.B.1

2 ESS2.A: Earth Materials and Systems HS.WC.DCI.ESS2.A

a 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. (HS-ESS2-4) HS.WC.DCI.ESS2.A.1

3 ESS2.D: Weather and Climate HS.WC.DCI.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. (HS-ESS2-4),(secondary to HS-ESS2-2) HS.WC.DCI.ESS2.D.1

b Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate. (HS-ESS2-4) HS.WC.DCI.ESS2.D.2

c (NYSED) Concepts of density and heat energy can be used to explain observations of weather patterns (HSESS2-8). HS.WC.DCI.ESS2.D.3

4 ESS3.D: Global Climate Change HS.WC.DCI.ESS3.D

a Though the magnitudes of human impacts are greater than they have ever been, so too are human abilities to model, predict, and manage current and future impacts. (HS-ESS3-5) HS.WC.DCI.ESS3.D.1

D Crosscutting Concepts HS.WC.CC

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1 Patterns HS.WC.CC.1

   a Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS-ESS2-8) HS.WC.CC.1A

   b Empirical evidence is needed to identify patterns. (HS-ESS2-8) HS.WC.CC.1B

2 Cause and Effect HS.WC.CC.2

   a Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-ESS2- 4) HS.WC.CC.2A

3 Stability and Change HS.WC.CC.3

   a Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible. (HSESS3-5) HS.WC.CC.3A