



Earth and Space Sciences Disciplinary Core Ideas Learning Progressions

Introduction

The New Jersey Student Learning Standards for Science (NJSL-S) are built on the notion of learning as a developmental progression. They are designed to help children continually build on and revise their knowledge and abilities, starting from their curiosity about what they see around them and their initial conceptions about how the world works. The goal of science education is to guide their knowledge toward a more evidence-based and coherent view of the natural sciences and engineering (NGSS Lead States, 2013).

The following tables provide readers with the progression of increasing complexity that each disciplinary core idea undergoes from kindergarten through grade 12. The tables provide invaluable insight into what the current focus of learning should be and provides insight into what the students learned before they came to your classroom, and what they will learn in a future course. The full range of information enables educators to scaffold learning experiences when there is unfinished learning from the previous year. It also provides a clear stopping point for current learning experiences.

Earth and Space Sciences Disciplinary Core Ideas

ESS1: Earth's Place in the Universe:

- **ESS1.A:** The Universe and Its Stars
- **ESS1.B:** Earth and the Solar System
- **ESS1.C:** The History of Planet Earth

ESS2: Earth's Systems:

- **ESS2.A:** Earth Materials and Systems
- **ESS2.B:** Plate Tectonics and Large-Scale System Interactions
- **ESS2.C:** The Roles of Water in Earth's Surface Processes
- **ESS2.D:** Weather and Climate
- **ESS2.E:** Biogeology.

ESS3: Earth and Human Activity:

- **ESS3.A:** Natural Resources
- **ESS3.B:** Natural Hazards
- **ESS3.C:** Human Impacts on Earth Systems
- **ESS3.D:** Global Climate Change

ESS1: Earth’s Place in the Universe

Overarching Question for ESS1: What is the universe, and what is Earth’s place in it? (NRC, 2012, p. 173 – 180)

Component Ideas	Grades K – 2	Grades 3 – 5	Grades 6 – 8	Grades 9 – 12
<p>ESS1.A: The Universe and Its Stars</p> <p>What is the universe, and what goes on in stars? (p. 173–174)</p>	<p>Patterns of the motion of the sun, moon, and stars in the sky can be observed, described, and predicted. (1-ESS1-1)</p>	<p>The sun is a star that appears larger and brighter than other stars because it is closer. Stars range greatly in their distance from Earth. (5-ESS1-1)</p>	<ul style="list-style-type: none"> • Patterns of the apparent motion of the sun, the moon, and stars in the sky can be observed, described, predicted, and explained with models. (MS-ESS1-1) • Earth and its solar system are part of the Milky Way galaxy, which is one of many galaxies in the universe. (MS-ESS1-2)– 	<ul style="list-style-type: none"> • The star called the sun is changing and will burn out over a lifespan of approximately 10 billion years. (HS-ESS1-1) • 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) • 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. (HSESS1-2) • 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), (HS-ESS1-3)

Component Ideas	Grades K – 2	Grades 3 – 5	Grades 6 – 8	Grades 9 – 12
<p>ESS1.B: Earth and The Solar System</p> <p>What are the predictable patterns caused by Earth’s movement in the solar system? (p. 175–176)</p>	<p>Seasonal patterns of sunrise and sunset can be observed, described, and predicted. (1ESS1-2)</p>	<p>The orbits of Earth around the sun and of the moon around Earth, together with the rotation of Earth about an axis between its North and South poles, cause observable patterns. These include day and night; daily changes in the length and direction of shadows; and different positions of the sun, moon, and stars at different times of the day, month, and year. (5-ESS1-2)</p>	<ul style="list-style-type: none"> • The solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them. (MS-ESS1-2), (MSESS1-3) • This model of the solar system can explain eclipses of the sun and the moon. Earth’s spin axis is fixed in direction over the short-term but tilted relative to its orbit around the sun. The seasons are a result of that tilt and are caused by the differential intensity of sunlight on different areas of Earth across the year. (MS-ESS1-1) • The solar system appears to have formed from a disk of dust and gas, drawn together by gravity. (MS-ESS1-2) 	<ul style="list-style-type: none"> • 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) • 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. (<i>secondary to HS-ESS2-4</i>)
<p>ESS1.C: The History of Planet Earth</p> <p>How do people reconstruct and date events in Earth’s planetary history? (p. 177–179)</p>	<p>Some events happen very quickly; others occur very slowly, over a time period much longer than one can observe. (2-ESS1-1)</p>	<p>Local, regional, and global patterns of rock formations reveal changes over time due to earth forces, such as earthquakes. The presence and location of certain fossil types indicate the order in which rock layers were formed. (4ESS1-1)</p>	<ul style="list-style-type: none"> • The geologic time scale interpreted from rock strata provides a way to organize Earth’s history. Analyses of rock strata and the fossil record provide only relative dates, not an absolute scale. (MS-ESS1-4) • Tectonic processes continually generate new ocean sea floor at ridges and destroy old sea floor at trenches. (HS.ESS1.C GBE) (<i>secondary to MS-ESS2-3</i>) 	<ul style="list-style-type: none"> • 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) • 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)

ESS2: Earth's Systems

Overarching Question for ESS2: How and why is Earth constantly changing? (NRC, 2012. p. 179–190)

Component Ideas	Grades K – 2	Grades 3 – 5	Grades 6 – 8	Grades 9 – 12
<p>ESS2.A: Earth Materials and Systems</p> <p>How do Earth's major systems interact? (p. 179–182)</p>	<p>Wind and water can change the shape of the land. (2-ESS2-1)</p>	<ul style="list-style-type: none"> Rainfall helps to shape the land and affects the types of living things found in a region. Water, ice, wind, living organisms, and gravity break rocks, soils, and sediments into smaller particles and move them around. (4-ESS2-1) Earth's major systems are the geosphere (solid and molten rock, soil, and sediments), the hydrosphere (water and ice), the atmosphere (air), and the biosphere (living things, including humans). These systems interact in multiple ways to affect Earth's surface materials and processes. The ocean supports a variety of ecosystems and organisms, shapes landforms, and influences climate. Winds and clouds in the atmosphere interact with the landforms to determine patterns of weather. (5-ESS2-1) 	<ul style="list-style-type: none"> All Earth processes are the result of energy flowing and matter cycling within and among the planet's systems. This energy is derived from the sun and Earth's hot interior. The energy that flows and matter that cycles produce chemical and physical changes in Earth's materials and living organisms. (MS-ESS2-1) The planet's systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth's history and will determine its future. (MS-ESS2-2) 	<ul style="list-style-type: none"> Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. (HSESS2-1), (HS-ESS2-2) 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) 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-ESS2-3)

Component Ideas	Grades K – 2	Grades 3 – 5	Grades 6 –8	Grades 9 – 12
<p>ESS2.B: Plate Tectonics and Large-Scale System Interactions</p> <p>Why do the continents move, and what causes earthquakes and volcanoes? (p. 182–183)</p>	<p>Maps show where things are located. One can map the shapes and kinds of land and water in any area. (2-ESS2-2)</p>	<p>The locations of mountain ranges, deep ocean trenches, ocean floor structures, earthquakes, and volcanoes occur in patterns. Most earthquakes and volcanoes occur in bands that are often along the boundaries between continents and oceans. Major mountain chains form inside continents or near their edges. Maps can help locate the different land and water features areas of Earth. (ESS2.B-E1)</p>	<p>Maps of ancient land and water patterns, based on investigations of rocks and fossils, make clear how Earth’s plates have moved great distances, collided, and spread apart. (MS-ESS2-3)</p>	<ul style="list-style-type: none"> • 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-ESS2-3) • 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) (HS-ESS2-1) (<i>secondary to HS-ESS1-5</i>)
<p>ESS2.C: The Roles of Water in Earth’s Surface Processes</p> <p>How do the properties and movement of water shape Earth’s surface and affect its systems? (p. 184–187)</p>	<p>Water is found in the ocean, rivers, lakes, and ponds. Water exists as solid ice and in liquid form. (2-ESS2-2)</p>	<p>Nearly all of Earth’s available water is in the ocean. Most fresh water is in glaciers or underground; only a tiny fraction is in streams, lakes, wetlands, and the atmosphere. (4-ESS2-2)</p>	<ul style="list-style-type: none"> • Water continually cycles among land, ocean, and atmosphere via transpiration, evaporation, condensation and crystallization, and precipitation, as well as downhill flows on land. (MS-ESS2-6) • The complex patterns of the changes and the movement of water in the atmosphere, determined by winds, landforms, and ocean temperatures and currents, are major determinants of local weather patterns. (MS-ESS2-5) • Global movements of water and its changes in form are propelled by sunlight and gravity. (MS-ESS2-4) • Variations in density due to variations in temperature and salinity drive a global pattern of interconnected ocean currents. (MS-ESS2-6) 	<p>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)</p>

Component Ideas	Grades K – 2	Grades 3 – 5	Grades 6 – 8	Grades 9 – 12
			<ul style="list-style-type: none"> Water’s movements—both on the land and underground—cause weathering and erosion, which change the land’s surface features and create underground formations. (MS-ESS2-2) 	
<p>ESS2.D: Weather and Climate</p> <p>What regulates weather and climate? (p. 186–189)</p>	<p>Weather is the combination of sunlight, wind, snow or rain, and temperature in a particular region at a particular time. People measure these conditions to describe and record the weather and to notice patterns over time. (ESS2.D-P1)</p>	<ul style="list-style-type: none"> Scientists record patterns of the weather across different times and areas so that they can make predictions about what kind of weather might happen next. (3-ESS2-1) Climate describes a range of an area’s typical weather conditions and the extent to which those conditions vary over years. (3-ESS2-2) 	<ul style="list-style-type: none"> Weather and climate are influenced by interactions involving sunlight, the ocean, the atmosphere, ice, landforms, and living things. These interactions vary with latitude, altitude, and local and regional geography, all of which can affect oceanic and atmospheric flow patterns. (MS-ESS2-6) Because these patterns are so complex, weather can only be predicted probabilistically. (MS-ESS2-5) The ocean exerts a major influence on weather and climate by absorbing energy from the sun, releasing it over time, and globally redistributing it through ocean currents. (MS-ESS2-6) 	<ul style="list-style-type: none"> 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) Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen. (HSESS2-6), (HS-ESS2-7) Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate. (HS-ESS2-6), (HS-ESS2-4) 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. (<i>secondary to HSESS3-6</i>)

Component Ideas	Grades K – 2	Grades 3 – 5	Grades 6 – 8	Grades 9 – 12
<p>ESS2.E: Biogeology</p> <p>How do living organisms alter Earth’s processes and structures? (p. 189–190)</p>	Plants and animals can change their environment. (K-ESS2-2)	Living things affect the physical characteristics of their regions. (4-ESS2-1)	Intentionally left blank	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. (HS-ESS2-7)

ESS3: Earth and Human Activity

Overarching Question for ESS3: How do Earth’s surface processes and human activities affect each other (NRC, 2012, p. 190 – 199)?

Component Ideas	Grades K – 2	Grades 3 – 5	Grades 6 – 8	Grades 9 – 12
<p>ESS3.A: Natural Resources</p> <p>How do humans depend on Earth’s resources? (p. 191–192)</p>	Living things need water, air, and resources from the land, and they live in places that have the things they need. Humans use natural resources for everything they do. (K-ESS3-1)	Energy and fuels that humans use are derived from natural sources, and their use affects the environment in multiple ways. Some resources are renewable over time, and others are not. (4-ESS3-1)	Humans depend on Earth’s land, ocean, atmosphere, and biosphere for many different resources. Minerals, fresh water, and biosphere resources are limited, and many are not renewable or replaceable over human lifetimes. These resources are distributed unevenly around the planet as a result of past geologic processes. (MS-ESS3-1)	<ul style="list-style-type: none"> Resource availability has guided the development of human society. (HS-ESS3-1) 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. (HS-ESS3-2)
<p>ESS3.B: Natural Hazards</p> <p>How do natural hazards affect individuals and societies? (p. 192–195)</p>	Some kinds of severe weather are more likely than others in a given region. Weather scientists forecast severe weather so that the communities can prepare for and respond to these events. (K-ESS3-2)	A variety of natural hazards result from natural processes. Humans cannot eliminate natural hazards but can take steps to reduce their impacts. (3-ESS3-1), (4-ESS3-2)	Mapping the history of natural hazards in a region, combined with an understanding of related geologic forces can help forecast the locations and likelihoods of future events. (MS-ESS3-2)	Natural hazards and other geologic events have shaped the course of human history; [they] have significantly altered the sizes of human populations and have driven human migrations. (HS-ESS3-1)

Component Ideas	Grades K – 2	Grades 3 – 5	Grades 6 – 8	Grades 9 – 12
<p>ESS3.C: Human Impacts on Earth Systems</p> <p>How do humans change the planet? (p. 194–196)</p>	<p>Things that people do to live comfortably can affect the world around them. But they can make choices that reduce their impacts on the land, water, air, and other living things. (K-ESS3-3), (secondary to (K-ESS3-2)</p>	<p>Human activities in agriculture, industry, and everyday life have had major effects on the land, vegetation, streams, ocean, air, and even outer space. But individuals and communities are doing things to help protect Earth’s resources and environments. (5-ESS3-1)</p>	<ul style="list-style-type: none"> Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth’s environments can have different impacts (negative and positive) for different living things. (MS-ESS3-3) Typically, as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise. (MS-ESS3-3), (MS-ESS3-4) 	<ul style="list-style-type: none"> The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources. (HS-ESS3-3) Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude ecosystem degradation. (HS-ESS3-4)
<p>ESS3.D: Global Climate Change</p> <p>How do people model and predict the effects of human activities on Earth’s climate? (p. 196 – 189)</p>	<p>Intentionally left blank</p>	<p>Intentionally left blank</p>	<p>Human activities, such as the release of greenhouse gases from burning fossil fuels, are major factors in the current rise in Earth’s mean surface temperature (global warming). Reducing the level of climate change and reducing human vulnerability to whatever climate changes do occur depend on the understanding of climate science, engineering capabilities, and other kinds of knowledge, such as understanding of human behavior and on applying that knowledge wisely in decisions and activities. (MS-ESS3-5)</p>	<ul style="list-style-type: none"> 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) 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. (HS-ESS3-6)

References

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