



Science Standards of Learning Curriculum Framework

Earth Science

Commonwealth of Virginia
Board of Education
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Standard ES.1 a, b

The student will plan and conduct investigations in which

- a) volume, area, mass, elapsed time, direction, temperature, pressure, distance, density, and changes in elevation/depth are calculated utilizing the most appropriate tools; and
- b) technologies, including computers, probeware, and global positioning systems (GPS), are used to collect, analyze, and report data and to demonstrate concepts and simulate experimental conditions.

Essential Understandings

- *Density* expresses the relationship between mass and volume.

Essential Knowledge and Skills

Skills

- Measure mass and volume of materials in the lab.
- Calculate density.
- Interpret data from a graph or table that shows change in mass, density, or temperature over time.
- Interpret data from a graph or table that shows changes in temperature or pressure with depth.

Standard ES.1 c, d, e

The student will plan and conduct investigations in which

- c) scales, diagrams, maps, charts, graphs, tables, and profiles are constructed and interpreted;
- d) variables are manipulated with repeated trials; and
- e) a scientific viewpoint is constructed and defended (the nature of science).

Essential Understandings

- Information and data collected can be organized and expressed in the form of charts, graphs, and diagrams.
- Changing relevant variables will generally change the outcome.
- A hypothesis can be supported, modified, or rejected based on collected data. A *hypothesis* is a tentative explanation that accounts for a set of facts and can be tested by further investigation.
- Experiments are designed to test hypotheses.
- *Scientific laws* are generalizations of observational data that describe patterns and relationships. Laws may change as new data become available.
- *Scientific theories* are systematic sets of concepts that offer explanations for observed patterns in nature. Theories provide frameworks for relating data and guiding future research. Theories may change as new data become available.

Essential Knowledge and Skills

Skills

- Compare topographic maps of different scales.
- Construct a graph, table, chart, and/or diagram from data.
- Interpret graphs and diagrams.
- Use scientific methodology to design and test a hypothesis.
- Compare and contrast hypotheses, theories, and scientific laws. For example, students should be able to compare/contrast the Law of Superposition and the Theory of Plate Tectonics.

Standard ES.2 a, b, c, d, e

The student will demonstrate scientific reasoning and logic by

- a) analyzing how science explains and predicts the interactions and dynamics of complex Earth systems;
- b) recognizing that evidence is required to evaluate hypotheses and explanations;
- c) comparing different scientific explanations for a set of observations about the Earth;
- d) explaining that observation and logic are essential for reaching a conclusion; and
- e) evaluating evidence for scientific theories.

Essential Understandings

- Earth is a dynamic system, and all atmospheric, geological, and oceanographic processes interrelate and influence one another.
- Conclusions are only as good as the quality of the collected data.
- Any valid hypothesis can be tested.
- Any valid scientific theory has passed tests designed to invalidate it.
- A hypothesis can be supported, modified, or rejected based on collected data.
- Experiments are designed to test hypotheses.
- There can be more than one explanation for any phenomena.

Essential Knowledge and Skills

Skills

- Make predictions, using scientific data and data analysis.
- Use data to support or reject a hypothesis.
- Explain how the scientific method is used to validate scientific theories.

Standard ES.3 a, b, c, d

The student will investigate and understand how to read and interpret maps, globes, models, charts, and imagery. Key concepts include

- a) maps (bathymetric, geologic, topographic, and weather) and star charts;
- b) imagery (aerial photography and satellite images);
- c) direction and measurements of distance on any map or globe; and
- d) location by latitude and longitude and topographic profiles.

Essential Understandings

- Scale relates to actual distance.
- Topographic maps, air photos, and satellite images relate to actual 3-D landforms.
- Grid systems are used to define locations and directions on maps, globes, and charts.

Essential Knowledge and Skills

Skills

- Read and interpret maps, including legends and lines (e.g., contour and isobar).
- Locate points and directions on maps and globes, using latitude and longitude.
- Construct profiles from topographic contours.
- Determine distance and elevation on a map.
- Identify a hilltop, stream, and valley on a topographic map.

Standard ES.4 a, b

The student will investigate and understand the characteristics of the Earth and the solar system. Key concepts include

- a) position of the earth in the solar system; and
- b) sun-Earth-moon relationships (seasons, tides, and eclipses).

Essential Understandings	Essential Knowledge and Skills
<ul style="list-style-type: none">• Earth is one of nine planets in the solar system.	<p><u>Knowledge</u></p> <ul style="list-style-type: none">• Earth is the third planet from the sun and is located between the sun and the asteroid belt. It has one natural satellite, the moon.• Earth revolves around the sun, tilted on its axis, causing seasons (equinoxes and solstices).• The moon revolves around Earth creating the moon phases and eclipses.• Solar eclipses occur when the moon blocks sunlight from Earth’s surface, while lunar eclipses occur when Earth blocks sunlight from reaching the moon’s surface.• The tides are the daily, periodic rise and fall of water level caused by the gravitational pull of the sun and moon.• Water occurs on Earth as a solid (ice), a liquid, or a gas (water vapor) due to Earth’s position in the solar system.

Standard ES.4 c, d

The student will investigate and understand the characteristics of the Earth and the solar system. Key concepts include

- c) characteristics of the sun, planets and their moons, comets, meteors, and asteroids; and
- d) the history and contribution of the space program.

Essential Understandings

- The solar system consists of many types of celestial bodies.
- Much of our knowledge about the solar system is a result of space exploration efforts. These efforts continue to improve our understanding of the solar system

Essential Knowledge and Skills

Knowledge

- The sun consists largely of hydrogen gas. Its energy comes from nuclear fusion of hydrogen to helium.
- There are essentially two types of planets in our solar system.
- The four inner (terrestrial) planets consist mostly of solid rock.
- Four of the outer planets are gas giants, consisting of thick outer layers of gaseous materials, perhaps with small rocky cores.
- The fifth outer planet, Pluto, has an unknown composition but appears to be solid.
- Moons are natural satellites of planets that vary widely in composition.
- Comets orbit the sun and consist mostly of frozen gases.

Standard ES.4 c, d (continued)

Essential Understandings	Essential Knowledge and Skills
	<ul style="list-style-type: none">• Asteroids are rocky or metallic iron objects ranging in size from millimeters to kilometers. They are the source of most meteorites.• Apollo 11 was the first manned landing on the moon.• The Hubble Space Telescope has greatly improved our understanding of the universe. <p><u>Skills</u></p> <ul style="list-style-type: none">• Draw a diagram of the solar system, and label the planets.

Standard ES.5 a, b

The student will investigate and understand how to identify major rock-forming and ore minerals based on physical and chemical properties. Key concepts include

- a) hardness, color and streak, luster, cleavage, fracture, and unique properties; and
- b) use of minerals.

Essential Understandings

- There is a difference between rocks and minerals.
- Minerals can be identified based on specific chemical and physical properties.
- Minerals are important to human wealth and welfare.

Essential Knowledge and Skills

Knowledge

- A *mineral* is a naturally occurring, inorganic, solid substance with a definite chemical composition and structure.
- Minerals may be identified by their physical properties, such as hardness, color, luster, and streak.
- Most rocks are made of one or more minerals.
- Some major rock-forming minerals are quartz, feldspar, calcite, and mica.
- Ore minerals include pyrite, magnetite, hematite, galena, graphite, and sulfur.
- The major elements found in Earth’s crust are oxygen, silicon, aluminum, and iron. The most abundant group of minerals is the silicates, which contain silicon and oxygen.

Standard ES.6 a, b, c

The student will investigate and understand the rock cycle as it relates to the origin and transformation of rock types and how to identify common rock types based on mineral composition and textures. Key concepts include

- a) igneous (intrusive and extrusive) rocks;
- b) sedimentary (clastic and chemical) rocks; and
- c) metamorphic (foliated and unfoliated) rocks.

Essential Understandings

- Rocks can be identified on the basis of mineral content and texture.
- The processes by which rocks are formed define the three major groups of rocks.
- The *rock cycle* is the process by which all rocks are formed and how basic Earth materials are recycled through time.

Essential Knowledge and Skills

Knowledge

- Igneous rock forms from molten rock that cools and hardens either below or on Earth’s surface.
- Sedimentary rocks may be formed either by rock fragments or organic matter being bound together or by chemical precipitation.
- Metamorphic rocks form when any rock is changed by the effects of heat, pressure, or chemical action.
- Extrusive igneous rocks have small or no crystals, resulting in fine-grained or glassy textures.
- Intrusive igneous rocks have larger crystals and a coarser texture.
- Extrusive igneous rocks include pumice, obsidian, and basalt.
- Intrusive igneous rocks include granite.

Standard ES.6 a, b, c (continued)

Essential Understandings	Essential Knowledge and Skills
	<ul style="list-style-type: none">• Sedimentary rocks are clastic or chemical.• Clastic sedimentary rocks are made up of fragments of other rocks and include sandstone, conglomerate, and shale.• Non-clastic sedimentary rocks include limestone and rock salt.• Metamorphic rocks can be foliated or unfoliated (non-foliated).• Foliated metamorphic rocks have bands of different minerals. Slate, schist, and gneiss are foliated metamorphic rocks.• Unfoliated metamorphic rocks have little or no banding and are relatively homogenous throughout. Marble and quartzite are unfoliated metamorphic rocks. <p><u>Skills</u></p> <ul style="list-style-type: none">• Interpret the rock cycle diagram.• Classify the following rock types as igneous, metamorphic, or sedimentary: pumice, obsidian, basalt, granite, sandstone, conglomerate, shale, limestone, slate, schist, gneiss, marble, and quartzite.

Standard ES.7 a, b, c, d, e

The student will investigate and understand the difference between renewable and nonrenewable resources. Key concepts include

- a) fossil fuels, minerals, rocks, water, and vegetation;
- b) advantages and disadvantages of various energy sources;
- c) resources found in Virginia;
- d) making informed judgments related to resource use and its effects on Earth systems; and
- e) environmental cost and benefits.

Essential Understandings	Essential Knowledge and Skills
<ul style="list-style-type: none">• Resources are limited and are either renewable or nonrenewable.• There are advantages and disadvantages to using any energy source.• Virginia has many natural resources.• Modern living standards are supported by extensive use of both renewable and nonrenewable resources.• Extraction and use of any resource carries an environmental cost that must be weighed against economic benefit.	<p><u>Knowledge</u></p> <ul style="list-style-type: none">• Renewable resources can be replaced by nature at a rate close to the rate at which they are used. Renewable resources include vegetation, sunlight, and surface water.• Nonrenewable resources are renewed very slowly or not at all. Nonrenewable resources include coal, oil, and minerals.• Fossil fuels are nonrenewable and may cause pollution, but they are relatively cheap and easy to use.• In Virginia, major rock and mineral resources include coal for energy, gravel and crushed stone for road construction, and limestone for making concrete. <p><u>Skills</u></p> <ul style="list-style-type: none">• Analyze the advantages and disadvantages of various energy sources.

Standard ES.8 a

The student will investigate and understand geologic processes including plate tectonics. Key concepts include

- a) how geologic processes are evidenced in the physiographic provinces of Virginia including the Coastal Plain, Piedmont, Blue Ridge, Valley and Ridge, and Appalachian Plateau.

Essential Understandings

- Virginia has a billion-year-long tectonic and geologic history.
- Virginia has five physiographic provinces produced by past tectonic and geologic activity.
- Each province has unique physical characteristics resulting from its geologic past.
- Geologic processes produce characteristic structures and features.

Essential Knowledge and Skills

Knowledge

- The five physiographic provinces of Virginia are Coastal Plain, Piedmont, Blue Ridge, Valley and Ridge, and Appalachian Plateau.
- The Coastal Plain is a flat area underlain by young, unconsolidated sediments. These layers of sediment were produced by erosion of the Appalachian Mountains and then deposited on the Coastal Plain.
- The Piedmont is an area of rolling hills underlain by mostly ancient igneous and metamorphic rocks. The igneous rocks are the roots of volcanoes formed during an ancient episode of subduction that occurred before the formation of the Appalachian Mountains.
- The Blue Ridge is a high ridge separating the Piedmont from the Valley and Ridge Province. The billion-year-old igneous and metamorphic rocks of the Blue Ridge are the oldest in the state. Some metamorphism of these rocks occurred during the formation of the Appalachian Mountains.

Standard ES.8 a (continued)

Essential Understandings	Essential Knowledge and Skills
	<ul style="list-style-type: none">• The Valley and Ridge province is an area with long parallel ridges and valleys underlain by ancient folded and faulted sedimentary rocks. The folding and faulting of the sedimentary rocks occurred during a collision between Africa and North America. The collision, which occurred in the late Paleozoic era, produced the Appalachian Mountains.• The Appalachian Plateau has rugged, irregular topography and is underlain by ancient, flat-lying sedimentary rocks. The area is actually a series of plateaus separated by faults. Most of Virginia’s coal resources are found in the plateau province. <p><u>Skills</u></p> <ul style="list-style-type: none">• Label on a map and recognize the major features of the physiographic provinces of Virginia.

Standard ES. 8 b, c

The student will investigate and understand geologic processes including plate tectonics. Key concepts include

- b) processes (faulting, folding, volcanism, metamorphism, weathering, erosion, deposition, and sedimentation) and their resulting features; and
- c) tectonic processes (subduction, rifting and sea floor spreading, and continental collision).

Essential Understandings

- Weathering, erosion, and deposition are interrelated processes.
- The core, mantle, and crust of Earth are dynamic systems, constantly in motion.
- Earth's lithosphere is divided into plates that are in motion with respect to one another.
- Most geologic activity (e.g., earthquakes, volcanoes, and mountain building) occurs as a result of relative motion along plate boundaries.
- Plate motion occurs as a consequence of convection in Earth's mantle. Plate tectonics is driven by convection in the mantle.
- There are two different types of crust — oceanic and continental — that have very different characteristics.

Essential Knowledge and Skills

Knowledge

- *Weathering* is the process by which rocks are broken down chemically and physically by the action of water, air, and organisms.
- *Erosion* is the process by which Earth materials are transported by moving water, ice, or wind.
- *Deposition* is the process by which Earth materials carried by wind, water, or ice settle out and are deposited.
- Earth consists of a solid, mostly iron inner core; a liquid, mostly iron outer core; a rocky, plastic mantle; and a rocky, brittle crust.
- Relative plate motions and plate boundaries are convergent (subduction and continental collision), divergent (sea floor spreading), or transform.
- Ocean crust is relatively thin, young, and dense.
- Continental crust is relatively thick, old, and less dense.

Standard ES. 8 b, c (continued)

Essential Understandings	Essential Knowledge and Skills
	<ul style="list-style-type: none">• Continental drift is a consequence of plate tectonics.• Hot spot volcanic activity, such as volcanic islands, is exceptional in that it is not related to plate boundaries.• Earthquake activity is associated with all plate boundaries.• Major features of convergent boundaries include collision zones (folded and thrust-faulted mountains) and subduction zones (volcanoes and trenches).• Major features of divergent boundaries include mid-ocean ridges, rift valleys, and fissure volcanoes.• Major features of transform boundaries include strike-slip faults.• A <i>fault</i> is a break or crack in Earth’s crust along which movement has occurred.• Most active faults are located at or near plate boundaries. Earthquakes result when movement occurs along a fault.• When rocks are compressed horizontally, their layers may be deformed into wave-like forms called folds. This commonly occurs during continental collisions.• A volcano is an opening where magma erupts onto Earth’s surface. Most volcanic activity is associated with subduction, rifting, or sea floor spreading.

Standard ES.9 a, b

The student will investigate and understand how freshwater resources are influenced by geological processes and the activities of humans. Key concepts include

- a) processes of soil development; and
- b) development of karst topography.

Essential Understandings

- Soil is formed from the weathering of rocks and organic activity.
- Karst topography is developed in areas underlain by carbonate rocks, including limestone and dolomite.

Essential Knowledge and Skills

Knowledge

- *Soil* is loose rock fragments and clay derived from weathered rock mixed with organic material.
- Karst topography includes features like caves and sinkholes.
- Karst topography forms when limestone is slowly dissolved away by slightly acidic groundwater.
- Where limestone is abundant in the Valley and Ridge province of Virginia, karst topography is common.

Standard ES.9 c, d, e, f

The student will investigate and understand how freshwater resources are influenced by geological processes and the activities of humans. Key concepts include

- c) identification of groundwater zones including the water table, zone of saturation, and zone of aeration;
- d) identification of other sources of fresh water including rivers, springs, and aquifers, with reference to the hydrologic cycle;
- e) dependence on freshwater resources and the effects of human usage on water quality; and
- f) identification of the major watershed systems in Virginia including the Chesapeake Bay and its tributaries.

Essential Understandings	Essential Knowledge and Skills
<ul style="list-style-type: none">• A substantial amount of water is stored in permeable soil and rock underground.• Earth’s fresh water supply is finite.• Water is continuously being passed through the hydrologic cycle.• Fresh water is necessary for survival and most human activities.	<p><u>Knowledge</u></p> <ul style="list-style-type: none">• Permeability is a measure of the ability of a rock or sediment to transmit water or other liquids.• Water does not pass through impermeable materials.• Geological processes, such as erosion, and human activities, such as waste disposal, can pollute water supplies.• The three major regional watershed systems in Virginia lead to the Chesapeake Bay, the North Carolina sounds, and the Gulf of Mexico. <p><u>Skills</u></p> <ul style="list-style-type: none">• Interpret a simple groundwater diagram showing the zone of aeration, the zone of saturation, the water table, and an aquifer.

Standard ES.9 c, d, e, f (continued)

Essential Understandings	Essential Knowledge and Skills
	<ul style="list-style-type: none">• Interpret a simple hydrologic cycle diagram, including evaporation, condensation, precipitation, and runoff.• Locate the major Virginia watershed systems on a map (Chesapeake Bay, Gulf of Mexico, and North Carolina sounds).

Standard ES.10 a, d

The student will investigate and understand that many aspects of the history and evolution of the Earth and life can be inferred by studying rocks and fossils. Key concepts include

- a) traces and remains of ancient, often extinct, life are preserved by various means in many sedimentary rocks; and
- d) rocks and fossils from many different geologic periods and epochs are found in Virginia.

Essential Understandings

- Evidence of ancient, often extinct life is preserved in many sedimentary rocks.
- Fossil evidence indicates that life forms have changed and become more complex over geologic time.

Essential Knowledge and Skills

Knowledge

- A *fossil* is the remains, impression, or other evidence preserved in rock of the former existence of life.
- Some ways in which fossils can be preserved are molds, casts, and original bone or shell.
- Nearly all fossils are found in sedimentary rocks.
- In Virginia, fossils are found mainly in the Coastal Plain, Valley and Ridge, and Appalachian Plateau provinces.
- Most Virginia fossils are of marine organisms. This indicates that large areas of the state have been periodically covered by seawater.
- Paleozoic, Mesozoic, and Cenozoic fossils are found in Virginia.

Skills

- Describe how life has changed and become more complex over geologic time.

Standard ES.10 b, c

The student will investigate and understand that many aspects of the history and evolution of the Earth and life can be inferred by studying rocks and fossils. Key concepts include

- b) superposition, cross-cutting relationships, index fossils, and radioactive decay are methods of dating bodies of rock; and
- c) absolute and relative dating have different applications but can be used together to determine the age of rocks and structures.

Essential Understandings

- Earth is very ancient — about 4.6 billion years old.
- The history of Earth and the ages of rocks can be investigated and understood by studying rocks and fossils.

Essential Knowledge and Skills

Knowledge

- Relative time places events in a sequence without assigning any numerical ages.
- Fossils, superposition, and crosscutting relations are used to determine the relative ages of rocks.
- Absolute time places a numerical age on an event.
- Radioactive decay is used to determine the absolute age of rocks.

Skills

- Interpret a simple geologic history diagram, using superposition and crosscutting relations.

Standard ES.11 a

The student will investigate and understand that oceans are complex, interactive physical, chemical, and biological systems and are subject to long- and short-term variations. Key concepts include

- a) physical and chemical changes (tides, waves, currents, sea level and ice cap variations, upwelling, and salinity variations).

Essential Understandings

- The ocean is a dynamic system in which many chemical, biological, and physical changes are taking place.

Essential Knowledge and Skills

Knowledge

- Most waves on the ocean surface are generated by wind.
- The *tides* are the daily, periodic rise and fall of water level caused by the gravitational pull of the sun and moon.
- There are large current systems in the oceans that carry warm water towards the poles and cold water towards the equator.
- Sea level falls when glacial ice caps grow and rises when the ice caps melt.
- Upwellings bring cold, nutrient-rich water from the deep ocean to the surface and are areas of rich biological activity.
- *Estuaries*, like the Chesapeake Bay, are areas where fresh and salt water mix, producing variations in salinity and high biological activity.

Standard ES.11 b, e

The student will investigate and understand that oceans are complex, interactive physical, chemical, and biological systems and are subject to long- and short-term variations. Key concepts include

- b) importance of environmental and geologic implications; and
- e) economic and public policy issues concerning the oceans and the coastal zone including the Chesapeake Bay.

Essential Understandings

- The oceans are environmentally and economically important.
- Human activities and public policy have important consequences for the oceans.
- The oceans’ resources are finite and should be utilized with care.
- The impact of human activities, such as waste disposal, construction, and agriculture, affect the water quality within watershed systems and ultimately the ocean.

Essential Knowledge and Skills

Knowledge

- Algae in the oceans are an important source of atmospheric oxygen.
- The oceans are an important source of food and mineral resources as well as a venue for recreation and transportation.
- Pollution and over-fishing can harm or deplete valuable resources.
- Chemical pollution and sedimentation are great threats to the chemical and biological well-being of estuaries and oceans.

Skill

- Identify the effects of human activities on the oceans.

Standard ES.11 c, d

The student will investigate and understand that oceans are complex, interactive physical, chemical, and biological systems and are subject to long- and short-term variations. Key concepts include

- c) systems interactions (density differences, energy transfer, weather, and climate); and
- d) features of the sea floor (continental margins, trenches, mid-ocean ridges, and abyssal plains) as reflections of tectonic processes.

Essential Understandings

- Convection is the major mechanism of energy transfer in the oceans, atmosphere, and Earth’s interior.
- The ocean is the single largest reservoir of heat at Earth’s surface.
- The topography of the seafloor is at least as variable as that on the continents.

Essential Knowledge and Skills

Knowledge

- The stored heat in the ocean drives much of Earth’s weather.
- The stored heat in the ocean causes climate near the ocean to be milder than climate in the interior of continents.
- Features of the sea floor that are related to plate tectonic processes include mid-ocean ridges and trenches.
- Other major topographic features of the oceans are continental shelves, continental slopes, abyssal plains, and seamounts.

Standard ES.12 a, b, c

The student will investigate and understand the origin and evolution of the atmosphere and the interrelationship of geologic processes, biologic processes, and human activities on its composition and dynamics. Key concepts include

- a) scientific evidence for atmospheric changes over geologic time;
- b) current theories related to the effects of early life on the chemical makeup of the atmosphere; and
- c) comparison of the Earth’s atmosphere to that of other planets.

Essential Understandings

- The composition of Earth’s atmosphere has changed over geologic time.
- Earth’s atmosphere is unique in the solar system in that it contains substantial oxygen.

Essential Knowledge and Skills

Knowledge

- The early atmosphere contained little oxygen and more carbon dioxide than the modern atmosphere.
- Early photosynthetic life such as cyanobacteria (blue-green algae) consumed carbon dioxide and generated oxygen.
- It was only after early photosynthetic life generated oxygen that animal life became possible.
- Earth’s atmosphere is 21 percent oxygen, 78 percent nitrogen, and 1 percent trace gases.
- The atmosphere of Venus is mostly carbon dioxide and very dense.
- The atmosphere of Mars is very thin and mostly carbon dioxide.

Standard ES.12 d, e

The student will investigate and understand the origin and evolution of the atmosphere and the interrelationship of geologic processes, biologic processes, and human activities on its composition and dynamics. Key concepts include

- d) atmospheric regulation mechanisms including the effects of density differences and energy transfer; and
- e) potential atmospheric compositional changes due to human, biologic, and geologic activity.

Essential Understandings

- The composition of the atmosphere can change due to human, biologic, and geologic activity.

Essential Knowledge and Skills

Knowledge

- Human activities have increased the carbon dioxide content of the atmosphere.
- Man-made chemicals have decreased the ozone concentration in the upper atmosphere.
- Volcanic activity and meteorite impacts can inject large quantities of dust and gases into the atmosphere.
- The ability of Earth’s atmosphere to absorb and retain heat is affected by the presence of gases like water vapor and carbon dioxide.

Skills

- Explain how volcanic activity or meteor impacts could affect the atmosphere and life on Earth.
- Explain how biologic activity, including human activities, may influence global temperature and climate.

Standard ES.13 a, b, c, d

The student will investigate and understand that energy transfer between the sun and the Earth and its atmosphere drives weather and climate on Earth. Key concepts include

- a) observation and collection of weather data;
- b) prediction of weather patterns;
- c) severe weather occurrences, such as tornadoes, hurricanes, and major storms; and
- d) weather phenomena and the factors that affect climate including radiation and convection.

Essential Understandings

- Weather and climate are different.
- Earth's surface is much more efficiently heated by the sun than is the atmosphere.
- The amount of energy reaching any given point on Earth's surface is controlled by the angle of sunlight striking the surface and varies with the seasons.
- Winds are created by uneven heat distribution at Earth's surface and modified by the rotation of Earth.
- Energy transfer between Earth's surface and the atmosphere creates the weather.
- Both weather and climate are measurable and, to a certain extent, predictable.
- Convection is the major mechanism of energy transfer in the oceans, atmosphere, and Earth's interior.
- Convection in the atmosphere is a major cause of weather.

Essential Knowledge and Skills

Knowledge

- Weather describes day-to-day changes in atmospheric conditions.
- Climate describes the typical weather patterns for a given location over a period of many years.
- Areas near the equator receive more of the sun's energy per unit area than areas nearer the poles.
- The conditions necessary for cloud formation are air at or below dew point and presence of condensation nuclei. Cloud droplets can join together to form precipitation.
- The four major factors affecting climate are latitude, elevation, proximity to bodies of water, and position relative to mountains.

Standard ES.13 a, b, c, d (continued)

Essential Understandings	Essential Knowledge and Skills
	<ul style="list-style-type: none">• The Coriolis effect causes deflections of the atmosphere due to the rotation of Earth. Global wind patterns result from the uneven heating of Earth by the sun and are influenced by the Coriolis effect.• Earth’s major climatic zones are the polar, temperate, and tropical zones.• A <i>tornado</i> is a narrow, violent funnel-shaped column of spiral winds that extends downward from the cloud base toward Earth.• A <i>hurricane</i> is a tropical cyclone (counterclockwise movement of air) characterized by sustained winds of 120 kilometers per hour (75 miles per hour) or greater. <p><u>Skills</u></p> <ul style="list-style-type: none">• Label a diagram of global wind patterns.• Read and interpret data from a thermometer, a barometer, and a psychrometer.• Read and interpret a weather map.• Predict weather based on cloud type, temperature, and barometric pressure.

Standard ES.14 a, b, c, d, e

The student will investigate and understand scientific concepts related to the origin and evolution of the universe. Key concepts include

- a) nebulae;
- b) the origin of stars and star systems;
- c) stellar evolution;
- d) galaxies; and
- e) cosmology including the big bang theory.

Essential Understandings

- The universe is vast and very old.
- The big bang theory is our best current model for the origin of the universe.
- The solar nebular theory is our best current idea for the origin of the solar system.
- Stars have a finite lifetime and evolve over time.
- The mass of a star controls its evolution, length of its lifetime, and ultimate fate.

Essential Knowledge and Skills

Knowledge

- The big bang theory states that the universe began in a very hot, dense state that expanded and eventually condensed into galaxies.
- The solar nebular theory explains that the planets formed through the condensing of the solar nebula.
- Stars form by condensation of interstellar gas.
- The Hertzsprung-Russell diagram illustrates the relationship between the absolute magnitude and the surface temperature of stars. As stars evolve, their position on the Hertzsprung-Russell diagram moves.
- *Galaxies* are collections of billions of stars. The basic types of galaxies are spiral, elliptical, and irregular.
- The solar system is located in the Milky Way galaxy.

Standard ES.14 a, b, c, d, e (continued)

Essential Understandings	Essential Knowledge and Skills
	<ul style="list-style-type: none">• A <i>light-year</i> is the distance light travels in one year and is the most commonly used measurement for distance in astronomy.• Much of our information about our galaxy and the universe comes from ground-based observations.