**Indiana Academic Standards for Earth and Space Science**

 **Standards Resource Guide Document**

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| This Teacher Resource Guide has been developed to provide supporting materials to help educators successfully implement the Indiana Academic Standards for Earth and Space Science. These resources are provided to help you in your work to ensure all students meet the rigorous learning expectations set by the Academic Standards. Use of these resources is optional – teachers should decide which resource will work best in their school for their students.  |
| This resource document is a living document and will be frequently updated. Please send any suggested links and report broken links to: Jarred CorwinSecondary Science Specialistjcorwin@doe.in.gov |
| The resources, clarifying statements, and vocabulary in this document are for illustrative purposes only, to promote a base of clarity and common understanding. Each item illustrates a standard but please note that the resources, clarifying statements, and vocabulary are not intended to limit interpretation or classroom applications of the standards.  |

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| **Standard 1: The Universe** |
| **Indiana Academic Standard** | **Clarifying Statement** | **Highlighted Vocabulary Words from the Standard Defined** | **Crosscutting Concept** |
| ES. 1.1: Construct an explanation detailing how space can be studied by observing all frequencies of the electromagnetic radiation with differentiated telescopes and observational tools. |  | Space – the physical universe beyond earth’s atmosphereFrequencies – number of complete oscillations per second of energy in the form of wavesElectromagnetic Radiation – energy in the form of electromagnetic waves; a series of electromagnetic wavesTelescopes - instrument used for viewing distant objects | Systems and system modelsEnergy and matter |
| ES. 1.2: Describe the expanding universe theory, also known as the "Big Bang Theory," based on observed astronomical evidence including: The Doppler Effect, red shift, Hubble's Law, and the cosmic microwave background. | Emphasis is on the astronomical evidence of the red shift of light from galaxies as an indication that the universe is currently expanding, the cosmic microwave background as the remnant radiation from the big bang, 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 big bang theory (3/4 hydrogen and ¼ helium) | Expanding Universe Theory – the universe is constantly expanding based on evidence posed from redshifts of distant galaxiesThe Doppler Effect – increase or decrease in the frequency of sound light or other waves as the source and observer move toward or away from the other.Red Shift – the displacement of spectral lines toward longer wavelengths in radiation from distant galaxies and celestial objectsHubble’s Law – rate at which astronomical objects in the universe move apart from each other is proportional to their distance from each otherCosmic Microwave Background – thermal radiation left from the time of recombination in Big Bang cosmology | Systems and system modelsEnergy and matter |
| ES. 1.3: Create a diagram, flowchart, or explanation that details the cooling of energy into protons and early elements, and early elements into superstars and galaxies. Explain the role of gravitational attraction in the formation of stars and galaxies from clouds of these early elements. |  | Energy – fundamental entity of nature that is transferred between parts of a system in the production of physical change within the system and usually regarded as the capacity for doing workProtons – elementary particle that is identical with the nucleus of the hydrogen atom, carries a positive charge numerically equal to the charge of an electronElements – basic substance that is made of atoms that have the same number of protons and cannot be separated further by ordinary chemical means into simpler substancesGalaxies – a system of millions or billions of stars, together with gas and dust, held together by gravitational attractionGravitational Attraction – the force of attraction between all masses in the universeStars – a self-luminous gaseous spheroidal celestial body of great mass which produces energy by means of nuclear fusion reactions | Systems and system modelsEnergy and matter |
| ES.1.4: Differentiate between the life cycles of stars of different masses found on the Hertzsprung-Russell Diagram. Differentiate between low, medium (including our sun), and high mass stars by what elements can be produced, and therefore whether or not they can achieve red giant phase or go supernova. | Emphasis on the way nucleosynthesis, and therefore the different elements created, varies as a function of the mass of a star and the stage of its lifetime. | Life Cycles – the series of stages in form through which something passesMasses – Measure of the amount of matter in a sampleHertzsprung-Russell Diagram – A two-dimensional graph, devised independently by Ejnar Hertzsprung and Henry Russell, in which the absolute magnitudes of stars are plotted against their spectral typesRed Giant Phase – luminous giant star of low or intermediate mass in a late phase of stellar evolutionSupernova – star that suddenly increases greatly in brightness because of a catastrophic explosion that ejects most of its mass | Scale, proportion, and quantitySystems and system models |
| ES.1.5 Illustrate the hierarchical relationship and scales of stars, planetary systems including multiple-star systems, star clusters, galaxies and galactic groups in the universe. |  | Planetary Systems – gravitationally bound non stellar objects in orbit around a star or star systemMultiple star system – three or more stars that are bound together by gravity and orbit a common center of massStar Cluster – group of stars that share a common origin and are gravitationally bound for some length of timeGalactic Groups – aggregation of galaxies comprising of about 50 or fewer gravitationally bound members | Scale, proportion, and quantitySystems and system models |

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| **Standard 2: The Solar System** |
| **Indiana Academic Standard** | **Clarifying Statement** | **Highlighted Vocabulary Words from the Standard Defined** | **Crosscutting Concept** |
| ES. 2.1: Construct a flowchart with diagrams and descriptions outlining the nebular theory of solar system formation. Include the formation of one or more stars, planetesimals, protoplanets, Jovian and terrestrial planets, and other objects including satellites and small bodies. |  | Nebular theory of solar system formation – rotating nebula underwent gravitational collapse into a star with an accretion disk, from which planets condensed by coagulation of dust particles into increasingly larger bodiesPlanetesimals – a minute planet, a body that could or did come together with many others under gravitation to form a planetProtoplanets – a large body of matter in orbit around the sun or a star and thought to be developing into a planet.Jovian – class of giant planets to which Jupiter belongsTerrestrial Planets – planet comprised primarily of silicate rocks or metalsSatellites – object in orbitSmall Bodies – object in the solar system that is neither a planet nor a dwarf planet nor a natural satellite | Scale, proportion, and quantitySystems and system models |
| ES.2.2: Describe the characteristics of the various kinds of objects in the solar system including planets, satellites, comets, asteroids, and protoplanets. Recognize that planets have been identified orbiting stars other than the sun, or exist outside of solar systems orbiting no sun at all. Describe the organization of our solar system including terrestrial and Jovian planets, asteroid belts, and the Oort Cloud. |  | Planets – celestial body moving in an elliptical orbit around a starSatellites – object in orbitComets – celestial object consisting of a nucleus of ice and dust and when near the sun a tail of gas and dust particles pointing away from the sunAsteroids – small rocky body orbiting the sunProtoplanets – large body of matter in orbit around the sun or a star and thought to be developing into a planetAsteroid Belts – region of space between the orbits of mars and Jupiter where most of the asteroids in our solar system are found orbiting the sunOort Cloud – a spherical shell of cometary bodies believed to surround the sun far beyond the orbits of the outermost planets and from which some are dislodged when perturbed to fall toward the sun | Scale, proportion, and quantitySystems and system models |
| ES. 2.3: Develop a model illustrating the layers and life span of the sun. Explain how nuclear fusion in the core produces elements and energy, which are both retained through convection and released to space, including Earth, through radiation. Additionally, elements heavier than iron cannot form in stars, and form only as a result of supernovae. |  | Nuclear Fusion – nuclear reaction in which atomic nuclei of low atomic number fuse to form a heavier nucleus with the release of energyCore – center of the sun to about 0.25 of the solar radiusConvection – movement caused within a fluid by the tendency of hotter and therefore less dense material to rise, colder, denser material to sink under the influence of gravity, which results in a transfer of heatRadiation – emission of energy as electromagnetic waves or as moving subatomic particles. | Scale, proportion, and quantitySystems and system models |
| ES. 2.4: Use mathematical and/or computational representations to demonstrate the motions of the various kinds of objects in our solar system including planets, satellites, comets, and asteroids. Explain that Kepler’s Laws determine the orbits of those objects and know that Kepler’s Laws are a direct consequence of Newton’s Law of Universal Gravitation together with his laws of motion. | Emphasis is on Newtonian gravitational laws governing orbital motions, which apply to human-made satellites as well as planets and moons. | Kepler’s Laws – the orbit of each planet is an ellipse that hast he sun at one focus, the radius vector from the sun to each planet generates equal orbital areas in equal timesOrbits – the curved path of a celestial object or a spacecraft around a star, planet, or moon, typically a periodic elliptical revolutionNewton’s Law of Universal Gravitation – any two bodies in the universe attract each other with a force that is directly proportional to the product of their masses and inversely proportional to the square of the distance between them | Scale, proportion, and quantitySystems and system models |
| ES. 2.5: Explain how scientific theory changes over time with the introduction of new information and observational data. Use works from ancient Greeks such as Ptolemy, and other astronomers including Copernicus, Brahe, Kepler, and Galileo to demonstrate the effect of observational data and scientific discussion on our understanding of the mechanics and motion of our solar system. |  | Scientific Theory – well – substantiated explanation of some aspect of the natural world that is acquired through the scientific method and repeatedly tested and confirmed through observation and experimentationPtolemy – Greek astronomer and mathematician who based his astronomy on the belief that all heavenly bodies revolved around EarthCopernicus – Polish astronomer who believed that earth and other planets revolved around the sunBrahe – Danish astronomer whose observations of the planets provided the basis for Kepler’s Laws of planetary motionKepler – German astronomer and mathematician who is considered the founder of celestial mechanics, accurately described the elliptical orbits of EarthGalileo – Italian astronomer and mathematician who was the first to use a telescope to study the stars, demonstrated that different weights descend at the same rate | Systems and system modelsStability and change |

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| **Standard 3: Earth Cycles and Systems** |
| **Indiana Academic Standard** | **Clarifying Statement** | **Highlighted Vocabulary Words from the Standard Defined** | **Crosscutting Concept** |
| ES 3.1: Create flowcharts that show the exchange of carbon and oxygen between the lithosphere, hydrosphere, biosphere, and atmosphere, including carbon dioxide and methane. Explain how human activities such as farming and industry, temperature change in oceans, and natural processes such as volcanic eruptions can speed or slow the cycling from reservoirs within the solid earth and oceans into the atmosphere. |  | Lithosphere – Rigid outer part of the earthHydrosphere – All the waters on the earth’s surfaceBiosphere – regions of the surface, atmosphere and hydrosphere of the earth occupied by living organismsAtmosphere – envelope of gases surrounding the earth or another planetFarming – activity or business of growing crops and raising livestockIndustry – economic activity concerned with the processing of raw materials and manufacture of goods in factoriesVolcanic Eruptions – vent in the earth’s crust through which molten rock, rock fragments, gases, and ashes are ejected from the earth’s interiorAtmosphere - envelope of gases surrounding the earth or another planet | PatternsSystems and system models |
| ES 3.2: Create diagrams and flowcharts that show the cycling of between the lithosphere, hydrosphere, biosphere, and atmosphere for nitrogen. Complete the same for phosphorus excluding the atmosphere. Explain how human activities can alter the amounts of both phosphorus and nitrogen between these layers. |  |  | Scale, proportion, and quantityEnergy and matter |
| ES 3.3: Analyze and explain how events on one side of the world can alter temperature and precipitation around the globe. Analyze and explain the possible effects of natural and human-driven processes on our atmosphere and climate. |  | 1. Temperature – the degree or intensity of heat present in a substance or object, especially as expressed according to a comparative scale and shown by a thermometer or perceived by touch
2. Precipitation – rain, snow, sleet, or hail that falls to the ground
3. Climate – the weather conditions prevailing in an area in general or over a long period.
 | PatternsStructure and function |
| ES. 3.4: Evaluate the use of sustainable versus nonrenewable resources. Explain the consequences of overuse and continued increased consumption of limited resources. Analyze and evaluate the benefits of researching, designing, and developing sustainable resources for private use and industry. |  | Sustainable resources – resources that can be replenished at least as fast as they are consumedNonrenewable resources – resource of economic value that cannot be readily replaced by natural means on a level equal to its consumption. | PatternsEnergy and matter |

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| **Standard 4: The Atmosphere and Hydrosphere** |
| **Indiana Academic Standard** | **Clarifying Statement** | **Highlighted Vocabulary Words from the Standard Defined** | **Crosscutting Concept** |
| ES. 4.1: Create a model that shows the composition, distribution, and circulation of gases in Earth's atmosphere. Show how carbon and oxygen cycles affect the composition through gas exchange with organisms, oceans, the solid earth, and industry. |  | 1. Composition – the nature of something's ingredients or constituents; the way in which a whole or mixture is made up
2. Organisms – an individual animal, plant, or single-celled life form.
 | Scale, proportion, and quantityEnergy and matter |
| ES. 4.2: Create models to demonstrate the circulation, retention, and reflection of heat in regards to the atmosphere, solid land, and bodies of water including lakes and oceans. Demonstrate the effects of cities, various terrain, cloud cover, sea ice, and open water on albedo. Examine local and global heat exchanges, including land & sea breezes, lake effects, urban heat islands, and thermohaline circulation. |  | 1. Terrain – a stretch of land, especially with regard to its physical features
2. Albedo – the proportion of the incident light or radiation that is reflected by a surface, typically that of a planet or moon.
3. Land breeze – a breeze blowing toward the sea from the land, especially at night, owing to the relative warmth of the sea
4. Sea breeze – a breeze blowing toward the land from the sea, especially during the day owing to the relative warmth of the land.

Lake effect – when a cold air mass moves across long expanses of warmer lake water, warming the lower layer of air which picks up water vapor from the lake, rises up through the colder air above, freezes and is deposited on the leeward (downwind) shoresUrban heat islands – city or metropolitan area that is significantly warmer than its surrounding rural areas due to human activities.Thermohaline circulation - part of the large-scale ocean circulation that is driven by global density gradients created by surface heat and freshwater fluxes. | Cause and effectSystems and system models |
| ES. 4.3: Create a presentation that demonstrates the process of the water cycle on both local and global scales. Illustrate the process of water cycling both from the solid earth to the atmosphere and around the solid earth. Examine the interaction of ground water, surface water, and ocean circulation. Illustrate the effects of human activity on water systems. |  | Water cycle – processes by which water circulates between the earth's oceans, atmosphere, and land, involving precipitation as rain and snow, drainage in streams and rivers, and return to the atmosphere by evaporation and transpirationHuman activity –Something that people do or cause to happen | PatternsSystems and system models |
| ES 4.4: Create a model to demonstrate how the Coriolis effect influences the global circulation of the atmosphere. Explain how changes in the circulation of the atmosphere and oceans can create events such as El Niño and La Niña. |  | 1. Coriolis effect – an effect whereby a mass moving in a rotating system experiences a force (the Coriolis force ) acting perpendicular to the direction of motion and to the axis of rotation

El Niño – irregularly occurring and complex series of climatic changes affecting the equatorial Pacific region and beyond every few years, characterized by the appearance of unusually warm, nutrient-poor water off northern Peru and Ecuador, typically in late DecemberLa Niña – coupled ocean-atmosphere phenomenon that is the counterpart of El Niño as part of the broader El Niño–Southern Oscillation climate pattern | Scale, proportion, and quantitySystems and system models |
| ES 4.5: Chart and explain the changes in weather as it relates to humidity, air pressure, and temperature. Explain how these factors result in local wind patterns and cloud cover. Explain the origin, life cycle, and behavior of weather systems, especially severe weather. Create an emergency plan for severe storms, both summer and winter. |  | * + Humidity – a quantity representing the amount of water vapor in the atmosphere or a gas

Air pressure – the force exerted by air, whether compressed or unconfined, on any surface in contact with it.1. Temperature – the degree or intensity of heat present in a substance or object, especially as expressed according to a comparative scale and shown by a thermometer or perceived by touch

Wind patterns – trend of wind direction and interaction1. Cloud cover – a mass of cloud covering all or most of the sky

Severe weather – any dangerous meteorological phenomena with the potential to cause damage, serious social disruption, or loss of human lifeEmergency plan – course of action developed to mitigate the damage of potential events that could endanger an organization's ability to function. Such a plan should include measures that provide for the safety of personnel and, if possible, property and facilities | Cause and effectSystems and system models |
| ES. 4.6: Differentiate between weather and climate. Examine long term, natural climate change and periods of glaciation as influenced by Milankovitch Cycles due to the gravity of other solar system bodies (obliquity and precession of axis and eccentricity of orbit). Explain how these are different from any short term (less than thousands of years) changes to climate. |  | 1. Weather - the state of the atmosphere at a place and time as regards heat, dryness, sunshine, wind, rain, etc
2. climate – the weather conditions prevailing in an area in general or over a long period
3. Glaciation – the process, condition, or result of being covered by glaciers or ice sheets

Milankovitch Cycles – cyclical movement related to the Earth's orbit around the Sun. There are three of them: eccentricity, axial tilt, and precessionObliquity – the angle between the planes of the earth's equator and orbitPrecession of axis – change in the orientation of the rotational axis of a rotating bodyEccentricity of orbit – parameter that determines the amount by which its orbit around another body deviates from a perfect circle | Scale, proportion, and quantitySystems and system models |
| ES. 4.7: Create diagrams or models to demonstrate the effect of the gravitational pull of the sun and moon on Earth's oceans. Explain the difference between daily (high and low) tides and monthly (spring and neap) tides. Explain how monthly tides relate to the revolution of the moon, and therefore its phases. |  | 1. Tides – the alternate rising and falling of the sea, usually twice in each lunar day at a particular place, due to the attraction of the moon and sun.
 | Systems and system modelsEnergy and matter |

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| **Standard 5: The Solid Earth** |
| **Indiana Academic Standard** | **Clarifying Statement** | **Highlighted Vocabulary Words from the Standard Defined** | **Crosscutting Concept** |
| ES. 5.1: Construct a lab to analyze minerals based on their physical and chemical properties. Explain how rocks may contain many minerals, one mineral, or no minerals, and minerals can be made of either single elements (such as gold) or compounds (such a silicates). |  | 1. Minerals – a solid inorganic substance of natural occurrence

Physical properties – a property (as color, hardness, boiling point) of matter not involving in its manifestation a chemical changeChemical properties – characteristic of a substance that is observed during a reaction in which the chemical composition or identity of the substance is changed | Systems and system modelsEnergy and matter |
| ES 5.2: Create a rock cycle flowchart or diagram that demonstrates the processes involved in the formation, breakdown, and reformation of igneous, sedimentary, and metamorphic rock. Show how each type can melt and reform igneous rock, undergo the various metamorphic processes, and undergo physical and chemical weathering to form sedimentary rock. |  | Igneous – rocks formed through the cooling and solidification of magma or lavaSedimentary – formed by the deposition and subsequent cementation of that material at the Earth's surface and within bodies of waterMetamorphic rock – once one form of rock but has changed to another under the influence of heat, pressure, or some other agent without passing through a liquid phase | Cause and effectSystems and system models |
| ES 5.3: Construct a model that demonstrates the difference between weathering, erosion, transportation of material, deposition, and new soil and sedimentary rock formation. Differentiate between types of physical and chemical weathering. |  | Weathering – Any of the chemical or mechanical processes by which rocks exposed to the weather undergo chemical decomposition and physical disintegrationErosion – A type of weathering in which surface soil and rock are worn away through the action of glaciers, water, and windTransportation of material – movement of material across the Earth's surface by water, wind, ice or gravityDeposition – laying down of matter by a natural processsoil – dynamic natural body on the surface of the earth in which plants grow, composed of mineral and organic materials and living formsSedimentary rock – rock that are formed by the deposition and subsequent cementation of that material at the Earth's surface and within bodies of water | Systems and system modelsStructure and function |
| ES 5.4: Differentiate between relative and absolute geological time. Detail how sedimentary rock can be dated based on relative-age dating and positioning, while igneous formations can be radiometrically dated. Differentiate between radiocarbon dating used for organic materials and other types of radiometric dating for inorganic rock formation. |  | Relative - events may be placed relatively to one anotherAbsolute geological time – process of determining an age on a specified time scaleIgneous formations – Rock formations formed by the cooling and solidifying of molten materialsRadiometrically – measurement of geologic time by means of the rate of disintegration of radioactive elementsRadiocarbon dating – technique for determining the age of organic materials, such as wood, based on their content of the radioisotope 14C acquired from the atmosphere when they formed part of a living plantOrganic materials – composed of organic compounds that has come from the remains of organisms such as plants and animals and their waste products in the environmentInorganic rock formation – rock formation that is made from or containing material that does not come from plants or animals | Scale, proportion, and quantitySystems and system models |
| ES 5.5: Create a timeline detailing the processes that have occurred in Indiana to create mostly sedimentary bedrock. Explain how changing sea levels, climate, and glaciation have shaped Indiana geology. |  | Sedimentary bedrock – hard, solid rock beneath surface materials such as soil and gravel1. sea levels – the level of the sea's surface, used in reckoning the height of geographical features such as hills and as a barometric standard
2. Climate – the weather conditions prevailing in an area in general or over a long period
3. Glaciation – the process, condition, or result of being covered by glaciers or ice sheets
4. geology – the science that deals with the earth's physical structure and substance, its history, and the processes that act on it
 | Systems and system modelsEnergy and matter |
| ES 5.6 Create models or diagrams to show how plate movement and sea level changes have changed continental land masses over time. Include the creation and destruction of inland seas, sedimentary rock formations including evaporites and biochemical formations, and the shaping and destruction of surface features. |  | Plate movement – Earth's outer shell is divided into several plates that glide over the mantleSea level – the level of the sea's surface, used in reckoning the height of geographical features such as hills and as a barometric standardContinental land masses – a part of the continental crust above sea level having a distinct identity, as a continent or large island.1. Evaporites – a natural salt or mineral deposit left after the evaporation of a body of water

Biochemical formations – sedimentary rocks form from sediment derived by biological processes | Systems and system modelsStructure and function |

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| **Standard 6: Earth Processes** |
| **Indiana Academic Standard** | **Clarifying Statement** | **Highlighted Vocabulary Words from the Standard Defined** | **Crosscutting Concept** |
| ES 6.1: Construct a diagram or model that identifies and describes the physical and chemical properties of the crust, mantle, outer core, and inner core of Earth. |  | Crust – the outer layer of the earth, about 22 miles (35 km) deep under the continents (continental crust) and 6 miles (10 km) deep under the oceans (oceanic crust)Mantle – the portion of the earth, about 1800 miles (2900 km) thick, between the crust and the core.Outer core – fluid layer about 2,300 km (1,400 mi) thick and composed of iron and nickel that lies above Earth's solid inner core and below its mantleInner core – Earth's innermost part and according to seismological studies, it has been believed to be primarily a solid ball with a radius of about 1220 kilometers, or 760 miles (about 70% of the Moon's radius). It is composed of an iron–nickel alloy and some light elements. | PatternsSystems and system models |
| ES 6.2: Explain how Earth's fluid outer core creates the magnetosphere and how this helps protect both humans and technology (such as satellites) from solar winds. |  | 1. Magnetosphere – the region surrounding the earth or another astronomical body in which its magnetic field is the predominant effective magnetic field

Solar winds – stream of particles (mostly protons) emitted by the sun and permeating the solar system | Systems and system modelsStructure and function |
| ES 6.3: Construct a diagram and explanation showing the convection of Earth's mantle and its impact on the movements of tectonic plates. Explain how the decay of radioactive isotopes and residual energy from Earth's original formation provide the heat to fuel this convective process, which, along with ridge push and slab pull, drive the movements of tectonic plates. |  | 1. Convection – the movement caused within a fluid by the tendency of hotter and therefore less dense material to rise, and colder, denser material to sink under the influence of gravity, which consequently results in transfer of heat.

Tectonic plates – two sub-layers of the earth's crust (lithosphere) that move, float, and sometimes fracture and whose interaction causes continental drift, earthquakes, volcanoes, mountains, and oceanic trenchesRadioactive isotopes – any of several species of the same chemical element with different masses whose nuclei are unstable and dissipate excess energy by spontaneously emitting radiation in the form of alpha, beta, and gamma raysRidge push – proposed mechanism for plate motion in plate tectonics. Because mid-ocean ridges lie at a higher elevation than the rest of the ocean floor, gravity causes the ridge to push on the lithosphere that lies farther from the ridgeSlab pull – portion of motion of a tectonic plate that can be accounted for by its subduction. Plate motion is partly driven by the weight of cold, dense plates sinking into the mantle at trenches | Systems and system modelsEnergy and matter |
| ES. 6.4: Create a timeline to show the development of modern tectonic plate theory. Identify and explain how the evidence from the theory of continental drift, seafloor spreading, and paleomagnetism built upon each other to support tectonic plate theory. |  | Modern tectonic plate theory – lithosphere of the earth is divided into a small number of plates which float on and travel independently over the mantle and much of the earth's seismic activity occurs at the boundaries of these platesTheory of continental drift – gradual movement of the continents across the earth's surface through geological timeSeafloor spreading – formation of new areas of oceanic crust, which occurs through the upwelling of magma at midocean ridges and its subsequent outward movement on either side.Paleomagnetism – branch of geophysics concerned with the magnetism in rocks that was induced by the earth's magnetic field at the time of their formation | Systems and system modelsEnergy and matter |
| ES. 6.5: Create models that demonstrate different types of orogeny resulting from plate tectonics. Show how the interactions between oceanic and continental plates create different geological features (such as volcanic island arcs or high altitude plateaus) depending on what types of plates are involved in the motions along different plate boundaries. |  | Orogeny – process in which a section of the earth's crust is folded and deformed by lateral compression to form a mountain rangeVolcanic island arcs – chain of volcanoes formed above a subducting plate, positioned in an arc shape as seen from above. Offshore volcanoes form islands, resulting in a volcanic island arc1. High altitude plateaus – an area of relatively level high ground.

At high altitudes | Cause and effectStructure and function |
| ES. 6.6: Create models and differentiate between shield, composite, and cinder cone volcanoes. Explain how volcanoes form, how the chemical composition of lava affects the type of volcanoes formed, and how the location (such as hot spots or along continental or oceanic margins) can affect the types of magma present. |  | 1. Shield – a broad, domed volcano with gently sloping sides, characteristic of the eruption of fluid, basaltic lava

Composite – conical volcano built up by many layers (strata) of hardened lava, tephra, pumice, and volcanic ashCinder cone volcanoes – A steep, conical hill consisting of glassy volcanic fragments that accumulate around and downwind from a volcanic vent.1. Magma – hot fluid or semifluid material below or within the earth's crust from which lava and other igneous rock is formed by cooling
 | Scale, proportion, and quantitySystems and system models |
| ES. 6.7: Use models, diagrams, and captions to explain how tectonic motion creates earthquakes and tsunamis. Using resources such as indianamap.org, analyze how close the school is to known faults and liquefaction potential. Differentiate between intraplate fault zones such as the Wabash Valley Fault System and the more commonly discussed faults along tectonic margins. |  | 1. Earthquakes – a sudden and violent shaking of the ground, sometimes causing great destruction, as a result of movements within the earth's crust or volcanic action
2. Tsunamis – a long high sea wave caused by an earthquake, submarine landslide, or other disturbance

Faults – a fracture in the crust of a planet (as the earth) or moon accompanied by a displacement of one side of the fracture with respect to the other usually in a direction parallel to the fractureLiquefaction potential – phenomenon whereby a saturated or partially saturated soil substantially loses strength and stiffness in response to an applied stress, usually earthquake shaking or other sudden change in stress condition, causing it to behave like a liquid  | Cause and effectSystems and system models |

Crosscutting Concepts

 1. Patterns. Observed patterns of forms and events guide organization and classification, and they prompt questions about relationships and the factors that influence them.

2. Cause and effect: Mechanism and explanation. Events have causes, sometimes simple, sometimes multifaceted. A major activity of science is investigating and explaining causal relationships and the mechanisms by which they are mediated. Such mechanisms can then be tested across given contexts and used to predict and explain events in new contexts.

3. Scale, proportion, and quantity. In considering phenomena, it is critical to recognize what is relevant at different measures of size, time, and energy and to recognize how changes in scale, proportion, or quantity affect a system’s structure or performance.

4. Systems and system models. Defining the system under study—specifying its boundaries and making explicit a model of that system—provides tools for understanding and testing ideas that are applicable throughout science and engineering.

5. Energy and matter: Flows, cycles, and conservation. Tracking fluxes of energy and matter into, out of, and within systems helps one understand the systems’ possibilities and limitations.

6. Structure and function. The way in which an object or living thing is shaped and its substructure determine many of its properties and functions.

7. Stability and change. For natural and built systems alike, conditions of stability and determinants of rates of change or evolution of a system are critical elements of study.