

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

### **Standards Resource Guide Document**

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:

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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.

<b>Standard 1: The Universe</b>			
<b>Indiana Academic Standard</b>	<b>Clarifying Statement</b>	<b>Highlighted Vocabulary Words from the Standard Defined</b>	<b>Crosscutting Concept</b>
ES. 1.1: Construct an explanation detailing how <b>space</b> can be studied by observing all <b>frequencies</b> of the <b>electromagnetic radiation</b> with differentiated <b>telescopes</b> and observational tools.		Space – the physical universe beyond earth's atmosphere Frequencies – number of complete oscillations per second of energy in the form of waves Electromagnetic Radiation – energy in the form of electromagnetic waves; a series of electromagnetic waves Telescopes - instrument used for viewing distant objects	Systems and system models Energy and matter

<p>ES. 1.2: Describe the <b>expanding universe theory</b>, also known as the "Big Bang Theory," based on observed astronomical evidence including: <b>The Doppler Effect, red shift, Hubble's Law</b>, and the <b>cosmic microwave background</b>.</p>	<p>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 1/4 helium)</p>	<p>Expanding Universe Theory – the universe is constantly expanding based on evidence posed from redshifts of distant galaxies  The 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 objects  Hubble's Law – rate at which astronomical objects in the universe move apart from each other is proportional to their distance from each other  Cosmic Microwave Background – thermal radiation left from the time of recombination in Big Bang cosmology</p>	<p>Systems and system models  Energy and matter</p>
<p>ES. 1.3: Create a diagram, flowchart, or explanation that details the cooling of <b>energy</b> into <b>protons</b> and early <b>elements</b>, and early elements into superstars and <b>galaxies</b>. Explain the role of <b>gravitational attraction</b> in the formation of <b>stars</b> and galaxies from clouds of these early elements.</p>		<p>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 work  Protons – elementary particle that is identical with the nucleus of the hydrogen atom, carries a positive charge numerically equal to the charge of an electron  Elements – 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 substances  Galaxies – a system of millions or billions of stars, together with gas and dust, held together by gravitational attraction  Gravitational Attraction – the force of attraction between all masses in the universe  Stars – a self-luminous gaseous spheroidal celestial body of great mass which produces energy by means of nuclear fusion reactions</p>	<p>Systems and system models  Energy and matter</p>

<p>ES.1.4: Differentiate between the <a href="#">life cycles</a> of stars of different <a href="#">masses</a> found on the <a href="#">Hertzsprung-Russell Diagram</a>.</p> <p>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 <a href="#">red giant phase</a> or go <a href="#">supernova</a>.</p>	<p>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.</p>	<p><b>Life Cycles</b> – the series of stages in form through which something passes</p> <p><b>Masses</b> – Measure of the amount of matter in a sample</p> <p><b>Hertzsprung-Russell Diagram</b> – A two-dimensional graph, devised independently by Ejnar Hertzsprung and Henry Russell, in which the absolute magnitudes of stars are plotted against their spectral types</p> <p><b>Red Giant Phase</b> – luminous giant star of low or intermediate mass in a late phase of stellar evolution</p> <p><b>Supernova</b> – star that suddenly increases greatly in brightness because of a catastrophic explosion that ejects most of its mass</p>	<p>Scale, proportion, and quantity</p> <p>Systems and system models</p>
<p>ES.1.5 Illustrate the hierarchical relationship and scales of stars, <a href="#">planetary systems</a> including <a href="#">multiple-star systems</a>, <a href="#">star clusters</a>, <a href="#">galaxies</a> and <a href="#">galactic groups</a> in the universe.</p>		<p><b>Planetary Systems</b> – gravitationally bound non stellar objects in orbit around a star or star system</p> <p><b>Multiple star system</b> – three or more stars that are bound together by gravity and orbit a common center of mass</p> <p><b>Star Cluster</b> – group of stars that share a common origin and are gravitationally bound for some length of time</p> <p><b>Galactic Groups</b> – aggregation of galaxies comprising of about 50 or fewer gravitationally bound members</p>	<p>Scale, proportion, and quantity</p> <p>Systems and system models</p>

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 <b>nebular theory of solar system formation</b> . Include the formation of one or more stars, <b>planetesimals</b> , <b>protoplanets</b> , <b>Jovian</b> and <b>terrestrial planets</b> , and other objects including <b>satellites</b> and <b>small bodies</b> .		<p>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 bodies</p> <p>Planetesimals – a minute planet, a body that could or did come together with many others under gravitation to form a planet</p> <p>Protoplanets – a large body of matter in orbit around the sun or a star and thought to be developing into a planet.</p> <p>Jovian – class of giant planets to which Jupiter belongs</p> <p>Terrestrial Planets – planet comprised primarily of silicate rocks or metals</p> <p>Satellites – object in orbit</p> <p>Small Bodies – object in the solar system that is neither a planet nor a dwarf planet nor a natural satellite</p>	<p>Scale, proportion, and quantity</p> <p>Systems and system models</p>
ES.2.2: Describe the characteristics of the various kinds of objects in the solar system including <b>planets</b> , <b>satellites</b> , <b>comets</b> , <b>asteroids</b> , and <b>protoplanets</b> . 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, <b>asteroid belts</b> , and the <b>Oort Cloud</b> .		<p>Planets – celestial body moving in an elliptical orbit around a star</p> <p>Satellites – object in orbit</p> <p>Comets – 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 sun</p> <p>Asteroids – small rocky body orbiting the sun</p> <p>Protoplanets – large body of matter in orbit around the sun or a star and thought to be developing into a planet</p> <p>Asteroid Belts – region of space between the orbits of mars and Jupiter where most of the asteroids in our solar system are found orbiting the sun</p> <p>Oort 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</p>	<p>Scale, proportion, and quantity</p> <p>Systems and system models</p>

<p>ES. 2.3: Develop a model illustrating the layers and life span of the sun. Explain how <b>nuclear fusion</b> in the <b>core</b> produces elements and energy, which are both retained through <b>convection</b> and released to space, including Earth, through <b>radiation</b>. Additionally, elements heavier than iron cannot form in stars, and form only as a result of supernovae.</p>		<p>Nuclear Fusion – nuclear reaction in which atomic nuclei of low atomic number fuse to form a heavier nucleus with the release of energy  Core – center of the sun to about 0.25 of the solar radius  Convection – 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 heat  Radiation – emission of energy as electromagnetic waves or as moving subatomic particles.</p>	Scale, proportion, and quantity  Systems and system models
<p>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 <b>Kepler's Laws</b> determine the <b>orbits</b> of those objects and know that Kepler's Laws are a direct consequence of <b>Newton's Law of Universal Gravitation</b> together with his laws of motion.</p>	<p>Emphasis is on Newtonian gravitational laws governing orbital motions, which apply to human-made satellites as well as planets and moons.</p>	<p>Kepler's Laws – the orbit of each planet is an ellipse that has the sun at one focus, the radius vector from the sun to each planet generates equal orbital areas in equal times  Orbits – the curved path of a celestial object or a spacecraft around a star, planet, or moon, typically a periodic elliptical revolution  Newton'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</p>	Scale, proportion, and quantity  Systems and system models

<p>ES. 2.5: Explain how <b>scientific theory</b> changes over time with the introduction of new information and observational data. Use works from ancient Greeks such as <b>Ptolemy</b>, and other astronomers including <b>Copernicus, Brahe, Kepler</b>, and <b>Galileo</b> to demonstrate the effect of observational data and scientific discussion on our understanding of the mechanics and motion of our solar system.</p>	<p>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 experimentation</p> <p>Ptolemy – Greek astronomer and mathematician who based his astronomy on the belief that all heavenly bodies revolved around Earth</p> <p>Copernicus – Polish astronomer who believed that earth and other planets revolved around the sun</p> <p>Brahe – Danish astronomer whose observations of the planets provided the basis for Kepler's Laws of planetary motion</p> <p>Kepler – German astronomer and mathematician who is considered the founder of celestial mechanics, accurately described the elliptical orbits of Earth</p> <p>Galileo – 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</p>	<p>Systems and system models Stability and change</p>
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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 <b>lithosphere</b> , <b>hydrosphere</b> , <b>biosphere</b> , and <b>atmosphere</b> , including carbon dioxide and methane. Explain how human activities such as <b>farming</b> and <b>industry</b> , temperature change in oceans, and natural processes such as <b>volcanic eruptions</b> can speed or slow the cycling from reservoirs within the solid earth and oceans into the <b>atmosphere</b> .		<p>Lithosphere – Rigid outer part of the earth          Hydrosphere – All the waters on the earth's surface          Biosphere – regions of the surface, atmosphere and hydrosphere of the earth occupied by living organisms          Atmosphere – envelope of gases surrounding the earth or another planet          Farming – activity or business of growing crops and raising livestock          Industry – economic activity concerned with the processing of raw materials and manufacture of goods in factories          Volcanic Eruptions – vent in the earth's crust through which molten rock, rock fragments, gases, and ashes are ejected from the earth's interior          Atmosphere - envelope of gases surrounding the earth or another planet</p>	Patterns  Systems 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 quantity  Energy and matter

<p>ES 3.3: Analyze and explain how events on one side of the world can alter <b>temperature</b> and <b>precipitation</b> around the globe. Analyze and explain the possible effects of natural and human-driven processes on our atmosphere and <b>climate</b>.</p>		<p>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</p> <p>Precipitation – rain, snow, sleet, or hail that falls to the ground</p> <p>Climate – the weather conditions prevailing in an area in general or over a long period.</p>	<p>Patterns Structure and function</p>
<p>ES. 3.4: Evaluate the use of <b>sustainable</b> versus <b>nonrenewable resources</b>. 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.</p>		<p>Sustainable resources – resources that can be replenished at least as fast as they are consumed</p> <p>Nonrenewable resources – resource of economic value that cannot be readily replaced by natural means on a level equal to its consumption.</p>	<p>Patterns Energy and matter</p>

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 <b>composition</b> , distribution, and circulation of gases in Earth's atmosphere. Show how carbon and oxygen cycles affect the composition through gas exchange with <b>organisms</b> , oceans, the solid earth, and industry.		<p>Composition – the nature of something's ingredients or constituents; the way in which a whole or mixture is made up</p> <p>Organisms – an individual animal, plant, or single-celled life form.</p>	<p>Scale, proportion, and quantity</p> <p>Energy and matter</p>

<p>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.</p> <p>Demonstrate the effects of cities, various <a href="#">terrain</a>, cloud cover, sea ice, and open water on <a href="#">albedo</a>. Examine local and global heat exchanges, including <a href="#">land &amp; sea breezes</a>, <a href="#">lake effects</a>, <a href="#">urban heat islands</a>, and <a href="#">thermohaline circulation</a>.</p>	<p>Terrain – a stretch of land, especially with regard to its physical features</p> <p>Albedo – the proportion of the incident light or radiation that is reflected by a surface, typically that of a planet or moon.</p> <p>Land breeze – a breeze blowing toward the sea from the land, especially at night, owing to the relative warmth of the sea</p> <p>Sea breeze – a breeze blowing toward the land from the sea, especially during the day owing to the relative warmth of the land.</p> <p>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) shores</p> <p>Urban heat islands – city or metropolitan area that is significantly warmer than its surrounding rural areas due to human activities.</p> <p>Thermohaline circulation - part of the large-scale ocean circulation that is driven by global density gradients created by surface heat and freshwater fluxes.</p>	<p>Cause and effect Systems and system models</p>
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<p>ES. 4.3: Create a presentation that demonstrates the process of the <b>water cycle</b> 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 <b>human activity</b> on water systems.</p>		<p>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 transpiration</p> <p>Human activity –Something that people do or cause to happen</p>	<p>Patterns Systems and system models</p>
<p>ES 4.4: Create a model to demonstrate how the <b>Coriolis effect</b> influences the global circulation of the atmosphere. Explain how changes in the circulation of the atmosphere and oceans can create events such as <b>El Niño</b> and <b>La Niña</b>.</p>		<p>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</p> <p>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 December</p> <p>La Niña – coupled ocean-atmosphere phenomenon that is the counterpart of El Niño as part of the broader El Niño–Southern Oscillation climate pattern</p>	<p>Scale, proportion, and quantity Systems and system models</p>

<p>ES 4.5: Chart and explain the changes in weather as it relates to <b>humidity</b>, <b>air pressure</b>, and <b>temperature</b>. Explain how these factors result in local <b>wind patterns</b> and <b>cloud cover</b>. Explain the origin, life cycle, and behavior of weather systems, especially <b>severe weather</b>. Create an <b>emergency plan</b> for severe storms, both summer and winter.</p>	<p>Humidity – a quantity representing the amount of water vapor in the atmosphere or a gas</p> <p>Air pressure – the force exerted by air, whether compressed or unconfined, on any surface in contact with it.</p> <p>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</p> <p>Wind patterns – trend of wind direction and interaction</p> <p>Cloud cover – a mass of cloud covering all or most of the sky</p> <p>Severe weather – any dangerous meteorological phenomena with the potential to cause damage, serious social disruption, or loss of human life</p> <p>Emergency 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</p>	<p>Cause and effect Systems and system models</p>
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<p>ES. 4.6: Differentiate between <b>weather</b> and <b>climate</b>. Examine long term, natural climate change and periods of <b>glaciation</b> as influenced by <b>Milankovitch Cycles</b> due to the gravity of other solar system bodies (<b>obliquity</b> and <b>precession of axis</b> and <b>eccentricity of orbit</b>). Explain how these are different from any short term (less than thousands of years) changes to climate.</p>		<p>Weather - the state of the atmosphere at a place and time as regards heat, dryness, sunshine, wind, rain, etc         climate – the weather conditions prevailing in an area in general or over a long period         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 precession        Obliquity – the angle between the planes of the earth's equator and orbit        Precession of axis – change in the orientation of the rotational axis of a rotating body        Eccentricity of orbit – parameter that determines the amount by which its orbit around another body deviates from a perfect circle</p>	<p>Scale, proportion, and quantity         Systems and system models</p>
<p>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) <b>tides</b> and monthly (spring and neap) tides. Explain how monthly tides relate to the revolution of the moon, and therefore its phases.</p>		<p>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.</p>	<p>Systems and system models         Energy and matter</p>

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 <b>minerals</b> based on their <b>physical and chemical properties</b> . 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 as silicates).		<p>Minerals – a solid inorganic substance of natural occurrence</p> <p>Physical properties – a property (as color, hardness, boiling point) of matter not involving in its manifestation a chemical change</p> <p>Chemical properties – characteristic of a substance that is observed during a reaction in which the chemical composition or identity of the substance is changed</p>	<p>Systems and system models</p> <p>Energy and matter</p>
ES 5.2: Create a rock cycle flowchart or diagram that demonstrates the processes involved in the formation, breakdown, and reformation of <b>igneous</b> , <b>sedimentary</b> , and <b>metamorphic rock</b> . 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.		<p>Igneous – rocks formed through the cooling and solidification of magma or lava</p> <p>Sedimentary – formed by the deposition and subsequent cementation of that material at the Earth's surface and within bodies of water</p> <p>Metamorphic 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</p>	<p>Cause and effect</p> <p>Systems and system models</p>

<p>ES 5.3: Construct a model that demonstrates the difference between <b>weathering</b>, <b>erosion</b>, <b>transportation of material</b>, <b>deposition</b>, and new <b>soil</b> and <b>sedimentary rock</b> formation. Differentiate between types of physical and chemical weathering.</p>		<p>Weathering – Any of the chemical or mechanical processes by which rocks exposed to the weather undergo chemical decomposition and physical disintegration</p> <p>Erosion – A type of weathering in which surface soil and rock are worn away through the action of glaciers, water, and wind</p> <p>Transportation of material – movement of material across the Earth's surface by water, wind, ice or gravity</p> <p>Deposition – laying down of matter by a natural process</p> <p>soil – dynamic natural body on the surface of the earth in which plants grow, composed of mineral and organic materials and living forms</p> <p>Sedimentary rock – rock that are formed by the deposition and subsequent cementation of that material at the Earth's surface and within bodies of water</p>	<p>Systems and system models Structure and function</p>
<p>ES 5.4: Differentiate between <b>relative</b> and <b>absolute geological time</b>. Detail how sedimentary rock can be dated based on relative-age dating and positioning, while <b>igneous formations</b> can be <b>radiometrically</b> dated. Differentiate between <b>radiocarbon dating</b> used for <b>organic materials</b> and other types of radiometric dating for <b>inorganic rock formation</b>.</p>		<p>Relative - events may be placed relatively to one another</p> <p>Absolute geological time – process of determining an age on a specified time scale</p> <p>Igneous formations – Rock formations formed by the cooling and solidifying of molten materials</p> <p>Radiometrically – measurement of geologic time by means of the rate of disintegration of radioactive elements</p> <p>Radiocarbon dating – technique for determining the age of organic materials, such as wood, based on their content of the radioisotope <math>^{14}\text{C}</math> acquired from the atmosphere when they formed part of a living plant</p> <p>Organic materials – composed of organic compounds that has come from the remains of organisms such as plants and animals and their waste products in the environment</p> <p>Inorganic rock formation – rock formation that is made from or containing material that does not come from plants or animals</p>	<p>Scale, proportion, and quantity Systems and system models</p>

<p>ES 5.5: Create a timeline detailing the processes that have occurred in Indiana to create mostly <b>sedimentary bedrock</b>. Explain how changing <b>sea levels, climate, and glaciation</b> have shaped <b>Indiana geology</b>.</p>		<p>Sedimentary bedrock – hard, solid rock beneath surface materials such as soil and gravel      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        Climate – the weather conditions prevailing in an area in general or over a long period        Glaciation – the process, condition, or result of being covered by glaciers or ice sheets        geology – the science that deals with the earth's physical structure and substance, its history, and the processes that act on it</p>	<p>Systems and system models        Energy and matter</p>
<p>ES 5.6 Create models or diagrams to show how <b>plate movement</b> and <b>sea level</b> changes have changed <b>continental land masses</b> over time. Include the creation and destruction of inland seas, sedimentary rock formations including <b>evaporites</b> and <b>biochemical formations</b>, and the shaping and destruction of surface features.</p>		<p>Plate movement – Earth's outer shell is divided into several plates that glide over the mantle      Sea level – the level of the sea's surface, used in reckoning the height of geographical features such as hills and as a barometric standard        Continental land masses – a part of the continental crust above sea level having a distinct identity, as a continent or large island.      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</p>	<p>Systems and system models        Structure and function</p>

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 <b>crust</b> , <b>mantle</b> , <b>outer core</b> , and <b>inner core</b> of Earth.		<p>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)</p> <p>Mantle – the portion of the earth, about 1800 miles (2900 km) thick, between the crust and the core.</p> <p>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 mantle</p> <p>Inner 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.</p>	<p>Patterns</p> <p>Systems and system models</p>
ES 6.2: Explain how Earth's fluid outer core creates the <b>magnetosphere</b> and how this helps protect both humans and technology (such as satellites) from <b>solar winds</b> .		<p>Magnetosphere – the region surrounding the earth or another astronomical body in which its magnetic field is the predominant effective magnetic field</p> <p>Solar winds – stream of particles (mostly protons) emitted by the sun and permeating the solar system</p>	<p>Systems and system models</p> <p>Structure and function</p>

<p>ES 6.3: Construct a diagram and explanation showing the <b>convection</b> of Earth's mantle and its impact on the movements of <b>tectonic plates</b>. Explain how the decay of <b>radioactive isotopes</b> and residual energy from Earth's original formation provide the heat to fuel this convective process, which, along with <b>ridge push</b> and <b>slab pull</b>, drive the movements of tectonic plates.</p>	<p>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.</p> <p>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 trenches</p> <p>Radioactive 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 rays</p> <p>Ridge 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 ridge</p> <p>Slab 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</p>	<p>Systems and system models Energy and matter</p>
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<p>ES. 6.4: Create a timeline to show the development of <b>modern tectonic plate theory</b>. Identify and explain how the evidence from the <b>theory of continental drift</b>, <b>seafloor spreading</b>, and <b>paleomagnetism</b> built upon each other to support tectonic plate theory.</p>		<p>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 plates</p> <p>Theory of continental drift – gradual movement of the continents across the earth's surface through geological time</p> <p>Seafloor 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.</p> <p>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</p>	<p>Systems and system models Energy and matter</p>
<p>ES. 6.5: Create models that demonstrate different types of <b>orogeny</b> resulting from plate tectonics. Show how the interactions between oceanic and continental plates create different geological features (such as <b>volcanic island arcs</b> or <b>high altitude plateaus</b>) depending on what types of plates are involved in the motions along different plate boundaries.</p>		<p>Orogeny – process in which a section of the earth's crust is folded and deformed by lateral compression to form a mountain range</p> <p>Volcanic 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 arc</p> <p>High altitude plateaus – an area of relatively level high ground. At high altitudes</p>	<p>Cause and effect Structure and function</p>

<p>ES. 6.6: Create models and differentiate between <b>shield</b>, <b>composite</b>, and <b>cinder cone volcanoes</b>. 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 <b>magma</b> present.</p>		<p>Shield – a broad, domed volcano with gently sloping sides, characteristic of the eruption of fluid, basaltic lava</p> <p>Composite – conical volcano built up by many layers (strata) of hardened lava, tephra, pumice, and volcanic ash</p> <p>Cinder cone volcanoes – A steep, conical hill consisting of glassy volcanic fragments that accumulate around and downwind from a volcanic vent.</p> <p>Magma – hot fluid or semifluid material below or within the earth's crust from which lava and other igneous rock is formed by cooling</p>	<p>Scale, proportion, and quantity</p> <p>Systems and system models</p>
<p>ES. 6.7: Use models, diagrams, and captions to explain how tectonic motion creates <b>earthquakes</b> and <b>tsunamis</b>. Using resources such as <a href="http://indianamap.org">indianamap.org</a>, analyze how close the school is to known <b>faults</b> and <b>liquefaction potential</b>. Differentiate between intraplate fault zones such as the Wabash Valley Fault System and the more commonly discussed faults along tectonic margins.</p>		<p>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</p> <p>Tsunamis – a long high sea wave caused by an earthquake, submarine landslide, or other disturbance</p> <p>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 fracture</p> <p>Liquefaction 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</p>	<p>Cause and effect</p> <p>Systems and system models</p>

### 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.