# 9 – 12 Crosswalk

**The intent of this crosswalk is to enhance understanding of the changes to the science expectations. The column on the left contains the newly adopted science expectations (2016). The column on the right contains the previous expectations (2008) which show some alignment. This document is intended to assist teachers with some of the issues associated with implementing new science standards: planning, pacing, professional development and curricular materials.**

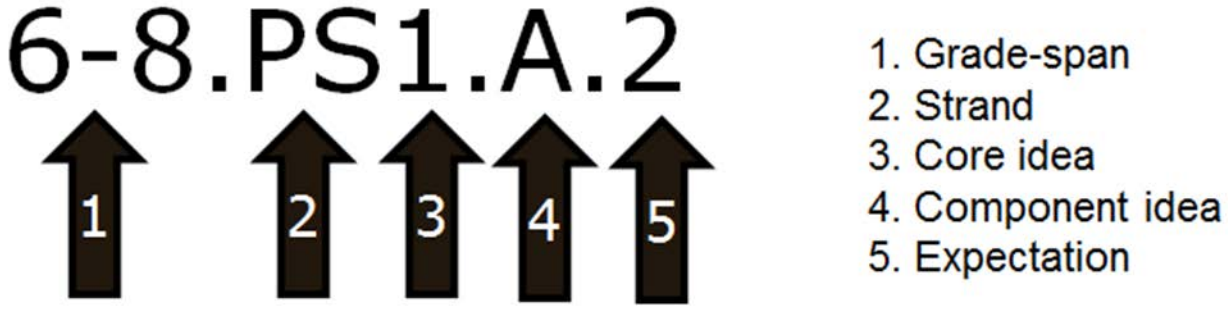
**Expectations for middle school strands are based on 9 – 12 grade-spans: Physical Science (PS), Life Science (LS), Earth and Space Science (ESS) and Engineering, Technology and Application of Science (ETS). Within each strand there are Core Ideas: PS1 - Matter and Its Interactions or PS2 - Motion and Stability: Forces and Interactions. The Core Ideas are broken down to Component Ideas. Each Component Idea may have one or more performance expectations.**

**"A Framework for K-12 Science Education: Practices, Concepts and Core Ideas" explains a "3 dimensional" learning model in which the instruction of phenomena are accompanied by specific lists of practices and concepts. Review chapters 3 and 4 as these chapters illustrate the additional dimensions of science education. This book or individual chapters can be downloaded for free from the National Academies Press website (http://www.nap.edu/).**

**Strand 7 of the 9 – 12 GLEs primarily align with the "science and engineering practices" and "crosscutting concepts" from "A Framework for K-12 Science Educations: Practices, Concepts and Core Ideas". Review available resources to understand the alignment of the scientific inquiry skills from Strand 7with the practices and concepts from the 3 Dimensional Learning Model.**

***Assessments for the new expectations are currently scheduled for the 2018 – 2019 school year.***

**Note the changes to the coding of science expectations:**



| **Missouri Learning Standards: Grade-Level Expectations** (Adopted April 2016 for implementation in the 2016 – 2017 school year, assessed beginning in the 2018 – 2019 school year.) | | **Missouri Learning Standards** (Revised edition 2008) | | |
|---|---|---|---|---|
| | **Physical Science** | | | |
| | **PS1 - Matter and Its Interactions** | | | |
| | **A. Structure and Properties of Matter** | | | |
| 9-12.PS1.A.1 | Use the organization of the periodic table to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms. [Clarification Statement: Examples of properties that could be predicted from patterns could include reactivity of metals, types of bonds formed, numbers of bonds formed, and reactions with oxygen.] | ME.1.E | a. Describe the atom as having a dense, positive nucleus surrounded by a cloud of negative electrons<br><br>b. Calculate the number of protons, neutrons, and electrons of an element/isotopes given its mass number and atomic number<br><br>c. Describe the information provided by the atomic number and the mass number (i.e., electrical charge, chemical stability) | |
| | | ME.1.F | a. Explain the structure of the periodic table in terms of the elements with common properties (groups/families) and repeating properties (periods)<br><br>b. Classify elements as metals, nonmetals, metalloids (semi-conductors), and noble gases according to their location on the Periodic Table<br><br>c. Predict the chemical reactivity of elements, and the type of bonds that may result between them, using the Periodic Table | |
| | | | | |
| 9-12.PS1.A.2 | Construct and revise an explanation for the products of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties. [Clarification Statement: Examples of chemical reactions could include the reaction of sodium and chlorine, or of oxygen and hydrogen.] | | a. Describe how the valence electron configuration determines how atoms interact and may bond | |
| 9-12.PS1.A.3 | Plan and conduct an investigation to gather evidence to compare physical and chemical properties of substances such as melting point, boiling point, vapor pressure, surface tension, and chemical reactivity to infer the relative strength of attractive forces between particles. [Clarification Statement: Emphasis is on understanding | **ME.1.A.PS** | a. Compare the densities of regular and irregular objects using their respective measures of volume and mass<br><br>b. Identify pure substances by their physical and chemical properties (i.e., color, luster/reflectivity, hardness, | |

| | | | | |
|---|---|---|---|---|
| | the relative strengths of forces between particles. Examples of particles could include ions, atoms, molecules, and networked materials (such as graphite). | | conductivity, density, pH, melting point, boiling point, specific heat, solubility, phase at room temperature, chemical reactivity)<br><br>c. Classify a substance as being made up of one kind of atom (element) or a compound when given the molecular formula or structural formula (introduce electron dot diagram) for the substance<br><br>d. Compare and contrast the common properties of metals, nonmetals, metalloids (semi-conductors) and noble gases | |
| | | **ME.1.D** | a. Using the Kinetic Theory model, explain the changes that occur in the distance between atoms/molecules and temperature of a substance as energy is absorbed or released during a phase change<br><br>b. Predict the effect of a temperature change on the properties (e.g., pressure, density) of a material (solids, liquids, gases)<br><br>c. Predict the effect of pressure changes on the properties (e.g., temperature, density) of a material (solids, liquids, gases) | |
| | | **ME.1.B.** | a. Classify solutions as either dilute or concentrated; as either saturated, unsaturated, or supersaturated<br><br>b. Compare and contrast the properties of acidic, basic, and neutral solutions<br><br>c. Predict the effects of solvent and solute polarity on solubility ("like dissolves like"); and predict the effects of temperature, surface area, particle size, and agitation on rates of solubility | |
| | | **ME.1.G** | a. Distinguish between physical and chemical changes in matter | |
| 9-12.PS1.A.4 | Apply the concepts of bonding and crystalline/molecular structure to explain the macroscopic properties of various categories of structural materials, i.e. metals, ionic (ceramics), and polymers. [Clarification Statement: Emphasis is on the attractive and repulsive forces that determine the functioning of the material. Examples could include why electrically conductive materials are often made of metal, flexible but durable materials are made up of long chained molecules, and pharmaceuticals are designed to interact with specific receptors.] | **ME1.H** | c. Compare and contrast the types of chemical bonds (i.e., ionic, covalent) | |

| | | | |
|---|---|---|---|
| 9-12.PS1.A.5 | Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy. [Clarification Statement: Emphasis is on the idea that a chemical reaction is a system that affects the energy change. Examples of models could include molecular-level drawings and diagrams of reactions, graphs showing the relative energies of reactants and products, and representations showing energy is conserved.] | | |
| | | | |
| | **PS1 - Matter and Its Interactions** | | |
| | **B. Chemical Reactions** | | |
| 9-12.PS1.B.1 | Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs. [Clarification Statement: Emphasis is on student reasoning that focuses on the number and energy of collisions between molecules.] | **ME.1.H** | b. Chem II Content Predict the reaction rates of different substances based on their properties (i.e., concentrations of reactants, pressure, temperature, state of matter, surface area, type of reactant material) |
| 9-12.PS1.B.2 | Refine the design of a chemical system by specifying a change in conditions that would alter the amount of products at equilibrium. [Clarification Statement: Emphasis is on the application of Le Chatelier's Principle and on refining designs of chemical reaction systems, including descriptions of the connection between changes made at the macroscopic level and what happens at the molecular level. Examples of designs could include different ways to increase product formation including adding reactants or removing products.] | | a. Differentiate between thermal energy (the total internal energy of a substance which is dependent upon mass), heat (thermal energy that transfers from one object or system to another due to a difference in temperature), and temperature (the measure of average kinetic energy of molecules or atoms in a substance) |
| 9-12.PS1.B.3 | Use symbolic representations and mathematical calculations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction. [Clarification Statement: Emphasis is on conservation of matter and mass through balanced chemical equations, use of the mole concept and proportional relationships.] | **ME.1.H** | d. Predict the products of an acid/base (neutralization), oxidation (rusting), and combustion (burning) reaction |
| | | **ME.1.I** | a. Compare the mass of the reactants to the mass of the products in a chemical reaction or physical change as support for the Law of Conservation of Mass<br><br>b. Recognize whether the number of atoms of the reactants and products in a chemical equation are balanced |
| | | | |
| | C. **Nuclear Process** | | |
| 9-12.PS1.C | Use symbolic representations to illustrate the changes in the composition of the nucleus of the atom and the energy released | **ME.2.E** | a. Describe how changes in the nucleus of an atom during a nuclear reaction (i.e., nuclear decay, fusion, fission) result in emission of |

| | | | |
|---|---|---|---|
| | during the processes of fission, fusion, and radioactive decay. [Clarification Statement: Emphasis is on simple qualitative models, such as pictures or diagrams, and on the scale of energy released in nuclear processes relative to other kinds of transformations.] | | radiation)<br><br>b. Identify the role of nuclear energy as it serves as a source of energy for the Earth, stars, and human activity (e.g., source of electromagnetic radiation, thermal energy within mantle, nuclear power plants, fuel for stars) |
| | **PS2 - Motion and Stability: Forces and Interactions** | | |
| | **A. Forces and Motion** | | |
| 9-12.PS2.A. | Analyze data to support and verify the concepts expressed by Newton's 2nd law of motion, as it describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration. [Clarification Statement: Examples of data could include tables or graphs of position or velocity as a function of time for objects subject to a net unbalanced force, such as a falling object, an object rolling down a ramp, or a moving object being pulled by a constant force.] | | a. Relate kinetic energy to an object's mass and its velocity<br><br>b. Relate an object's gravitational potential energy to its weight and height relative to the surface of the Earth<br><br>c. Distinguish between examples of kinetic and potential energy (i.e., gravitational, elastic) within a system<br><br>d. Describe the effect of work on an object's kinetic and potential energy |
| | | FM. 1.A | a. Represent and analyze the motion of an object graphically<br><br>b. Analyze the velocity of two objects in terms of distance and time (i.e., verbally, diagrammatically, graphically, mathematically) |
| | | FM.1.B | Measure and analyze an object's motion in terms of speed, velocity, and acceleration (i.e., verbally, diagrammatically, graphically, mathematically) |
| | | FM.2.D | a. Recognize that inertia is a property of matter that can be described as an object's tendency to resist a change in motion, and is dependent upon the object's mass (Newton's First Law of Motion)<br><br>b. Determine the effect (i.e., direction and magnitude) of the sum of the forces acting on an object (i.e., net force)<br><br>c. Using information about net force and mass determine the effect on acceleration<br>e. (Newton's Second Law of Motion)<br>Analyze force pairs (i.e., action/reaction forces) when given a scenario (e.g., handball hits concrete wall, shotgun firing) and describe their magnitudes and directions. (Newton's Third Law of Motion) |
| | | | |

| | | | |
|---|---|---|---|
| 9-12.PS2.A.2 | Use mathematical representations to support and verify the concepts that the total momentum of a system of objects is conserved when there is no net force on the system. [Clarification Statement: Emphasis is on the quantitative conservation of momentum in interactions and the qualitative meaning of this principle.] | **ME.2.F** | a. Describe the transfer of energy that occurs as energy changes from kinetic to potential within a system (e.g., car moving on rollercoaster track, child swinging, diver jumping off a board) (Do NOT assess calculations) |
| | | **FM.1.C** | a. Compare the momentum of two objects in terms of mass and velocity (Do NOT assess calculations)<br><br>b. Explain that the total momentum remains constant within a system |
| 9-12.PS2.A.3 | Apply scientific principles of motion and momentum to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision. [Clarification Statement: Examples of evaluation and refinement could include determining the success of the device at protecting an object from damage and modifying the design to improve it. Examples of a device could include a football helmet or a parachute.] | **FM.2.A** | Identify and describe the forces acting on an object (i.e., type of force, direction, magnitude in Newtons) using a force diagram and calculating net force |
| | | **FM.2.D** | e. Analyze force pairs (i.e., action/reaction forces) when given a scenario (e.g., handball hits concrete wall, shotgun firing) and describe their magnitudes and directions. (Newton's Third Law of Motion) |
| | **B. Types of Interaction** | | |
| 9-12.PS2.B.1 | Use mathematical representations of Newton's Law of Gravitation to describe and predict the gravitational forces between objects. [Clarification Statement: Emphasis is on both quantitative and conceptual descriptions of gravitational fields.] | **FM.2.B** | a. Describe gravity as an attractive force among all objects<br><br>b. Compare and describe the gravitational forces between two objects in terms of their masses and the distances between them<br><br>c. Describe weight in terms of the force of a planet's or moon's gravity acting on a given mass<br><br>d. Recognize all free falling bodies accelerate at the same rate due to gravity regardless of their mass |
| | | **FM.2.D** | d. Identify forces acting on a falling object (i.e., weight, air resistance) and how those forces affect the rate of acceleration |
| 9-12.PS2.B.2 | Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current. | **FM.2.C** | a. Physics II Content Recognize changing magnetic fields can produce electrical current and electric currents can produce magnetic forces<br><br>b. Physics II Content Predict the effects of an electromagnetic force on the motion of objects (attract or repel) |

| | | | |
|---|---|---|---|
| | | | |
| | | | |
| | **PS3 - Energy** | | |
| | **A. Definitions of Energy** | | |
| 9-12.PS3.A.1 | Create a computational model to calculate the change in the energy of one component in a system when the changes in energy are known. [Clarification Statement: Emphasis is on explaining the meaning of mathematical expressions used in the model.] | | |
| 9-12.PS3.A.2 | Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative position of particles (objects). [Clarification Statement: Examples of phenomena at the macroscopic scale could include the conversion of kinetic energy to thermal energy, the energy stored due to position of an object above the earth, and the energy stored between two electrically-charged plates. Examples of models could include diagrams, drawings, descriptions, and computer simulations.] | **ME.2.A.CH** | c. Chem II Content Describe sources and common uses of different forms of energy: chemical (the energy stored in the electrical fields between atoms in a compound), nuclear, thermal, mechanical, electromagnetic |
| 9-12.PS3.A.3 | Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy. [Clarification Statement: Emphasis is on both qualitative and quantitative evaluations of devices. Examples of devices could include Rube Goldberg devices, wind turbines, solar cells, solar ovens, and generators. Examples of constraints could include use of renewable energy forms and efficiency.] | **ME.2.A.PH** | c. Physics II Content Differentiate between the properties and examples of conductors and insulators of different forms of energy (i.e., thermal, mechanical, electromagnetic) |
| | | **ME.2.F** | b. Compare the efficiency of systems (recognizing that, as work is done, the amount of usable energy decreases)<br><br>c. Classify the different ways to store energy (i.e., chemical, nuclear, thermal, mechanical, electromagnetic) and describe the transfer of energy as it changes from kinetic to potential, while the total amount of energy remains constant, within a system (e.g., using gasoline to move a car, photocell generating electricity, electromagnetic motor doing work, energy generated by nuclear reactor) |
| | | **ME.2.A** | d. Identify and evaluate advantages/disadvantages of using various sources of energy (e.g., wind, solar, geothermal, hydroelectric, biomass, fossil fuel) for human activity |

| | | | |
|---|---|---|---|
| | | | |
| | **B. Conservation of Energy and Energy Transfer** | | |
| 9-12.PS3.B | Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics). [Clarification Statement: Emphasis is on analyzing data from student investigations and using mathematical thinking to describe the energy changes both quantitatively and conceptually. Examples of investigations could include mixing liquids at different initial temperatures or adding objects at different temperatures to water.] | **ME.2.D**<br><br>**ME.2.A** | a. Describe evidence of energy transfer and transformations that occur during exothermic and endothermic chemical reactions<br><br>f. Interpret examples of heat transfer (e.g., home heating, solar panels) as convection, conduction, or radiation |
| | **C. Relationship Between Energy and Forces** | | |
| 9-12.PS3.C | Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction. . [Clarification Statement: Examples of models could include drawings, diagrams, and texts, such as drawings of what happens when two charges of opposite polarity are near each other.] | | |
| | **PS4 - Waves and Their Applications in Technologies for Information Transfer** | | |
| | **A. Wave Properties** | | |
| 9-12.PS4.A.1 | Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media. [Clarification Statement: Examples of data could include electromagnetic radiation traveling in a vacuum and glass, sound waves traveling through air and water, and seismic waves traveling through the Earth.] | **ME.2.A** | a. Differentiate between thermal energy (the total internal energy of a substance which is dependent upon mass), heat (thermal energy that transfers from one object or system to another due to a difference in temperature), and temperature (the measure of average kinetic energy of molecules or atoms in a substance) |
| 9-12.PS4.A.2 | Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other. [Clarification Statement: Emphasis is on how the experimental evidence supports the claim and how a theory is generally modified in light of new evidence. Examples of a phenomenon could include resonance, interference, diffraction, and photoelectric effect.] | | |
| | **B. Electromagnetic Radiation** | | |
| 9-12.PS4.B.1 | Communicate technical information about how electromagnetic radiation interacts with matter. [Clarification Statement: Examples | | d. Describe the effect of different frequencies of electromagnetic waves on the Earth and living organisms (e.g., radio, infrared, |

| | | | |
|---|---|---|---|
| | could include solar cells capturing light and converting it to electricity; medical imaging; and communications technology.] | | visible, ultraviolet, gamma, cosmic rays |
| 9-12.PS4.B.2 | Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter. [Clarification Statement: Emphasis is on the idea that photons associated with different frequencies of light have different energies, and the damage to living tissue from electromagnetic radiation depends on the energy of the radiation. Examples of published materials could include trade books, magazines, web resources, videos, and other passages that may reflect bias.] | | |
| | **LS1 - From Molecules to Organisms: Structure and Processes** | | |
| | **A. Structure and Function** | | |
| 9-12.LS1.A.1 | Construct a model of how the structure of DNA determines the structure of proteins which carry out the essential functions of life through systems of specialized cells. [Clarification Statement: Genes are the regions in DNA that code for proteins. Basic transcription and translation explain the roles of DNA and RNA in coding the instructions for making polypeptides.] | **LO.1.C** | a. * Recognize all organisms are composed of cells, the fundamental units of structure and function |
| | | **LO.1.D** | d.* Explain how protein enzymes affect chemical reactions (e.g., the breakdown of food molecules, growth and repair, regulation) |
| | | **LO.2.E** | a. Explain how the DNA code determines the sequence of amino acids necessary for protein synthesis<br>b.* Recognize the function of protein in cell structure and function (i.e., enzyme action, growth and repair of body parts, regulation of cell division and differentiation) |
| | | **LO.3.B** | a. Describe the chemical and structural properties of DNA (e.g., DNA is a large polymer formed from linked subunits of four kinds of nitrogen bases; genetic information is encoded in genes based on the sequence of subunits; each DNA molecule in a cell forms a single chromosome) (Assess the concepts – NOT memorization of nitrogen base pairs)<br>b. Recognize that DNA codes for proteins, which are expressed as the heritable characteristics of an organism |
| 9-12.LS1.A.1 | Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms. [Clarification Statement: Emphasis is on functions at the organism system level such as nutrient uptake, water delivery, and organism movement in response to stimuli.] | **LO.1.B** | a. Recognize cells both increase in number and differentiate, becoming specialized in structure and function, during and after embryonic development<br>b. * Identify factors (e.g., biochemical, temperature) that may affect the differentiation of cells and the development of an organism |
| 9-12.LS1.A.1 | Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis. [Clarification Statement: Examples of investigations could include heart rate response to exercise, stomata response to moisture and temperature, and root | **LO.1.C** | b. Describe the structure of cell parts (e.g., cell wall, cell membrane, cytoplasm, nucleus, chloroplast, mitochondrion, ribosome, vacuole) found in different types of cells (e.g., bacterial, plant, skin, nerve, blood, muscle) and the functions they perform (e.g., |

| | | | |
|---|---|---|---|
| | development in response to water levels.] | | structural support, transport of materials, storage of genetic information, photosynthesis and respiration, synthesis of new molecules, waste disposal) that are necessary to the survival of the cell and organism |
| | | **LO.2.F** | a. Explain the significance of the selectively permeable membrane to the transport of molecules<br>b. Predict the movement of molecules across a selectively permeable membrane (i.e., diffusion, osmosis, active transport) needed for a cell to maintain homeostasis given concentration gradients and different sizes of molecules<br>c. Explain how water is important to cells (e.g., is a buffer for body temperature, provides soluble environment for chemical reactions, serves as a reactant in chemical reactions, provides hydration that maintains cell turgidity, maintains protein shape) |
| | **B. Growth and Development of Organisms** | | |
| 9-12.LS1.B | Develop and use models to communicate the role of mitosis, cellular division, and differentiation in producing and maintaining complex organisms. [Clarification Statement: Major events of the cell cycle include cell growth, DNA replication, preparation for division, separation of chromosomes, and separation of cell contents.] | **LO.3.C** | a. Recognize the chromosomes of daughter cells, formed through the processes of asexual reproduction and mitosis, the formation of somatic (body) cells in multicellular organisms, are identical to the chromosomes of the parent cell |
| | | | |
| | **C. Organization for Matter and Energy Flow in Organisms** | | |
| 9-12.LS1.C.1 | Use a model to demonstrate how photosynthesis transforms light energy into stored chemical energy. [Clarification Statement: Emphasis is on illustrating inputs and outputs of matter and the transfer and transformation of energy in photosynthesis by plants and other photosynthesizing organisms. Examples of models could include diagrams, chemical equations, and conceptual models.] | | |
| 9-12.LS1.C.2 | Use a model to demonstrate that cellular respiration is a chemical process whereby the bonds of molecules are broken and the bonds in new compounds are formed resulting in a net transfer of energy. [Clarification Statement: Emphasis is on the conceptual understanding of the inputs and outputs of the process of cellular respiration.] | **LO.2.D** | a. Summarize how energy transfer occurs during photosynthesis and cellular respiration as energy is stored in and released from the bonds of chemical compounds (i.e. ATP)<br><br>c.* Recognize energy is absorbed or released in the breakdown and/or synthesis of organic compounds |
| 9-12.LS1.C.3 | Construct and revise an explanation based on evidence that organic macromolecules are primarily composed of six elements, where carbon, hydrogen, and oxygen atoms may combine with nitrogen, sulfur, and phosphorus to form large carbon-based molecules. [Clarification Statement: Large carbon-based molecules included are proteins, carbohydrates, nucleic acids, and lipids.] | **LO.3.D** | b. * Relate the structure of organic compounds (e.g., proteins, nucleic acids, lipids, carbohydrates) to their role in living systems |

| | | | |
|---|---|---|---|
| | **LS2 - Ecosystems: Interactions, Energy, and Dynamics** | | |
| | **A. Interdependent Relationships in Ecosystems** | | |
| 9-12.LS2.A | Explain how various biotic and abiotic factors affect the carrying capacity and biodiversity of an ecosystem using mathematical and/or computational representations. [Clarification Statement: Examples of biotic factors could include relationships among individuals (e.g., feeding relationships, symbioses, competition) and disease. Examples of abiotic factors could include climate and weather conditions, natural disasters, and availability of resources. Genetic diversity includes within a population and species within an ecosystem. Examples of mathematical comparisons could include graphs, charts, histograms, and population changes gathered from simulations or historical data sets.] | **EC.1.A** | a. Explain the nature of interactions between organisms in predator/prey relationships and different symbiotic relationships (i.e., mutualism, commensalisms, parasitism)<br>b. Explain how cooperative (e.g., symbiotic) and competitive (e.g., predator/prey) relationships help maintain balance within an ecosystem<br>c. * Explain why no two species can occupy the same niche in a community<br><br>(The functional role of a species is not limited to its placement along a food pyramid; it also includes the interactions of a species with other organisms while obtaining food. For example, the methods used to tolerate the physical factors of its environment, such as climate, water, nutrients, soils, and parasites, are all part of its functional role. In other words, the ecological niche of an organism is its natural history: all the interactions and interrelationships of the species with other organisms and the environment.) |
| | | **EC.1.B** | a. Identify and explain the limiting factors (biotic and abiotic) that may affect the carrying capacity of a population within an ecosystem<br>b. *Predict how populations within an ecosystem may change in number and/or structure in response to hypothesized changes in biotic and/or abiotic factors |
| | **B. Cycles of matter and Energy Transfer in Ecosystems** | | |
| 9-12.LS2.B.1 | Construct and revise an explanation based on evidence that the processes of photosynthesis, chemosynthesis, and aerobic and anaerobic respiration are responsible for the cycling of matter and flow of energy through ecosystems and that environmental conditions restrict which reactions can occur. [Clarification Statement: Examples of environmental conditions can include the availability of sunlight or oxygen.] | **LO.2.B** | a. Explain the interrelationship between the processes of photosynthesis and cellular respiration (e.g., recycling of oxygen and carbon dioxide), comparing and contrasting photosynthesis and cellular respiration reactions (Do NOT assess intermediate reactions)<br>b. Determine what factors affect the processes of photosynthesis and cellular respiration (i.e., light intensity, availability of reactants, temperature) |
| 9-12.LS2.B.2 | Communicate the pattern of the cycling of matter and the flow of energy among trophic levels in an ecosystem. [Clarification Statement: Emphasis is on using a model of stored energy in biomass to describe the transfer of energy from one tropic level to another. Emphasis is on atoms and molecules as they move through an ecosystem.] | **EC.2.A** | a. *Illustrate and describe the flow of energy within a food web<br>b. *Explain why there are generally more producers than consumers in an energy pyramid<br>c. Predict how the use and flow of energy will be altered due to changes in a food web |
| 9-12.LS2.B.3 | Use a model that illustrates the roles of photosynthesis, cellular | **EC.2.B** | a. *Explain the processes involved in the recycling of nitrogen, |

| | | | |
|---|---|---|---|
| | respiration, decomposition, and combustion to explain the cycling of carbon in its various forms among the biosphere, atmosphere, hydrosphere, and geosphere. [Clarification Statement: The primary forms of carbon include carbon dioxide, hydrocarbons, waste, and biomass. Examples of models could include simulations and mathematical and conceptual models.] | | oxygen, and carbon through an ecosystem<br>b. * Explain the importance of the recycling of nitrogen, oxygen, and carbon within an eco |
| | **C. Ecosystems Dynamics, Functioning and Resilience** | | |
| 9-12.LS2.C .1 | Evaluate the claims, evidence, and reasoning that the interactions in ecosystems maintain relatively consistent populations of species while conditions remain stable, but changing conditions may result in new ecosystem dynamics. [Clarification Statement: Examples of changes in ecosystem conditions could include modest biological or physical changes, such as moderate hunting or a seasonal flood; and extreme changes, such as volcanic eruption or sea level rise.] | | |
| 9-12.LS2.C.2 | Design, evaluate, and/or refine solutions that positively impact the environment and biodiversity. [Clarification Statement: Examples of solutions may include captive breeding programs, habitat restoration, pollution mitigation, energy conservation, agriculture and mining programs, and ecotourism.] | **EC.1.C** | a. *Devise a multi-step plan to restore the stability and/or biodiversity of an ecosystem when given a scenario describing the possible adverse effects of human interactions with that ecosystem (e.g., destruction caused by direct harvesting, pollution, atmospheric changes) |
| | **LS3 - Heredity: Inheritance and Variation of Traits** | | |
| | A. **Inheritance of Traits** | | |
| 9-12.LS3.A | Develop and use models to clarify relationships about how DNA in the form of chromosomes is passed from parents to offspring through the processes of meiosis and fertilization in sexual reproduction | **LO.3.C** | b. Recognize that during meiosis, the formation of sex cells, chromosomes are reduced to half the number present in the parent cell<br>c. Explain how fertilization restores the diploid number of chromosomes<br>d. *Identify the implications of human sex chromosomes for sex determination |
| | B. **Variation of Traits** | | |
| 9-12.LS3.B.1 | Compare and contrast asexual and sexual reproduction with regard to genetic information and variation in offspring | **LO.3.A** | a.* Distinguish between asexual (i.e., binary fission, budding, cloning) and sexual reproduction |
| | | **LO.3.D** | a. Describe the advantages and disadvantages of asexual and sexual reproduction with regard to variation within a population |
| 9-12.LS3.B.2 | Develop and use a model to describe why structural changes to genes (mutations) located on chromosomes may affect proteins and may result in harmful, beneficial, or neutral effects to the structure and function of the organism. [Clarification Statement: Emphasis is on conceptual understanding that changes in genetic material may result in making different proteins.] | **LO.3.B** | c. * Recognize that degree of relatedness can be determined by comparing DNA sequences<br>d. * Explain how an error in the DNA molecule (mutation) can be transferred during replication |

| | | | |
|---|---|---|---|
| | | | |
| 9-12.LS3.B.3 | Make and defend a claim that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) mutations occurring during replication, and/or (3) mutations caused by environmental factors. [Clarification Statement: Emphasis is on using data to support arguments for the way variation occurs.] | **LO.3.B** | e. Identify possible external causes (e.g., heat, radiation, certain chemicals) and effects of DNA mutations (e.g., altered proteins which may affect chemical reactions and structural development) |
| | | **LO.3.D** | b. * Describe how genes can be altered and combined to create genetic variation within a species (e.g., mutation, recombination of genes)<br>c. * Recognize that new heritable characteristics can only result from new combinations of existing genes or from mutations of genes in an organism's sex cells |
| | | | |
| 9-12.LS3.B.4 | Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population. [Clarification Statement: Emphasis is on the use of mathematics (Punnett Squares) to describe the probability of traits as it relates to genetic and environmental factors in the expression of traits.] | **LO.3.E** | a. Explain how genotypes (heterozygous and homozygous) contribute to phenotypic variation within a species<br>b. Predict the probability of the occurrence of specific traits, including sex-linked traits, in an offspring by using a monohybrid cross<br>c. *Explain how sex-linked traits may or may not result in the expression of a genetic disorder (e.g., hemophilia, muscular dystrophy, color blindness) depending on gender |
| | **LS4 - Biological Evolution; Unity and Diversity** | | |
| | **A. Evidence of Common Ancestry and Diversity** | | |
| 9-12.LS4.A.1 | Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence. (Clarification statement: Emphasis is on a conceptual understanding of the role each line of evidence has relating to common ancestry and biological evolution. Examples of evidence could include similarities in DNA sequences, anatomical structures, and order of appearance of structures in embryological development. Communicate could mean written report, oral discussion, etc.) | **EC.3.A** | a. *Interpret fossil evidence to explain the relatedness of organisms using the principles of superposition and fossil correlation<br>b. *Evaluate the evidence that supports the theory of biological evolution (e.g., fossil records, similarities between DNA and protein structures, similarities between developmental stages of organisms, homologous and vestigial structures) |
| 9-12.LS4.A.2 | Analyze displays of pictorial data to compare patterns of similarities in the embryological development across multiple species to identify relationships not evident in the fully formed anatomy. [Clarification Statement: Emphasis is on inferring general patterns of relatedness among embryos of different organisms by comparing the macroscopic appearance of diagrams or pictures.] | | |
| | **B. Natural Selection** | | |

| | | | |
|---|---|---|---|
| 9-12.LS4.B.1 | Construct an explanation based on evidence that the process of evolution primarily results from four factors: (1) the potential for a species to increase in number, (2) the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment. (Clarification Statement: Emphasis is on using evidence to explain the influence each of the four factors has on number of organisms, behaviors, morphology, or physiology in terms of ability to compete for limited resources and subsequent survival of individuals and adaptation of species. Examples of evidence could include mathematical models such as simple distribution graphs and proportional reasoning.) | **EC.3.C** | c. Explain how environmental factors (e.g., habitat loss, climate change, pollution, introduction of non-native species) can be agents of natural selection<br>d. *Given a scenario describing an environmental change, hypothesize why a given species was unable to survive |
| 9-12.LS4.B.2 | Apply concepts of statistics and probability to support explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait. [Clarification Statement: Emphasis is on analyzing shifts in numerical distribution of traits and using these shifts as evidence to support explanations.] | **EC.3.C** | b. *Explain how genetic homogeneity may cause a population to be more susceptible to extinction (e.g., succumbing to a disease for which there is no natural resistance) |
| | C. **Adaptation** | | |
| 9-12.LS4.C.1 | Construct an explanation based on evidence for how natural selection leads to adaptation of populations. [Clarification Statement: Emphasis is on using data to provide evidence for how specific biotic and abiotic differences in ecosystems (such as ranges of seasonal temperature, long-term climate change, acidity, light, geographic barriers, or evolution of other organisms) contribute to a change in gene frequency over time, leading to adaptation of populations.] | **EC.3C** | a. Identify examples of adaptations that may have resulted from variations favored by natural selection (e.g., long-necked giraffes, long-eared jack rabbits) and describe how that variation may have provided populations an advantage for survival |
| 9-12.LS4.C.2 | Evaluate the evidence supporting claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species. [Clarification statement: Emphasis is on determining cause and effect relationships for how changes to the environment such as deforestation, fishing, and application of fertilizers, droughts, flood, and the rate of change of the environment affect distribution or disappearance of traits in species.] | **EC.1.D** | a. Predict the impact (beneficial or harmful) a natural or human caused environmental event (e.g., forest fire, flood, volcanic eruption, avalanche, acid rain, global warming, pollution, deforestation, introduction of an exotic species) may have on the diversity of different species in an ecosystem<br>b. *Describe possible causes of extinction of a population |
| 9-12.LS4.C.3 | Create or revise a model to test a solution to mitigate adverse impacts of human activity on biodiversity. [Clarification Statement: Emphasis is on designing solutions for a proposed problem related to threatened or endangered species, or to genetic variation of | **EC.1.C** | b. *Predict and explain how natural or human caused changes (biological, chemical and/or physical) in one ecosystem may affect other ecosystems due to natural mechanisms (e.g., global wind patterns, water cycle, ocean currents) |

| | | | |
|---|---|---|---|
| | organisms for multiple species.] | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | **ESS1 - Earth's Place in the Universe** | | |
| | A. **The Universe and its Stars** | | |
| 9-12.ESS1.A.1 | Develop a model based on evidence to illustrate the life span of the Sun and the role of nuclear fusion in the Sun's core to release energy in the form of radiation. [Clarification Statement: Emphasis is on the energy transfer mechanisms that allow energy from nuclear fusion in the Sun's core to reach Earth. Examples of evidence for the model include observations of the masses and lifetimes of other stars, as well as the ways that the Sun's radiation varies due to sudden solar flares ("space weather").] | **ME.2.C** | a. Identify stars as producers of electromagnetic energy<br>b. Describe how electromagnetic energy is transferred through space as electromagnetic waves of varying wavelength and frequency |

| | | | |
|---|---|---|---|
| 9-12.ESS1.A.2 | Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the universe. [Clarification Statement: 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).] | **UN.2.C** | a. Identify information that the electromagnetic spectrum provides about the stars and the universe (e.g., chemical composition, temperature, age of stars, location of black holes, motion of celestial bodies)<br><br>b. Evaluate the advantages/ disadvantages of using different tools (e.g., spectroscope, different types of telescopes, probes) to gather information about the universe (e.g., background radiation, magnetic fields, discovery of previously unknown celestial bodies) |
| 9-12.ESS1.A.3 | Communicate scientific ideas about the way stars, over their life cycle, produce elements. [Clarification Statement: Emphasis is 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.] | | |
| | B. **Earth and the Solar System** | | |
| 9-12.ESS1.B | Use Kepler's Law to predict the motion of orbiting objects in the solar system. [Clarification Statement: Emphasis is on Newtonian gravitational laws governing orbital motions, which apply to human-made satellites as well as planets and moons.] | **UN.1.A** | Describe and relate the positions and motions of the Sun-Earth solar system, the Milky-Way galaxy, and other galaxies within the universe (i.e., it is just one of several solar systems orbiting the center of a rotating spiral galaxy; that spiral galaxy is just one of many galaxies which orbit a common center of gravity; the expanding universe causes the distance between galaxies to increase) |
| | C. **The History of Planet Earth** | **UN.2.D** | Explain orbital motions of moons around planets, and planets around the Sun, as the result of gravitational forces between those objects |
| 9-12.ESS1.C.1 | Evaluate evidence of the past and current movements of continental and oceanic crust, the theory of plate tectonics, and relative densities of oceanic and continental rocks to explain why continental rocks are generally much older than rocks of the ocean floor. [Clarification Statement: Examples include the ages of oceanic crust increasing with distance from mid-ocean ridges (a result of plate spreading) and the ages of North American continental crust increasing with distance away from a central ancient core (a result of past plate interactions).] | **ES.1.A** | a. Classify minerals (rock-forming and ore) based on physical and chemical properties (e.g., color, streak, luster/reflectivity, hardness, cleavage, fracture, conductivity, density, melting point, boiling point, solubility, pH, chemical reactivity)<br><br>b. Classify common igneous, metamorphic, and/or sedimentary rocks based on physical and chemical properties (e.g., mineral composition, texture, density, and other unique properties)<br><br>c. Classify earth materials as minerals, rocks, and soils by comparing and contrasting their components, unique properties, and the processes which formed them |
| 9-12.ESS1.C.2 | Apply scientific reasoning and evidence from ancient Earth materials, meteorites, and other planetary surfaces to construct an account of Earth's formation and early history. [Clarification Statement: Emphasis is on using available evidence within the solar | | |

| | | | |
|---|---|---|---|
| | system to reconstruct the early history of Earth, which formed along with the rest of the solar system 4.6 billion years ago. Examples of evidence include the absolute ages of ancient materials (obtained by radiometric dating of meteorites, moon rocks, and Earth's oldest minerals), the sizes and compositions of solar system objects, and the impact cratering record of planetary surfaces.] | | |
| | **ESS2 - Earth's Systems** | | |
| | A. **Earth Materials and Systems** | | |
| 9-12.ESS2.A.1 | Develop a model to illustrate how Earth's interior and surface processes (constructive and destructive) operate at different spatial and temporal scales to form continental and ocean-floor features. [Clarification Statement: Emphasis is on how the appearance of land features (such as mountains, valleys, and plateaus) and sea-floor features (such as trenches, ridges, and seamounts) are a result of both constructive forces (such as volcanism, tectonic uplift, and orogeny) and destructive mechanisms (such as weathering, mass wasting, and coastal erosion).] | **ES.2.B** | a. Describe the internal source of energy on Earth that results in uneven heating of the mantle (i.e., decay of radioactive isotopes)<br><br>b. Illustrate and explain the convection currents that result from the uneven heating inside the mantle and cause movement of crustal plates<br><br>e. Describe the effects of the movement of crustal plates (i.e., earthquakes, sea floor spreading, mountain building, volcanic eruptions) at a given location on the planet |
| 9-12.ESS2.A.2 | Analyze geoscientific data to make the claim that one change to Earth's surface can create changes to other Earth systems. | **ES.2.D** | Use evidence from relative and real dating techniques (e.g., correlation of trace fossils, landforms, and rock sequences; evidence of climate changes; presence of intrusions and faults; magnetic orientation; relative age of drill samples) to infer geologic history |
| 9-12.ESS2.A.3 | Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection. [Clarification Statement: Emphasis is on both a one-dimensional model of Earth, with radial layers determined by density, and a three-dimensional model, which is controlled by mantle convection and the resulting plate tectonics. Examples of evidence include maps of Earth's three-dimensional structure obtained from seismic waves, records of the rate of change of Earth's magnetic field (as constraints on convection in the outer core), and identification of the composition of Earth's layers from high-pressure laboratory experiments. | **ES.2.B** | c. Describe how the energy of an earthquake travels as seismic waves and provides evidence for the layers of the geosphere<br><br>d. Relate the densities of the materials found in continental and oceanic plates to the processes that result in each type of plate boundary (i.e., diverging, converging, transform)<br><br>e. Articulate the processes involved in the Theory of Plate Tectonics (i.e., uneven heating of the mantle due to the decay of radioactive isotopes, movement of materials via convection currents, movement of continental and oceanic plates along diverging, converging, or transform plate boundaries) and describe evidence that supports that theory (e.g., correlation of rock sequences, landforms, and fossils; presence of intrusions and faults; evidence of sea-floor spreading) |
| | | **ES.2.C** | Describe the rock cycle as it relates to the origin and transformation of rock types (i.e., igneous, metamorphic, and sedimentary) |

| | | | |
|---|---|---|---|
| 9-12.ESS2.A.4 | Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate. | | |
| | C. **The Role of Water in Earth's Surface Processes** | | |
| 9-12.ESS2.C | Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes. Clarification Statement: Emphasis is on mechanical and chemical investigations with water and a variety of solid materials to provide the evidence for connections between the hydrologic cycle and system interactions commonly known as the rock cycle. Examples of mechanical investigations include stream transportation and deposition using a stream table, erosion using variations in soil moisture content, or ice wedging by the expansion of water as it freezes. Examples of chemical investigations include chemical weathering and recrystallization (by testing the solubility of different materials) or melt generation (by examining how water lowers the melting temperature of most solids).] | **ES.1.B** | Recognize the importance of water as a solvent in the environment as it relates to karst geology (dissolution and mineralization), acid rain, water pollution, erosion and deposition of rock and soil materials<br><br>Recognize the importance of water as a solvent in the environment as it relates to acid rain and water pollution |
| | | **ES.2.B** | Explain the external processes (i.e., weathering, erosion, deposition of sediment) that result in the formation and modification of landforms<br><br>Describe the factors that affect rates of weathering and erosion of landforms (e.g., soil/rock type, amount and force of run-off, slope) |
| | | | |
| | D. **Weather and Climate** | | |
| 9-12.ESS2.D | Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere. [Clarification Statement: Emphasis is on modeling biogeochemical cycles that include the cycling of carbon through the ocean, atmosphere, soil, and biosphere (including humans), providing the foundation for living organisms.] | **ES.1.C** | a. Relate the composition of gases and temperature of the layers of the atmosphere (i.e., troposphere, stratosphere, ionosphere) to cloud formation and transmission of radiation (e.g., ultraviolet, infrared) |
| | | **ES.2.F** | a. Predict the weather (patterns of change in the atmosphere) at a designated location using weather maps (including map legends) and/or weather data (e.g., temperature, barometric pressure, cloud cover and type, wind speed and direction, precipitation)<br><br>b. Explain how global wind and ocean currents are produced on the Earth's surface (e.g., effects of unequal heating of the Earth's land masses, oceans, and air by the Sun due to latitude and surface material type; effects of gravitational forces acting on layers of air of different densities due to temperature differences; effects of the rotation of the Earth; effects of surface topography)<br><br>c. Describe the effects of natural phenomena (e.g., burning organic material, volcanic eruptions, lightning, changes in global wind and ocean currents) on the properties of the atmosphere<br><br>d. Explain how climate and weather patterns in a particular region |

| | | | |
|---|---|---|---|
| | | | are affected by factors such as proximity to large bodies of water or ice/ocean currents, latitude, altitude, wind and ocean currents, amount of solar radiation, changes in the atmosphere due to natural phenomena (e.g., burning organic material, volcanic eruptions) |
| | | | |
| | E. **Biogeology** | | |
| 9-12.ESS2.E | Construct an argument based on evidence about the simultaneous coevolution of Earth's systems and life on Earth. [Clarification Statement: Emphasis is on the dynamic causes, effects, and feedbacks between the biosphere and Earth's other systems, whereby geoscience factors control the evolution of life, which in turn continuously alters Earth's surface. Examples of coevolution include how photosynthetic life altered the atmosphere through the production of oxygen, which in turn increased weathering rates and allowed for the evolution of animal life; how microbial life on land increased the formation of soil, which in turn allowed for the evolution of land plants; or how the evolution of corals created reefs that altered patterns of erosion and deposition along coastlines and provided habitats for new life.] | **UN.1.A** | a. Explain how Earth's environmental characteristics and location in the universe (e.g., atmosphere, temperature, orbital path, magnetic field, mass-gravity, location in solar system) provide a life-supporting environment |
| | **ESS3 - Earth and Human Activity** | | |
| | A. **Natural Resources** | | |
| 9-12.ESS3.A.1 | Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity. [Clarification Statement: Examples of key natural resources include access to fresh water, regions of fertile soils such as river deltas, and high concentrations of minerals and fossil fuels. Examples of natural hazards can be from interior processes (such as volcanic eruptions and earthquakes), surface processes (such as tsunamis, mass wasting and soil erosion), and severe weather. Examples of the results of changes in climate that can affect populations or drive mass migrations include changes to sea level, regional patterns of temperature and precipitation, and the types of crops and livestock that can be raised.] | **ES.3.A** | a. Recognize the limited availability of some energy resources (i.e., solar radiation, wind, fossil fuels) and major mineral deposits in the United States (e.g., lead, petroleum, coal, copper, zinc, iron, gravel, aluminum) and the factors that affect their availability<br><br>b. Identify human activities that may adversely affect the composition of the atmosphere, hydrosphere, or geosphere<br><br>c. Predict local and/or global effects of environmental changes when given a scenario describing how the composition of the geosphere, hydrosphere, or atmosphere is altered by natural phenomena or human activities |
| 9-12.ESS3.A.2 | Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on economic, social, and environmental cost-benefit ratios. [Clarification Statement: Emphasis is on the conservation, recycling, and reuse of resources | **ES.3.A** | e. Recognize the economic, political, social, and ethical constraints associated with obtaining and using natural resources (e.g., mining and use of different types of Missouri mineral resources such as lead mining, gravel dredging, strip mining, coal burning, production of |

| | | | |
|---|---|---|---|
| | (such as minerals and metals) where possible, and on minimizing impacts where it is not. Examples include developing best practices for agricultural soil use, mining (for coal, tar sands, and oil shale), and pumping (for petroleum and natural gas). Science knowledge indicates what can happen in natural systems—not what should happen.] | | fertilizers and explosives; use of fossil fuels versus renewable resources) |
| | C. **Human Impacts on Earth's Systems** | | |
| 9-12.ESS3.C.1 | Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity. [Clarification Statement: Examples of factors that affect the management of natural resources include costs of resource extraction and waste management, per-capita consumption, and the development of new technologies. Examples of factors that affect human sustainability include agricultural efficiency, levels of conservation, and urban planning.] | **ES.3.A** | d. Recognize how the geomorphology of Missouri (i.e., different types of Missouri soil and rock materials such as limestone, granite, clay, loam; land formations such as karst (cave) formations, glaciated plains, river channels) affects the survival of organisms and the development of land use by humans (e.g., agriculture, recreation, planning and zoning, waste management) |
| 9-12.ESS3.C.2 | Evaluate or refine a technological solution that reduces impacts of human activities on natural systems in order to restore stability and or biodiversity of the ecosystem as well as prevent their reoccurrences. [Clarification Statement: Examples of human activities could include forest fires, acid rain, flooding, urban development, pollution, deforestation, and introduction of an invasive species.] | | |
| | D. **Global Climate Change** | | |
| 9-12.ESS3.D.1 | Analyze geoscientific data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems. [Clarification Statement: Examples of evidence, for both data and climate model outputs, are for climate changes (such as precipitation and temperature) and their associated impacts (such as on sea level, glacial ice volumes, or atmosphere and ocean composition).] | | |
| 9-12.ESS3.D.2 | Predict how human activity affects the relationships between Earth systems in both positive and negative ways. [Clarification Statement: Examples of Earth systems to be considered are the hydrosphere, atmosphere, cryosphere, geosphere, and/or biosphere.] | **ES.2.F** | e. Provide evidence (e.g., variations in sea level, glaciation, and permafrost layers, fossils, desertification) that supports theories of climate change due to natural phenomena and/or human interactions |
| | | | |

| | | | |
|---|---|---|---|
| | **ETS1 - Engineering Design** | | |
| | A. **Defining and Delimiting Engineering Problems** | | |
| 9-12.ETS1.A.1 | Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants. | | |
| 9-12.ETS1.A.2 | Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering. | | |
| | B. **Developing Possible Solutions** | | |
| 9-12.ETS1.B.1 | Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts. | | |
| 9-12.ETS1.B.2 | Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem. | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

**Science**

| | | | |
|---|---|---|---|
| | | | |
| | | | |
| | | | |