AFK12SE/NGSS Strand Disciplinary Core Idea	Conceptual Understanding for Teachers at 6-8
PS1. Matter and Its Interactions ***How can one explain the structure, properties, and interactions of matter?***	
PS1.A: Structure and properties of matter *How do particles combine to form the variety of matter one observes?* ● All substances are made from some 100 different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms. ● Pure substances are made from a single type of atom or molecule; each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it. ● Gases and liquids are made of molecules or inert atoms that are moving about relative to each other. In a liquid, the molecules are constantly in contact with each other; in a gas, they are widely spaced except when they happen to collide. ● In a solid, atoms are closely spaced and vibrate in position but do not change relative locations. Solids may be formed from molecules, or they may be extended structures with repeating subunits (e.g., crystals). ● The changes of state that occur with variations in temperature or pressure can be described and predicted using these models of matter.	What is matter? What are the properties of the various states of matter? What are chemical and physical properties and how are they used to identify substances? What are the relationships among number of moles, volume, temperature, and pressure of gases? What is the structure of an atom? What atomic models are/were commonly used and how were they developed over time? How was the Periodic Table developed? What trends exist in the Periodic Table and how do those trends reflect atomic structure? What are the characteristics of different types of bonding, and how can these be predicted using the Periodic Table? In what ways do atoms combine to form novel substances? What conventions do chemists use for naming chemical compounds and writing chemical formulas?

PS1.B: Chemical Reactions *How do substances combine or change (react) to make new substances?* *How does one characterize and explain these reactions and make predictions about them?* ● Substances react chemically in characteristic ways. ● In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants. The total number of each type of atom is conserved, and thus the mass does not change. ● Some chemical reactions release energy, others store energy.	How does kinetic molecular theory explain chemical processes? How is energy involved in a chemical reaction? How does a balanced chemical reaction represent conservation of mass in a given chemical reaction? How can the products and amount of a chemical reaction be predicted given the reactants? How does the strength of an acid and base impact the resulting reaction?
PS1.C: Nuclear Processes *What forces hold nuclei together and mediate nuclear processes?* ● Nuclear fusion can result in the merging of two nuclei to form a larger one, along with the release of significantly more energy per atom than any chemical process. It occurs only under conditions of extremely high temperature and pressure. ● Nuclear fusion taking place in the cores of stars provides the energy released (as light) from those stars and produced all of the more massive atoms from primordial hydrogen. Thus the elements found on Earth and throughout the universe (other than hydrogen and most of helium, which are primordial) were formed in the stars or supernovas by fusion processes.	How do the number of protons, electrons, and neutrons change during nuclear decay? How does the amount of radioactive materials change over the course of a nuclear decay reaction? How is half-life used to determine the age of rocks and other natural materials?
PS2: Motion and Stability: Forces and Interactions ***How can one explain and predict interactions between objects and within systems?***	

PS2.A: Forces and Motion *How can one predict an object's continued motion, changes in motion, or stability?* ● Each force acts on one particular object and has both a strength and a direction. ● An object at rest typically has multiple forces acting on it, but they add to give zero net force on the object. Forces that do not sum to zero can cause changes in the object's speed or direction of motion. ● The patterns of an object's motion in various situations can be observed and measured; when past motion exhibits a regular pattern, future motion can be predicted from it.	● What are the relationships among mass, velocity, acceleration, force, and momentum for macroscopic objects? ● How does Newton's Laws of Motion apply to macroscopic objects in a system? ● How are the conservation of momentum and energy related?
PS2.B: Types of Interactions *What underlying forces explain the variety of interactions observed?* ● Electric and magnetic (electromagnetic) forces can be attractive or repulsive, and their sizes depend on the magnitudes of the charges, currents, or magnetic strengths involved and on the distances between the interacting objects. ● Gravitational forces are always attractive. There is a gravitational force between any two masses, but it is very small except when one or both of the objects have large mass—for example, Earth and the sun. ● Long-range gravitational interactions govern the evolution and maintenance of large-scale systems in space, such as galaxies or the solar system, and determine the patterns of motion within those structures. ● Forces that act at a distance (gravitational, electric, and magnetic) can be explained by force fields that extend through space and can be mapped by their effect on a test object (a ball, a charged object, or a magnet, respectively).	● What is the nature of the gravitational relationship between two masses? ● What is the nature of the electrostatic relationship between two electrical charges? ● What are the mathematical representations of Newton's Law of Gravitation and Coulomb's Law of Electrostatic Forces? ● How do electric currents and magnetic fields interrelate? ● What are the practical applications of the relationship between electric currents and magnetic fields?
PS2.C: Stability and Instability in Physical Systems *Why are some physical systems more stable than others?* ● A stable system is one in which any small change results in forces that return the system to its prior state (e.g., a weight hanging from a string). A system can be static but unstable (e.g., a pencil standing on end).	● Why are some physical systems more stable than others? ● How do feedback mechanisms maintain stability in closed systems?

● A system can be changing but have a stable repeating cycle of changes; such observed regular patterns allow predictions about the system's future (e.g., Earth orbiting the sun). ● Many systems, both natural and engineered, rely on feedback mechanisms to maintain stability, but they can function only within a limited range of conditions. ● With no energy inputs, a system starting out in an unstable state will continue to change until it reaches a stable configuration (e.g., sand in an hourglass).	
PS3: Energy: ***How is energy transferred and conserved?***	
PS3.A: Definitions of Energy *What is energy?* ● Motion energy is properly called kinetic energy; it is proportional to the mass of the moving object and grows with the square of its speed. ● A system of objects may also contain stored (potential) energy, depending on their relative positions. For example, energy is stored—in gravitational interaction with Earth—when an object is raised, and energy is released when the object falls or is lowered. ● Energy is also stored in the electric fields between charged particles and the magnetic fields between magnets, and it changes when these objects are moved relative to one another. ● Stored energy is decreased in some chemical reactions and increased in others. ● The term "heat" as used in everyday language refers both to thermal energy (the motion of atoms or molecules within a substance) and energy transfers by convection, conduction, and radiation (particularly infrared and light). In science, heat is used only for this second meaning; it refers to energy transferred when two objects or systems are at different temperatures. ● Temperature is a measure of the average kinetic energy of particles of matter. ● The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present.	● What is energy and how do we measure it? ● What are the conceptual and mathematical relationships among energy, work, and power? ● How is energy transferred between objects? ● How are efficiency and conservation of energy related? ● How do we model energy and energy changes at the particulate level? ● What is relationship between thermal energy and temperature?

PS3.B: Conservation of Energy and Energy Transfer *What is meant by conservation of energy?* *How is energy transferred between objects or systems?* ● When the motion energy of an object changes, there is inevitably some other change in energy at the same time. For example, the friction that causes a moving object to stop also results in an increase in the thermal energy in both surfaces; eventually heat energy is transferred to the surrounding environment as the surfaces cool. ● Similarly, to make an object start moving or to keep it moving when friction forces transfer energy away from it, energy must be provided from, say, chemical (e.g., burning fuel) or electrical (e.g., an electric motor and a battery) processes. ● The amount of energy transfer needed to change the temperature of a matter sample by a given amount depends on the nature of the matter, the size of the sample, and the environment. ● Energy is transferred out of hotter regions or objects and into colder ones by the processes of conduction, convection, and radiation.	● How is energy converted from one form to another? ● What are the practical applications of energy conversion for real-world examples? ● What is meant by conservation of energy? ● How do the amount and properties of matter affect the energy needed to change the temperature of the sample? ● How do various energy diagrams represent mechanical, light, and electric interactions?
PS3.C Relationship between Energy and Forces *How are forces related to energy?* ● When two objects interact, each one exerts a force on the other that can cause energy to be transferred to or from the object. For example, when energy is transferred to an Earth-object system as an object is raised, the gravitational field energy of the system increases. ● This energy is released as the object falls; the mechanism of this release is the gravitational force. ● Likewise, two magnetic and electrically charged objects interacting at a distance exert forces on each other that can transfer energy between the interacting objects.	● How are forces related to energy? ● What are the conceptual and mathematical relationships among conservation of mass, momentum, energy, and charge?

PS3.D: Energy in Chemical Processes and Everyday Life *How do food and fuel provide energy?* *If energy is conserved, why do people say it is produced or used?* ● The chemical reaction by which plants produce complex food molecules (sugars) requires an energy input (i.e., from sunlight) to occur. In this reaction, carbon dioxide and water combine to form carbon-based organic molecules and release oxygen. ● Both the burning of fuel and cellular digestion in plants and animals involve chemical reactions with oxygen that release stored energy. In these processes, complex molecules containing carbon react with oxygen to produce carbon dioxide and other materials. ● Machines can be made more efficient, that is, require less fuel input to perform a given task, by reducing friction between their moving parts and through aerodynamic design. ● Friction increases energy transfer to the surrounding environment by heating the affected materials.	● What are the chemical processes in which plants produce sugar? ● How is energy released from complex molecules containing carbon? ● In what ways can a mechanical system be made more energy efficient? ● How does friction affect the energy efficiency of a mechanical system?
PS4 Waves and Their Applications in Technologies for Information Transfer: ***How are waves used to transfer energy and information?***	
PS4.A: Wave Properties *What are the characteristic properties and behaviors of waves?* ● A simple wave has a repeating pattern with a specific wavelength, frequency, and amplitude. A sound wave needs a medium through which it is transmitted. ● Geologists use seismic waves and their reflection at interfaces between layers to probe structures deep in the planet.	● What is the relationship among, frequency, wavelength, and speed of waves traveling in different media? ● What are the characteristic properties and behaviors of waves? ● What are the different types of waves?
PS4.B: Electromagnetic Radiation *What is light?* *How can one explain the varied effects that involve light?* *What other forms of electromagnetic radiation are there?* ● When light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on the object's material and the frequency (color) of the light. ● The path that light travels can be traced as straight lines, except at surfaces between different transparent materials (e.g., air and	● What is light? ● How does light behave given the two models of electromagnetic behavior (e.g., particle versus wave)? ● What happens to light what it interacts with different materials?

water, air and glass) where the light path bends. Lenses and prisms are applications of this effect. ● A wave model of light is useful for explaining brightness, color, and the frequency-dependent bending of light at a surface between media (prisms). ● However, because light can travel through space, it cannot be a matter wave, like sound or water waves.	
PS4.C: Information Technologies and Instrumentation *How are instruments that transmit and detect waves used to extend human senses?* ● Appropriately designed technologies (e.g., radio, television, cell phones, wired and wireless computer networks) make it possible to detect and interpret many types of signals that cannot be sensed directly. ● Designers of such devices must understand both the signal and its interactions with matter. Many modern communication devices use digitized signals (sent as wave pulses) as a more reliable way to encode and transmit information.	● How do different technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy? ● How are instruments that transmit and detect waves used to explore the world around us beyond what we can see and hear?
AFK12SE Strand	**Conceptual Understandings for Teachers at Grades 6-8**
ESS1: Earth's Place in the Universe ***What is the universe, and what is Earth's place in it?***	
ESS1.A: The Universe and its stars *What is the Universe and what goes on in Stars?* ● Patterns of the apparent motion of the sun, the moon, and stars in the sky can be observed, described, predicted, and explained with models. ● The universe began with a period of extreme and rapid expansion known as the Big Bang. ● Earth and its solar system are part of the Milky Way galaxy, which is one of many galaxies in the universe.	● How can the position and motion of the Sun, planets, and stars be observed, described, predicted, and explained with models? ● What evidence is used to support the current model for the formation and expansion of the universe?

ESS1.B: Earth and the Solar System *What are the predictable patterns caused by Earth's motion in the Solar System?* ● The solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them. This model of the solar system can explain tides, eclipses of the sun and the moon, and the motion of the planets in the sky relative to the stars. ● Earth's spin axis is fixed in direction over the short term but tilted relative to its orbit around the sun. The seasons are a result of that tilt and are caused by the differential intensity of sunlight on different areas of Earth across the year.	● What types of objects can be found in the Solar System? ● How does gravity affect the motion of objects around the sun and/or around planets? ● What causes seasonal change on Earth?
ESS1.C: History of Planet Earth *How do people reconstruct and date events in Earth's planetary history?* ● The geological time scale interpreted from rock strata provides a way to organize Earth's history. Major historical events include the formation of mountain chains and ocean basins, the evolution and extinction of particular living organisms, volcanic eruptions, periods of massive glaciation, and development of watersheds and rivers through glaciation and water erosion. ● Analyses of rock strata and the fossil record provide only relative dates, not an absolute scale.	● What evidence is collected and how is it interpreted to reconstruct Earth's history? ● What are the limitations of analyzing rock strata and the fossil record in reconstructing Earth's history?
ESS2: Earth's Systems ***How and why is Earth constantly changing?***	
ESS2.A: Earth Materials and Systems *How do Earth's major systems interact?* ● All Earth processes are the result of energy flowing and matter cycling within and among the planet's systems. This energy is derived from the sun and Earth's hot interior. ● The energy that flows and matter that cycles produce chemical and physical changes in Earth's materials and living organisms. ● The planet's systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth's	● How do Earth's major systems interact to impact Earth processes? ● What spatial and temporal scales must be employed to observe changes and interactions in Earth's systems?

history and will determine its future.	
ESS2.B: Plate Tectonics and Large-Scale System Interactions *Why do the continents move, and what causes earthquakes and volcanoes?* ● Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth's surface and provides a framework for understanding its geological history. ● Plate movements are responsible for most continental and ocean floor features and for the distribution of most rocks and minerals within Earth's crust. ● Maps of ancient land and water patterns, based on investigations of rocks and fossils, make clear how Earth's plates have moved great distances, collided, and spread apart.	● How does Plate Tectonic theory provide explanatory and predictive power for describing the evolution of Earth's surface? ● How does Plate Tectonics explain the distribution of rocks and minerals at Earth's surface? ● What map-pattern evidence can be employed to make retrodictions of the previous positions of Earth's plates?
ESS2.C: The Roles of Water in Earth's Surface Processes *How do the properties and movements of water shape Earth's surface and affect its systems?* ● Water continually cycles among land, ocean, and atmosphere via transpiration, evaporation, condensation and crystallization, and precipitation as well as downhill flows on land. ● The complex patterns of the changes and the movement of water in the atmosphere, determined by winds, landforms, and ocean temperatures and currents, are major determinants of local weather patterns. ● Global movements of water and its changes in form are propelled by sunlight and gravity. Variations in density due to variations in temperature and salinity drive a global pattern of interconnected ocean currents. ● Water's movements—both on the land and underground—cause weathering and erosion, which change the land's surface features and create underground formations.	● How do the chemical and physical properties of water and its movement create changes in the surface and subsurface of the Earth?

ESS2.D: Weather and Climate *What regulates weather and climate?* ● Weather and climate are influenced by interactions involving sunlight, the ocean, the atmosphere, ice, landforms, and living things. These interactions vary with latitude, altitude, and local and regional geography, all of which can affect oceanic and atmospheric flow patterns. Because these patterns are so complex, weather can be predicted only probabilistically. ● The ocean exerts a major influence on weather and climate by absorbing energy from the sun, releasing it over time, and globally redistributing it through ocean currents. ● Greenhouse gases in the atmosphere absorb and retain the energy radiated from land and ocean surfaces, thereby regulating Earth's average surface temperature and keeping it habitable.	● How can data and models be used to extrapolate weather and climate patterns? ● What regulates weather and climate?
ESS2.E: Biogeology *How do living organisms alter Earth's processes and structures?* ● Evolution is shaped by Earth's varying geological conditions. Sudden changes in conditions (e.g., meteor impacts, major volcanic eruptions) have caused mass extinctions, but these changes, as well as more gradual ones, have ultimately allowed other life forms to flourish. ● The evolution and proliferation of living things over geological time have in turn changed the rates of weathering and erosion of land surfaces, altered the composition of Earth's soils and atmosphere, and affected the distribution of water in the hydrosphere.	● How have organisms on Earth evolved in response to changes in the Earth's major systems? ● How can organisms impact Earth's major systems?
ESS3: Earth and Human Activity ***How do Earth's surface processes and human activities affect each other?***	
ESS3.A: Natural Resources *How do humans depend on Earth's resources?* ● Humans depend on Earth's land, ocean, atmosphere, and biosphere for many different resources. Minerals, fresh water, and biosphere resources are limited, and many are not renewable or replaceable over human lifetimes. These resources are distributed unevenly around the planet as a result of past geological processes. ● Renewable energy resources, and the technologies to exploit them,	● How do humans depend on Earth's resources? ● What has caused Earth's resources to be unevenly distributed? ● How has technology been employed to develop and exploit renewable energy resources?

are being rapidly developed.	
ESS3.B: Natural Hazards *How do natural hazards affect individuals and societies?* ● Some natural hazards, such as volcanic eruptions and severe weather, are preceded by phenomena that allow for reliable predictions. Others, such as earthquakes, occur suddenly and with no notice, and thus they are not yet predictable. However, mapping the history of natural hazards in a region, combined with an understanding of related geological forces can help forecast the locations and likelihoods of future events.	● What tools and models can be employed to make reliable predictions about the timing and intensity of natural hazards? ● How can we use information about past natural hazards to assist in forecasting future hazards?
ESS3.C: Human Impacts on Earth Systems *How do humans change the planet?* ● Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of many other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things. ● Typically, as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise.	● How have organisms responded to changes in their environment as a result of human activity? ● What changes in human behavior and technology can mitigate the negative impacts humans have had on Earth systems?
ESS3.D: Global Climate Change *How do people model and predict the effects of human activities on Earth's climate?* ● Human activities, such as the release of greenhouse gases from burning fossil fuels, are major factors in the current rise in Earth's mean surface temperature (global warming). ● Reducing human vulnerability to whatever climate changes do occur depend on the understanding of climate science, engineering capabilities, and other kinds of knowledge, such as understanding of human behavior and on applying that knowledge wisely in decisions and activities.	● What human activities have positively impacted Earth's climate? ● What human activities have negatively impacted Earth's climate? ● How can knowledge from STEM areas and social science disciplines be used to mitigate the impact of humans on the Earth's climate?

AFK12SE/NGSS Strand Disciplinary Core Idea	Conceptual Understandings for Teachers at 6-8
LS1: From Molecules to Organisms: Structures and Processes ***How do organisms live, grow, respond to their environment, and reproduce?***	
LS1.A: Structure and Function *How do the structures of organisms enable life's functions?* ● All living things are made up of cells, which is the smallest unit that can be said to be alive. An organism may consist of one single cell (unicellular) or many different numbers and types of cells (multicellular). ● Unicellular organisms (microorganisms), like multicellular organisms, need food, water, a way to dispose of waste, and an environment in which they can live. ● Within cells, special structures are responsible for particular functions, and the cell membrane forms the boundary that controls what enters and leaves the cell. ● In multicellular organisms, the body is a system of multiple interacting subsystems. These subsystems are groups of cells that work together to form tissues or organs that are specialized for particular body functions.	● What is a cell? ● How do cells functions similarly and differently in unicellular and multicellular organisms? ● What are major organelles, and how do these impact cell function? ● What evidence supports the argument that the body is a system of interacting sub-systems composed of cells, tissues, organs, and systems? ● Which scientists were most important in the development of cell theory and what did they contribute to the theory?
LS1.B: Growth and Development of Organisms *How do organisms grow and develop?* ● Organisms reproduce, either sexually or asexually, and transfer their genetic information to their offspring. ● Animals engage in characteristic behaviors that increase the odds of reproduction. ● Plants reproduce in a variety of ways, sometimes depending on animal behavior and specialized features (such as attractively colored flowers) for reproduction. ● Plant growth can continue throughout the plant's life through production of plant matter in photosynthesis. Genetic factors as well as local conditions affect the size of the adult plant. ● The growth of an animal is controlled by genetic factors, food intake, and interactions with other organisms, and each species has a typical adult size range.	● How do plants and animals ensure the continuation of their species? ● What specialized structures/behaviors are used by plants and animals to ensure reproductive success? ● What empirical evidence supports an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants, respectively? ● How do organisms grow and develop? ● What factors (genetic and environmental) impact the growth of organisms? ● How do these genetic and environmental factors impact the growth of organisms?
LS1.C: Organization for matter and energy flow in organisms *How do organisms obtain and use the matter and energy they need to*	● How do organisms obtain and use the matter and energy they need to live and grow?

live and grow? ● Plants, algae (including phytoplankton), and many microorganisms use the energy from light to make sugars (food) from carbon dioxide from the atmosphere and water through the process of photosynthesis, which also releases oxygen. These sugars can be used immediately or stored for growth or later use. ● Animals obtain food from eating plants or eating other animals. ● Within individual organisms, food moves through a series of chemical reactions in which it is broken down and rearranged to form new molecules, to support growth, or to release energy. ● In most animals and plants, oxygen reacts with carbon containing molecules (sugars) to provide energy and produce carbon dioxide; ● anaerobic bacteria achieve their energy needs in other chemical processes that do not require oxygen.	● How does energy flow in a typical food chain? ● How do organisms obtain energy through the chemical processes of photosynthesis, cellular respiration, and digestion? . ● In what different ways do aerobic and anaerobic bacteria achieve their energy needs?
LS1.D: Information Processing *How do organisms detect, process, and use information about the environment* ● Each sense receptor responds to different inputs (electromagnetic, mechanical, chemical), transmitting them as signals that travel along nerve cells to the brain. The signals are then processed in the brain, resulting in immediate behaviors or memories. ● Changes in the structure and functioning of many millions of interconnected nerve cells allow combined inputs to be stored as memories for long periods of time.	● How are different signals transferred from a sense receptor to the brain? ● How does the brain impact behavior and memory? ● How do organisms detect, process, and use information about the environment?
LS2: Ecosystems: Interactions, Energy, and Dynamics ***How and why do organisms interact with their environment and what are the effects of these interactions?***	

LS2.A: Interdependent Relationships in Ecosystems *How do organisms interact with the living and nonliving environments to obtain matter and energy?* ● Organisms and populations of organisms are dependent on their environmental interactions both with other living things and with nonliving factors. ● Growth of organisms and population increases are limited by access to resources. In any ecosystem, organisms and populations with similar requirements for food, water, oxygen, or other resources may compete with each other for limited resources, access to which consequently constrains their growth and reproduction. ● Similarly, predatory interactions may reduce the number of organisms or eliminate whole populations of organisms. ● Mutually beneficial interactions, in contrast, may become so interdependent that each organism requires the other for survival. ● Although the species involved in these competitive, predatory, and mutually beneficial interactions vary across ecosystems, the patterns of interactions of organisms with their environments, both living and nonliving, are shared.	● How are growth of organisms and populations limited by accessibility to resources? ● What types of community relationships exist among populations in an ecosystem? ● How do these relationships impact different populations within a community? ● How do the abiotic factors impact the biotic components of an ecosystem? ● How do competition, predation, and beneficial mutualism contribute to a healthy ecosystem?
LS2.B: Cycles of Matter and Energy Transfer in Ecosystems *How do matter and energy move through an ecosystem?* ● Food webs are models that demonstrate how matter and energy is transferred between producers (generally plants and other organisms that engage in photosynthesis), consumers, and decomposers as the three groups interact—primarily for food—within an ecosystem. ● Transfers of matter into and out of the physical environment occur at every level—for example, when molecules from food react with oxygen captured from the environment, the carbon dioxide and water thus produced are transferred back to the environment, and ultimately so are waste products, such as fecal material. ● Decomposers recycle nutrients from dead plant or animal matter back to the soil in terrestrial environments or to the water in aquatic environments. ● The atoms that make up the organisms in an ecosystem are	● How do matter and energy move through an ecosystem? ● How can a food web demonstrate how matter and energy is transferred within an ecosystem? ● What are the roles of producers, consumers, and decomposers in cycling in an ecosystem?

cycled repeatedly between the living and nonliving parts of the ecosystem.	
LS2.C: Ecosystem Dynamics, Functioning, and Resiliance *What happens to ecosystems when the environment changes?* ● Ecosystems are dynamic in nature; their characteristics can vary over time. ● Disruptions to any physical or biological component of an ecosystem can lead to shifts in all of its populations. ● Biodiversity describes the variety of species found in Earth's terrestrial and oceanic ecosystems. ● The completeness or integrity of an ecosystem's biodiversity is often used as a measure of its health.	● What happens to ecosystems when the environment changes? ● How does a disruption to a physical or biological component of an ecosystem impact a population? ● How is biodiversity linked to the health of an ecosystem?
LS2.D: Social Interactions and Group Behavior *How do organisms interact in groups so as to benefit individuals?* ● Groups may form because of genetic relatedness, physical proximity, or other recognition mechanisms (which may be species specific). They engage in a variety of signaling behaviors to maintain the group's integrity or to warn of threats. ● Groups often dissolve if they no longer function to meet individuals' needs, if dominant members lose their place, or if other key members are removed from the group through death, predation, or exclusion by other members.	● How do organisms interact in groups so as to benefit individuals? ● What factors impact the behaviors of individuals and entire populations?
LS3: Heredity: Inheritance and Variation of Traits ***are characteristics of one generation passed to the next?*** ***How can individuals of the same species and even siblings have different characteristics?***	
LS3.A: Inheritance of Traits *How are the characteristics of one generation related to the previous generation?* ● Genes are located in the chromosomes of cells, with each chromosome pair containing two variants of each of many distinct genes. ● Each distinct gene chiefly controls the production of a specific protein, which in turn affects the traits of the individual (e.g., human skin color results from the actions of proteins that control	● How are characteristics of one generation passed to the next? ● What are the relationships among genes, proteins and traits? ● In what ways do mutations occur? ● How do gene mutations result in changes in an organism?

the production of the pigment melanin). ● Changes (mutations) to genes can result in changes to proteins, which can affect the structures and functions of the organism and thereby change traits. ● Sexual reproduction provides for transmission of genetic information to offspring through egg and sperm cells. These cells, which contain only one chromosome of each parent's chromosome pair, unite to form a new individual (offspring). Thus offspring possess one instance of each parent's chromosome pair (forming a new chromosome pair). ● Variations of inherited traits between parent and offspring arise from genetic differences that result from the subset of chromosomes (and therefore genes) inherited or (more rarely) from mutations.	
LS3.B: Variation of Traits *Why do individuals of the same species vary in how they look, function, and behave?* ● In sexually reproducing organisms, each parent contributes half of the genes acquired (at random) by the offspring. ● Individuals have two of each chromosome and hence two alleles of each gene, one acquired from each parent. These versions may be identical or may differ from each other. ● In addition to variations that arise from sexual reproduction, genetic information can be altered because of mutations. Though rare, mutations may result in changes to the structure and function of proteins. ● Some changes are beneficial, others harmful, and some neutral to the organism.	● How can individuals of the same species and even siblings have different characteristics? ● Why do individuals of the same species vary in how they look, function, and behave?
LS4: Biological Evolution: Unity and Diversity ***y can there be so many similarities among organisms yet so many different kinds of plants, animals, and microorganisms?*** ***How does biodiversity affect humans?***	
LS4.A: Evidence of Common Ancestry and Diversity *What evidence shows that different species are related?* ● Fossils are mineral replacements, preserved remains, or traces of organisms that lived in the past.	● What forms of evidence can we use to infer evolutionary

● Thousands of layers of sedimentary rock not only provide evidence of the history of Earth itself but also of changes in organisms whose fossil remains have been found in those layers. ● The collection of fossils and their placement in chronological order (e.g., through the location of the sedimentary layers in which they are found or through radioactive dating) is known as the fossil record. It documents the existence, diversity, extinction, and change of many life forms throughout the history of life on Earth. ● Because of the conditions necessary for their preservation, not all types of organisms that existed in the past have left fossils that can be retrieved. ● Anatomical similarities and differences between various organisms living today and between them and organisms in the fossil record enable the reconstruction of evolutionary history and the inference of lines of evolutionary descent. ● Comparison of the embryological development of different species also reveals similarities that show relationships not evident in the fully formed anatomy.	relationships? ● How does the fossil record document the existence, diversity, extinction, and change of life forms throughout the history of life on Earth?
LS4.B: Natural Selection *How does genetic variation among organisms affect survival and reproduction?* ● Genetic variations among individuals in a population give some individuals an advantage in surviving and reproducing in their environment. This is known as natural selection. It leads to the predominance of certain traits in a population and the suppression of others. ● In artificial selection, humans have the capacity to influence certain characteristics of organisms by selective breeding. One can choose desired parental traits determined by genes, which are then passed on to offspring.	● How can there be so many similarities among organisms yet so many different kinds of plants, animals, and microorganisms? ● How can genetic variation impact an individual's or species' reproductive advantage? ● How can artificial selection influence the presence of certain characteristics of organisms? ● What technologies have changed the way humans influence the inheritance of desired traits in organisms?

LS4.C: Adaptation *How does the environment influence populations of organisms over multiple generations?* ● Adaptation by natural selection acting over generations is one important process by which species change over time in response to changes in environmental conditions. ● Traits that support successful survival and reproduction in the new environment become more common; those that do not become less common. Thus, the distribution of traits in a population changes. ● In separated populations with different conditions, the changes can be large enough that the populations, provided they remain separated (a process called reproductive isolation), evolve to become separate species.	● How does the environment influence populations of organisms over multiple generations? ● How can environmental changes impact the distribution of traits in a population? ● How can reproductive isolation lead to speciation? ● What conditions are necessary for natural selection to occur? ● How can mathematical modeling be used to describe how natural selection may lead to increases and decreases of specific traits in populations over time?
LS4.D: Biodiversity and Humans *What is biodiversity, how do humans affect it, and how does it affect humans?* ● Biodiversity is the wide range of existing life forms that have adapted to the variety of conditions on Earth, from terrestrial to marine ecosystems. ● Biodiversity includes genetic variation within a species, in addition to species variation in different habitats and ecosystem types (e.g., forests, grasslands, wetlands). ● Changes in biodiversity can influence humans' resources, such as food, energy, and medicines, as well as ecosystem services that humans rely on—for example, water purification and recycling.	● What is biodiversity? ● How do changes in biodiversity affect humans? ● How have humans impacted biodiversity? ● How does human impact on biodiversity affect environmental, economic, and social considerations of the community?