AFK12SE/NGSS Strand Disciplinary Core Idea	Conceptual Understanding for Teachers at 9-12
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?* • Systems of specialized cells within organisms help them perform the essential functions of life, which involve chemical reactions that take place between different types of molecules, such as water, proteins, carbohydrates, lipids, and nucleic acids. • All cells contain DNA. • Multicellular organisms have a hierarchical structural organization, in which any one system is made up of numerous parts and is itself a component of the next level.	• 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? • Which scientists were most important in the development of cell theory and what did they contribute to the theory? • What are the roles of DNA and chromosomes in determining an individual's traits? • What are the relationships among DNA, genes, and protein synthesis? • What is the importance of proteins for cells? • How is cell theory an example of a scientific theory? • How can the relationships among the hierarchical system of cells, tissues, organs, and systems be modeled? • How do organismal systems interact to assist in an organism's life processes? • What tools are used to examine microscopic structures?
LS1.B: Growth and Development of Organisms *How do organisms grow and develop?* • In multicellular organisms individual cells grow and then divide via a process called mitosis, thereby allowing the organism to grow.	• 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?

• Organisms begin as a single cell that divides successively to produce many cells, with each parent cell passing identical genetic material to both daughter cells. • With each subdivision the process of differentiation occurs which produces and maintains the complexity of organisms. • In sexual reproduction meiosis occurs resulting in the production of gametes, which contain one member from each chromosome pair in the parent cell.	• 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? • What is the relationship among mitosis, differentiation, and gene expression in the development of multicellular organisms? • How do cells grow and divide in multicellular organisms? • In what ways do different organisms grow and develop? • What argument can be constructed for why meiosis is essential for sexual reproduction? • How can the similarities and differences between mitosis and meiosis be modeled?
LS1.C: Organization for matter and energy flow in organisms *How do organisms obtain and use the matter and energy they need to live and grow?* • In plants, matter is obtained and converted into energy through the process of photosynthesis. This process results in sugars used for plant growth and the release of oxygen. • These sugar molecules are used to make amino acids and other carbon-based molecules. • As matter and energy flow through living systems, chemical elements are recombined to form different products. From these chemical reactions (i.e., aerobic and anaerobic) cellular respiration), energy is transferred.	• How do organisms obtain and use the matter and energy they need to live and grow? • 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? • What processes enable organisms to construct complex organic molecules from simple elements? • What occurs during the light and dark reactions of photosynthesis?

• Matter and energy are conserved in each transfer and this is true of all biological systems, from individual cells to ecosystems.	• What is the evidence for why photosynthesis is important for life on earth? • How does cellular respiration result in a net transfer of energy? • What models depict how matter and energy flow through living systems? • How are more complex carbon based molecules formed from simple sugar molecules? • What is the role of enzymes in the breakdown and synthesis of molecules?
LS1.D: Information Processing *How do organisms detect, process, and use information about the environment?* • In complex organisms, the brain has distinct regions responsible for different dedicated functions. • Additionally, some circuits give rise to emotions and memories that motivate organisms to seek or avoid particular interactions with members of their own species and, in some cases, to individuals of other species. • The integrated functioning of all parts of the brain is important for successful interpretation of inputs and generation of behaviors in response to them.	• 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? • What are the main regions of the brain, and what functions are associated with each of these regions? • What are reflexes, and how do they differ from more complex behaviors? • What is the importance of homeostasis? • How do feedback mechanisms impact an organism's internal conditions and mediate behaviors? • What are the impacts of emotions and memory on behavior?
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?* ● Ecosystems have carrying capacities, which are limits to the numbers of organisms and populations they can support based on the resources of the ecosystem.	● 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? ● What determines the carrying capacity of a particular environment? ● What is the importance of carrying capacity on sustainability of an ecosystem? ● What evidence would support the claim that complex interactions within an ecosystem help to maintain relatively stable numbers and types of organisms in that ecosystem?
LS2.B: CYCLES OF MATTER AND ENERGY TRANSFER IN ECOSYSTEMS *How do matter and energy move through an ecosystem?* ● Photosynthesis and cellular respiration (including anaerobic processes) provide most of the energy for life processes. ● At each link upward in a food web, only a small fraction of the matter consumed at the lower level is transferred upward, to produce growth and release energy. Given this inefficiency, there is a limit to the number of organisms that an ecosystem can sustain. ● At each link in an ecosystem matter and energy are conserved. ● Photosynthesis and cellular respiration are important components of the carbon cycle.	● How do matter and energy move through an ecosystem? ● What are the roles of producers, consumers, and decomposers in cycling in an ecosystem? ● What is the history of the development of current understanding of photosynthesis? ● What model best illustrates the role of photosynthesis and respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere and geosphere? ● How does cellular respiration result in a net transfer of energy? ● How do aerobic and anaerobic respiration compare in terms of reactants, products, and energy production? ● How can the change in mass and energy moving through a food web be modeled? ● Why is the amount of energy reduced as it moves through a food web? ● How can mathematical modeling be used to depict how the efficiency of energy flow impacts the number of organisms at increasingly higher trophic levels?

	• In what ways is the process of cellular respiration similar to the burning of fossil fuels as it relates to the carbon cycle?
LS2.C: ECOSYSTEM DYNAMICS, FUNCTIONING, AND RESILIENCE *What happens to ecosystems when the environment changes?* • A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions. • Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of ecosystems in terms of resources and habitat availability.	• What happens to ecosystems when the environment changes? • How does a disruption to a physical or biological component of an ecosystem impact population dynamics? • Why is biodiversity within an ecosystem important? • In what ways is homeostasis (resilience) of populations in an ecosystem maintained? • What anthropogenic changes have occurred in the environment? • In what ways can anthropogenic changes disrupt an ecosystem? • What is the relationship between anthropogenic changes and the species extinction?
LS2.D: SOCIAL INTERACTIONS AND GROUP BEHAVIOR *How do organisms interact in groups so as to benefit individuals?* • Animals, including humans, having a strong social affiliation with members of their own species will suffer, behaviorally as well as physiologically, if reared in isolation. • Group behavior evolves to increase the chances of survival for individuals and their genetic relatives	• What factors might influence the evolution of group behaviors in a species? • What role does group behavior plays in the survival of individuals and species?
LS3: Heredity: Inheritance and Variation of traits	***How 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?* ● In all organisms the genetic instructions for forming species' characteristics are carried in DNA. ● All cells in an organism have the same genetic content, but the genes used (expressed) by the cell may be regulated in different ways. ● Not all DNA codes for a protein; some segments of DNA are involved in regulatory or structural functions, and some have no as-yet known function.	● 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? ● How was the structure and model of DNA developed, critiqued, and accepted? ● What technologies were used in the development of the DNA model? ● Who are some of the notable scientists that developed and advanced the knowledge generated from DNA? ● How does the structure of the DNA molecule impact its function? ● How do DNA sequences lend themselves to regulatory functions?
LS3.B: VARIATION OF TRAITS *Why do individuals of the same species vary in how they look, function, and behave?* ● The information passed from parents to offspring is coded in the DNA molecules that form the chromosomes. ● In sexual reproduction, through meiosis cell division) chromosomes can create new genetic combinations and thus more genetic variation. ● Although DNA replication is regulated, errors do occur and result in mutations. Environmental factors can also cause mutations in genes and affect expression of traits, thus the variation and distribution of traits observed depend on both genetic and environmental factors.	● Why do individuals of the same species vary in how they look, function, and behave? ● What are the relationships among DNA, nucleotide sequences, protein formation, allele, gene, and chromosome? ● How can the process of DNA replication be modeled? ● In what ways does genetic variability occur (e.g., sexual reproduction, crossing over, recombination, mutations, environmental interactions)? ● How do sexual and asexual reproduction compare in terms of producing genetic diversity? ● How do both genetic and environmental factors affect expression of traits? ● In what ways is genetic variability important? ● How is the probability of occurrence of traits in future generations based on parental genotypes calculated?

	• Who are some of the notable scientists that developed and advanced the basic understanding of genetics?
LS4: Biological Evolution: Unity and Diversity	***How 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?* • Genetic information, like the fossil record, also provides evidence of evolution. • For example, multiple lines of descent can be inferred by comparing the DNA sequences of different organisms. • Such information is also derivable from the similarities and differences in amino acid sequences and from anatomical and embryological evidence.	• How does the fossil record document the existence, diversity, extinction, and change of life forms throughout the history of life on Earth? • What types of evidence support the process of evolution? • How is the current classification system based on similarities and differences in the anatomical, physiological and functional characteristics of organisms? • Given a data set about DNA sequences, how can can a phylogenetic tree be constructed?
LS4.B: NATURAL SELECTION *How does genetic variation among organisms affect survival and reproduction?* • Natural selection occurs only if there is both (1) variation in the genetic information between organisms in a population and (2) variation in the expression of that genetic information • Traits that positively affect survival are more likely to be reproduced and thus are more common in the population.	• 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? • How are shifts in the numerical distribution of traits used as evidence to support that advantageous heritable traits tend to increase in a population? • What is the relationship among natural selection, adaptations, and evolution?

	• Which scientists were important in the development of the theories of evolution by natural selection, and what did they contribute to the theory?
LS4.C: ADAPTATION *How does the environment influence populations of organisms over multiple generations?* • Natural selection leads to adaptation and is the result of four factors: (1) the potential for a species to increase in number, (2) the genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for an environment's limited supply of the resources that individuals need in order to survive and reproduce, and (4) the ensuing proliferation of those organisms that are better able to survive and reproduce in that environment. • Adaptation also means that the distribution of traits in a population can change when conditions change. These changes can result in expansion of some species, the emergence of new distinct species, or the decline of some species. • Species become extinct because they can no longer survive and reproduce in their altered environment.	• How can mathematical modeling be used to describe how natural selection may lead to increases and decreases of specific traits in populations over time? • What main factors are necessary for evolution to occur? • How can biotic and abiotic differences in ecosystems impact a change in gene frequency over time? • What is meant by virulence and resistance? • What is the potential impact of a new pathogen on a population? • How has the increase in prescribing antibiotics impacted the evolution of bacteria?
LS4.D: BIODIVERSITY AND HUMANS *What is biodiversity, how do humans affect it, and how does it affect humans?* • Biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction). • Humans depend on the living world for the resources and other benefits provided by biodiversity. But human activity can also adversely affect biodiversity through overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change. • Sustaining biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth.	• In what ways can changes in environmental conditions (e.g., drought, deforestation, flood) and the rate of change of the environment affect the distribution or disappearance of traits in a species? • What is the importance of sustaining biodiversity to support and enhance life on Earth? • What are potential causes of extinction? • What are potential causes of speciation? • How can modeling predict and test the impacts of proposed solutions for protection of a threatened or endangered species? • What are some impacts of human activity on biodiversity?
Supporting Competencies	

Math	● How are statistics used by scientists to support arguments? ● How are mathematical models used in life sciences?
Earth and Space Science	● How do Earth's major systems interact to impact Earth processes? ● How do humans depend on Earth's resources? ● What human activities have positively and negatively impacted Earth's climate? ● How do the chemical and physical properties of water and its movement create changes in the surface and subsurface of the Earth?
Physics	● What is energy and how is it measured? ● How is energy transferred between objects? ● What are the conceptual and mathematical relationships among energy, work, and power? ● What is meant by conservation of energy and conservation of mass? ● What is the relationship between thermal energy and temperature?
Chemistry	● What is matter? ● What trends exist in the Periodic Table and how do those trends reflect atomic structure? ● In what ways do atoms combine to form novel substances? ● What conventions do chemists use for naming chemical compounds and writing chemical formulas? ● How does a balanced chemical reaction represent conservation of mass in a given chemical reaction? ● How is half-life used to determine the age of rocks and other natural materials?