

HIGH SCHOOL - LIFE SCIENCE - MISSOURI LEARNING STANDARDS (2016)

9-12.Structure and Function		
Students who demonstrate understanding can:		
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.]		
9-12.LS1.A.2 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.]		
9-12.LS1.A.3 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 development in response to water levels.]		
The expectations above were developed using the following elements from the NRC document A Framework for K-12 Science Education:		
Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world. - Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system. (A.2) Planning and Carrying Out Investigations Planning and carrying out in 9–12 builds on K–8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models. - Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. (A.3) Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student generated sources of evidence consistent with scientific ideas, principles, and theories. - Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (A.1)	LS1.A: Structure and Function - Systems of specialized cells within organisms help them perform the essential functions of life. (A.1) - All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins, which carry out most of the work of cells. (A.1) - 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. (A.2) - Feedback mechanisms maintain a living system's internal conditions within certain limits and mediate behaviors, allowing it to remain alive and functional even as external conditions change within some range. Feedback mechanisms can encourage (through positive feedback) or discourage (negative feedback) what is going on inside the living system. (A.3)	Systems and System Models - Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy , matter, and information flows—within and between systems at different scales. (A.2) Structure and Function - Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem. (A.1) Stability and Change - Feedback (negative or positive) can stabilize or destabilize a system. (A.3)
Connections to other DCIs in this grade-band: 9-12.LS3.A (9-12.LS1.A.1)		
Articulation to DCIs across grade-bands: 6-8.LS1.A (9-12.LS1.A.1),(9-12.LS1.A.2),(9-12.LS1.A.3); 6-8.LS3.A (9-12.LS1.A.1); 6-8.LS3.B (9-12.LS1.A.1)		
Connections to MO LEAP Blocks: N/A		
Connections to other Missouri Learning Standards:		
ELA/Literacy -		
9-10.W.1.A Approaching the Task as a Researcher. (A.2), (A.3)		
9-10.W.2.A Follow a writing process to produce clear and coherent writing in which the development, organization, style, and voice are appropriate to the task, purpose and audience; self-select and blend (when appropriate) previously learned narrative, expository, and argumentative writing techniques. (A.1),		
9-10.W.3.A Review, revise, and edit writing with consideration for the task, purpose, and audience. (A.1),		
9-10.SL.2.C Plan and deliver appropriate presentations concisely and logically based on the task, audience and purpose making strategic use of multimedia in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (A.2)		

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9-10.RL.1.D Using appropriate text, determine two or more themes in a text, analyze their development throughout the text, and relate the themes to life experiences; provide an objective and concise summary of the text. (A.1)
9-10.RI.1.D Explain two or more central/main ideas in a text, analyze their development throughout the text, and explain the significance of the central ideas; provide an objective and concise summary of the text. (A.1)
<i>Mathematics -</i>
None

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9-12.Matter and Energy in Organisms and Ecosystems		
Students who demonstrate understanding can:		
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.]	
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.]	
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.]	
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 trophic level to another. Emphasis is on atoms and molecules as they move through an ecosystem.]	
9-12.LS2.B.3	Use a model that illustrates the roles of photosynthesis, cellular respiration, decomposition, and combustion to explain the cycling of carbon in its various forms among the biosphere, atmosphere, 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.]	
The expectations above were developed using the following elements from the NRC document A Framework for K-12 Science Education:		
Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds. - Use a model based on evidence to illustrate the relationships between systems or between components of a system. (C.1),(C.2) - Develop a model based on evidence to illustrate the relationships between systems or components of a system. (B.3) Using Mathematics and Computational Thinking Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. - Use mathematical representations of phenomena or design solutions to support claims. (B.2) Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in	LS1.C: Organization for Matter and Energy Flow in Organisms - The process of photosynthesis converts light energy to stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen. (C.1) - The sugar molecules thus formed contain carbon, hydrogen, and oxygen: their hydrocarbon backbones are used to make amino acids and other carbon-based molecules that can be assembled into larger molecules (such as proteins or DNA), used for example to form new cells. (C.3) - As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products. (C.2),(C.3) - As a result of these chemical reactions, energy is transferred from one system of interacting molecules to another. Cellular respiration is a chemical process in which the bonds of food molecules and oxygen molecules are broken and new compounds are formed that can transport energy to muscles. Cellular respiration also releases the energy needed to maintain body temperature despite ongoing energy transfer to the surrounding environment.(C.2) LS2.B: Cycle of Matter and Energy Transfer in Ecosystems - Photosynthesis and cellular respiration (including anaerobic processes) provide most of the energy for life processes. (B.1) - Plants or algae form the lowest level of the food web. 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 in cellular respiration at the higher level. Given this inefficiency, there are generally fewer organisms at higher levels of a food web. Some matter reacts to release energy for life functions, some matter is	Systems and System Models - Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales. (B.3) Energy and Matter - Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. (C.1), (C.3) - Energy cannot be created or destroyed—it only moves between one place and another place, between objects and/or fields, or between systems.(C.2),(B.2) - Energy drives the cycling of matter within and between systems. (B.1)

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9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student generated sources of evidence consistent with scientific ideas, principles, and theories Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (C.3),(B.1)	stored in newly made structures, and much is discarded. The chemical elements that make up the molecules of organisms pass through food webs and into and out of the atmosphere and soil, and they are combined and recombined in different ways. At each link in an ecosystem, matter and energy are conserved. (B.2) - Photosynthesis and cellular respiration are important components of the carbon cycle, in which carbon is exchanged among the biosphere, atmosphere, oceans, and geosphere through chemical, physical, geological, and biological processes. (B.3) PS3.D: Energy in Chemical Processes - The main way that solar energy is captured and stored on Earth is through the complex chemical process known as photosynthesis. (secondary to B.3)	
<i>Connections to other DCIs in this grade-band:</i> 9-12.PS1.B (9-12.LS1.C.1),(9-12.LS1.C.3),(9-12.LS1.C.2),(9-12.LS2.B.1),(9-12.LS2.B.3); 9-12.PS2.B (9-12.LS1.C.2); 9-12.PS3.B (9-12.LS1.C.1),(9-12.LS1.C.2),(9-12.LS2.B.1),(9-12.LS2.B.2); 9-12.PS3.D (9-12.LS2.B.1),(9-12.LS2.B.2); 9-12.ESS2.A (9-12.LS2.B.1); 9-12.ESS2.D (9-12.LS2.B.3)		
<i>Articulation across grade-bands:</i> 6-8.PS1.A (9-12.LS1.C.3); 6-8.PS1.B (9-12.LS1.C.1),(9-12.LS1.C.3),(9-12.LS1.C.2),(9-12.LS2.B.1); 6-8.PS3.D (9-12.LS1.C.1),(9-12.LS1.C.3), (9-12.LS1.C.2),(9-12.LS2.B.1),(HS-LS2-4),(9-12.LS2.B.3); 6-8.LS1.C (9-12.LS1.C.1),(9-12.LS1.C.3),(9-12.LS1.C.2), (9-12.LS2.B.1),(9-12.LS2.B.2),(9-12.LS2.B.3); 6-8.LS2.B (9-12.LS1.C.1),(9-12.LS1.C.2),(9-12.LS2.B.1),(9-12.LS2.B.2),(9-12.LS2.B.3); 6-8.ESS2.A (9-12.LS2.B.3); 6-8.ESS2.E (9-12.LS1.C.3)		
Connections to MO LEAP Blocks: Carbon Cycle (9-12.LS2.B.1); Green Fingured Genius (9-12.LS2.B.1); The Freezer's Defrosting (9-12.LS2.B.3)		
Connections to other Missouri Learning Standards:		
ELA/Literacy -		
9-10.W.2.A Follow a writing process to produce clear and coherent writing in which the development, organization, style, and voice are appropriate to the task, purpose and audience; self-select and blend (when appropriate) previously learned narrative, expository, and argumentative writing techniques. (C.3)		
9-10.W.3.A Review, revise, and edit writing with consideration for the task, purpose, and audience. (C.3)		
9-10.SL.2.C Plan and deliver appropriate presentations concisely and logically based on the task, audience and purpose making strategic use of multimedia in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (C.1), (C.2)		
9-10.RL.1.A Draw conclusions, infer and analyze by citing relevant and thorough textual evidence to support analysis of what the text says explicitly as well as inferences drawn from the text. (C.3)		
9-10.RI.1.A Draw conclusions, infer and analyze by citing relevant and thorough textual evidence to support analysis of what the text says explicitly as well as inferences drawn from the text. (C.3)		
Mathematics -		
A1.NQ.B.3 Use units of measure as a way to understand and solve problems involving quantities. (B.2)		
A1.NQ.B.4 Define and use appropriate quantities for representing a given context or problem. (B.2)		
A1.NQ.B.5 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (B.2)		

9-12.Interdependent Relationships in Ecosystems

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Students who demonstrate understanding can:		
9-12.LS2.A.1 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.]		
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.]		
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 organisms for multiple species.]		
The expectations above were developed using the following elements from the NRC document A Framework for K-12 Science Education:		
Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Using Mathematics and Computational Thinking Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. - Use mathematical and/or computational representations of phenomena or design solutions to support explanations. (A.1) - Create or revise a simulation of a phenomenon, designed device, process, or system. (C.3) Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories - Design, evaluate, and refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade off considerations. (C.2) Engaging in Argument from Evidence Engaging in argument from evidence in 9–12 builds from K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments	LS2.A: Interdependent Relationships in Ecosystems - Ecosystems have carrying capacities, which are limits to the numbers of organisms and populations they can support. These limits result from such factors as the availability of living and nonliving resources and from such challenges such as predation, competition, and disease. Organisms would have the capacity to produce populations of great size were it not for the fact that environments and resources are finite. This fundamental tension affects the abundance (number of individuals) of species in any given ecosystem. (A.1) LS2.C: Ecosystem Dynamics, Functioning, and Resilience - 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. If a modest biological or physical disturbance to an ecosystem occurs, it may return to its more or less original status (i.e., the ecosystem is resilient), as opposed to becoming a very different ecosystem. Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of ecosystems in terms of resources and habitat availability. (C.1) - Moreover, anthropogenic changes (induced by human activity) in the environment—including habitat destruction, pollution, introduction of invasive species, overexploitation, and climate change—can disrupt an ecosystem and threaten the survival of some species. (C.2) LS4.C: Adaptation - Changes in the physical environment, whether naturally occurring or human induced, have thus contributed to the expansion of some species, the emergence of new distinct species as populations diverge under different conditions, and the decline—and sometimes the extinction—of some species. (C.3) LS4.D: Biodiversity and Humans - Biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction). (secondary to C.2) - Humans depend on the living world for the resources and other benefits provided by biodiversity. But human activity is also having adverse impacts on biodiversity through overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change. Thus sustaining biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth. Sustaining biodiversity also aids humanity by preserving landscapes of recreational or inspirational value. (secondary to C.2), (C.3) ETS1.B: Developing Possible Solutions - There are systematic processes for evaluating solutions with When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. (secondary to C.2),(secondary to C.3)	Cause and Effect - Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (C.3) Scale, Proportion, and Quantity - The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. (A.1) Stability and Change - Much of science deals with constructing explanations of how things change and how they remain stable. (C.1),(C.2)

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may also come from current scientific or historical episodes in science. Evaluate the claims, evidence, and reasoning behind currently accepted explanations or solutions to determine the merits of arguments. (C.1)	Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs. (secondary to C.3)	
<i>Connections to other DCIs in this grade-band:</i> 9-12.ESS2.D (9-12.LS2.C.2),(9-12.LS4.C.3); 9-12.ESS2.E (9-12.LS2.C.1),(9-12.LS2.C.2), (9-12.LS4.C.3); 9-12.ESS3.A (9-12.LS2.C.2), (9-12.LS4.C.3); 9-12.ESS3.C (9-12.LS2.C.2),(9-12.LS4.C.3); 9-12.ESS3.D (9-12.LS4.C.3)		
<i>Articulation across grade-bands:</i> 6-8.LS2.A (9-12.LS2.A.1),(9-12.LS2.C.1); 6-8.LS2.C (9-12.LS2.A.1),(9-12.LS2.C.1),(9-12.LS2.C.2), (9-12.LS4.C.3); 6-8.ESS2.E (9-12.LS2.C.1); 6-8.ESS3.A (9-12.LS2.A.1); 6-8.ESS3.C (9-12.LS2.A.1),(9-12.LS2.C.1),(9-12.LS2.C.2), (9-12.LS4.C.3); 6-8.ESS3.D (9-12.LS2.C.2)		
Connections to MO LEAP Blocks: N/A		
Connections to other Missouri Learning Standards:		
ELA/Literacy -		
9-10.RL.1.A Draw conclusions, infer and analyze by citing relevant and thorough textual evidence to support analysis of what the text says explicitly as well as inferences drawn from the text. (A.1), (C.1)		
9-10.RL.1.C Interpret visual elements of a text and draw conclusions from them (when applicable). (C.1), (C.2)		
9-10.RI.1.A Draw conclusions, infer and analyze by citing relevant and thorough textual evidence to support analysis of what the text says explicitly as well as inferences drawn from the text. (A.1), (C.1)		
9-10.RI.1.C Interpret visual elements of a text and draw conclusions from them (when applicable). (C.1), (C.2)		
9-10.W.1.A Approaching the Task as a Researcher (C.2), (C.3)		
9-10.W.2.A Follow a writing process to produce clear and coherent writing in which the development, organization, style, and voice are appropriate to the task, purpose and audience; self-select and blend (when appropriate) previously learned narrative, expository, and argumentative writing techniques. (A.1), (C.1), (C.2)		
9-10.W.3.A Review, revise, and edit writing with consideration for the task, purpose, and audience. (C.3)		
Mathematics -		
A1.DS.A.1 Analyze and interpret graphical displays of data. (C.1)		
A2.DS.A.1 Analyze how random sampling could be used to make inferences about population parameters. (C.1)		
A2.DS.A.6 Analyze decisions and strategies using probability concepts. (C.1)		
A1.NQ.B.3 Use units of measure as a way to understand and solve problems involving quantities. (A.1), (C.2)		
A1.NQ.B.4 Define and use appropriate quantities for representing a given context or problem. (A.1), (C.2)		
A1.NQ.B.5 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (A.1), (C.2)		

9-12.Inheritance and Variation of Traits

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Students who demonstrate understanding can:	
9-12.LS1.B.1	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.]
9-12.LS3.A.1	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.
9-12.LS3.B.1	Compare and contrast asexual and sexual reproduction with regard to genetic information and variation in offspring.
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.]
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.]
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.]

The expectations above were developed using the following elements from the NRC document A Framework for K-12 Science Education:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Analyzing and Interpreting Data Analyzing data in 6–8 builds on K–5 experiences and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis. - Apply concepts of statistics and probability (including determining function fits to data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible. (B.4) Developing and Using Models Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds. - Use a model based on evidence to illustrate the relationships between systems or between components of a system. (LS1.B.1) Asking Questions and Defining Problems Asking questions and defining problems in 9–12 builds on K–8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations. - Ask questions that arise from examining models or a theory to clarify relationships. (A.1), (LS3.B.1) Engaging in Argument from Evidence Engaging in argument from evidence in 9–12 builds on K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science. - Make and defend a claim based on evidence about the natural world that reflects scientific	LS1.A: Structure and Function - All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins. (secondary to A.1 and LS3.B.1) (Note: This Disciplinary Core Idea is also addressed by LS1.B.1.) LS1.B: Growth and Development of Organisms - In multicellular organisms individual cells grow and then divide via a process called mitosis, thereby allowing the organism to grow. The organism begins as a single cell (fertilized egg) that divides successively to produce many cells, with each parent cell passing identical genetic material (two variants of each chromosome pair) to both daughter cells. Cellular division and differentiation produce and maintain a complex organism, composed of systems of tissues and organs that work together to meet the needs of the whole organism. (LS1.B.1) LS3.A: Inheritance of Traits - Each chromosome consists of a single very long DNA molecule, and each gene on the chromosome is a particular segment of that DNA. The 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. (A.1), (LS3.B.1) LS3.B: Variation of Traits - In sexual reproduction, chromosomes can sometimes swap sections during the process of meiosis (cell division), thereby creating new genetic combinations and thus more genetic variation. Although DNA replication is tightly regulated and remarkably accurate, errors do occur and result in mutations, which are also a source of genetic variation. Environmental factors can also cause mutations in genes, and viable mutations are inherited. (B.2), (B.3) - Environmental factors also affect expression of traits, and hence affect the probability of occurrences of traits in a population. Thus	Systems and System Models - Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales. (LS1.B.1) Scale, Proportion, and Quantity - Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth). (B.4) Cause and Effect - Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (A.1), (B.2), (LS3.B.3)

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knowledge, and student-generated evidence. (B.2), (B.3)	the variation and distribution of traits observed depends on both genetic and environmental factors. (B.2), (B.3),(B.4)	
Connections to other DCIs in this grade-band: 9-12.LS2.A (9-12.LS3.B.4); 9-12.LS2.C (9-12.LS3.B.4); 9-12.LS4.B (9-12.LS3.B.4); 9-12.LS4.C (9-12.LS3.B.4)		
Articulation across grade-bands: 6-8.LS1.A (9-12.LS1.B.1); 6-8.LS1.B (9-12.LS1.B.1); 6-8.LS2.A (9-12.LS3.B.4); 6-8.LS3.A (9-12.LS1.B.1),(9-12.LS3.A.1), (9-12.LS3.B.1), (9-12.LS3.B.2), (9-12.LS3.B.3); 6-8.LS3.B (9-12.LS3.A.1), (9-12.LS3.B.1),(9-12.LS3- 2),(9-12.LS3.B.4); 6-8.LS4.C (9-12.LS3.B.4)		
Connections to MO LEAP Blocks: Leopard Gecko (9-12.LS3.B.3)		
Connections to other Missouri Learning Standards:		
ELA/Literacy -		
9-10.RL.1.D	Using appropriate text, determine two or more themes in a text, analyze their development throughout the text, and relate the themes to life experiences; provide an objective and concise summary of the text. (A.1), (LS3.B.1), (B.2), (B.3)	
9-10.RL.3.B	Explain how and why an author alludes to or transforms source material within his or her text. (LS3.B.1)	
9-10.RL.3.D	Read and comprehend literature, including stories, dramas and poems, independently and proficiently. (A.1)	
9-10.RI.1.D	Explain two or more central/main ideas in a text, analyze their development throughout the text, and explain the significance of the central ideas; provide an objective and concise summary of the text. (A.1),(LS3.B.1), (B.2), (B.3)	
9-10.W.2.A	Follow a writing process to produce clear and coherent writing in which the development, organization, style, and voice are appropriate to the task, purpose and audience; self-select and blend (when appropriate) previously learned narrative, expository, and argumentative writing techniques. (B.2), (B.3)	
Mathematics -		
A1.IF.C.7	Graph functions expressed symbolically and identify and interpret key features of the graph. (LS1.B.1)	
A1.BF.A.1	Analyze the effect of translations and scale changes on functions. (LS1.B.1)	

9-12.Natural Selection and Evolution

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Students who demonstrate understanding can:	
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.]
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.]
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 the 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.]
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.]
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.]
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.]
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 organisms for multiple species.]

The expectations above were developed using the following elements from the NRC document A Framework for K-12 Science Education:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s). - Use a model based on evidence to illustrate the relationships between systems or between components of a system. (B.2) Analyzing and Interpreting Data Analyzing data in 9–12 builds on K–8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data. - Apply concepts of statistics and probability (including determining function fits to data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and	LS3.A: Variation of Traits - In sexual reproduction, chromosomes can sometimes swap sections during the process of meiosis (cell division), thereby creating new genetic combinations and thus more genetic variation. (B.2) - Although DNA replication is tightly regulated and remarkably accurate, errors do occur and result in mutations, which are also a source of genetic variation. (B.2) - Environmental factors can also cause mutations in genes, and viable mutations are inherited. (B.2) - Environmental factors also affect expression of traits, and hence affect the probability of occurrences of traits in a population. Thus the variation and distribution of traits observed depends on both genetic and environmental factors. (B.2) LS4.A: Evidence of Common Ancestry and Diversity - Genetic information provides evidence of evolution. DNA sequences vary among species, but there are many overlaps; in fact, the ongoing branching that produces multiple lines of descent	Patterns - Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (A.1),(B.2) Cause and Effect - Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (B.1),(B.2),(C.1), (C.2) Stability and Change - Much of science deals with constructing explanations of how things change and how

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problems, using digital tools when feasible. (B.2) Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.. - Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (B.1),(C.1) Obtaining, Evaluating, and Communicating Information Obtaining, evaluating, and communicating information in 9–12 builds on K–8 experiences and progresses to evaluating the validity and reliability of the claims, methods, and designs. - Communicate scientific information (e.g., about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically , textually, and mathematically). (A.1) Engaging in Argument from Evidence Engaging in argument from evidence in 9-12 builds on K-8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science.. - Evaluate the evidence behind currently accepted explanations or solutions to determine the merits of arguments. (C.2)	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. (A.1) LS4.B: Natural Selection - 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—that is, trait variation—that leads to differences in performance among individuals. (B.1),(B.2) - The traits that positively affect survival are more likely to be reproduced, and thus are more common in the population.(B.2) LS4.C: Adaptation - Evolution is a consequence of the interaction 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. (B.1) - Natural selection leads to adaptation, that is, to a population dominated by organisms that are anatomically, behaviorally, and physiologically well suited to survive and reproduce in a specific environment. That is, the differential survival and reproduction of organisms in a population that have an advantageous heritable trait leads to an increase in the proportion of individuals in future generations that have the trait and to a decrease in the proportion of individuals that do not. (B.2),(C.1) - Adaptation also means that the distribution of traits in a population can change when conditions change. (B.2) - Changes in the physical environment, whether naturally occurring or human induced, have thus contributed to the expansion of some species, the emergence of new distinct species as populations diverge under different conditions, and the decline—and sometimes the extinction—of some species. (C.2) - Species become extinct because they can no longer survive and reproduce in their altered environment. If members cannot adjust to change that is too fast or drastic, the opportunity for the species' evolution is lost. (C.2)	they remain stable. (B.2) Systems and System Models Models (e.g., physical, mathematical, computer) can be used to simulate systems and interactions— including energy, matter and information flows—within and between systems at different scales.(B.2)
<i>Connections to other DCIs in this grade-band:</i> 9-12.LS2.A (9-12.LS4.B.1),(9-12.LS4.B.2),(9-12.LS4.C.1),(9-12.LS4.C.2); 9-12.LS2.D (9-12.LS4.B.1),(9-12.LS4.B.2),(9-12.LS4.C.1),(9-12.LS4.C.2); 9-12.LS3.A (9-12.LS4.A.1); 9-12.LS3.B (9-12.LS4.A.1),(9-12.LS4.B.1) (9-12.LS4.B.2),(9-12.LS4.C.2); 9-12.LS3.C (9-12.LS4.A.1); 9-12.ESS2.E (9-12.LS4.B.1),(9-12.LS4.C.2); 9-12.ESS3.A (9-12.LS4.B.1),(9-12.LS4.C.2)		
<i>Articulation across grade-bands:</i> 6-8.LS2.A (9-12.LS4.B.1),(9-12.LS4.B.2),(9-12.LS4.C.2); 6-8.LS2.C (9-12.LS4.C.2); 6-8.LS3.A (9-12.LS4.A.1); 6-8.LS3.B (9-12.LS4.A.1),(9-12.LS4.B.1),(9-12.LS4.B.2); 6-8.LS4.A (9-12.LS4.A.1), (9-12.LS4.B.1), (9-12.LS4.B.2),(9-12.LS4.C.1); 6-8.LS4.C (9-12.LS4.B.1),(9-12.LS4.B.2),(9-12.LS4.C.1),(9-12.LS4.C.2); 6-8.ESS1.C (9-12.LS4.A.1); 6-8.ESS3.C (9-12.LS4.C.2)		
Connections to MO LEAP Blocks: Tibetan Plateau (9-12.LS4.A.1, 9-12.LS4.C.1, 9-12.LS4.C.2); Swallows (9-12.LS4.B.2); Galapagos Ground Finches (9-12.LS4.B.2)		
Connections to other Missouri Learning Standards:		
ELA/Literacy -		
9-10.RL.1.D	Using appropriate text, determine two or more themes in a text, analyze their development throughout the text, and relate the themes to life experiences; provide an objective and concise summary of the text. (A.1), (A.2), (B.1), (B.2), (C.1)	
9-10.RI.1.D	Explain two or more central/main ideas in a text, analyze their development throughout the text, and explain the significance of the central ideas; provide an objective and concise summary of the text. (A.1), (A.2), (B.1), (B.2), (C.1)	
9-10.RI.2.D	Evaluate an author's argument, assessing whether the reasoning is valid and the evidence is relevant and sufficient; identify false statements and fallacious reasoning. (C.1), (C.2)	
9-10.W.1.A	Approaching the Task as a Researcher.(C.3)	
9-10.W.2.A	Follow a writing process to produce clear and coherent writing in which the development, organization, style, and voice are appropriate to the task, purpose and audience; self-select and blend (when appropriate) previously learned narrative, expository, and argumentative writing techniques. (A.1), (A.2), (B.1), (B.2), (C.1)	
9-10.W.3.A	Review, revise, and edit writing with consideration for the task, purpose, and audience. (C.3)	
9-10.SL.1.B	Delineate a speaker's argument and claims, evaluating the speaker's point of view, reasoning, and evidence in order to propel conversations by posing and responding to questions that relate the current discussion to broader themes or larger ideas; actively incorporate others into the	

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	discussion; and clarify, verify, or challenge ideas and conclusions. (C.1), (C.2)
9-10.SL.2.A	Speak audibly, and to the point, using conventions of language as appropriate to task, purpose and audience when presenting including appropriate volume, clear articulation and accurate pronunciation at an understandable pace, avoiding verbal filler that might be distracting to listeners. (A.1), (B.1)
9-10.SL.2.B	Make consistent eye contact with a range of listeners when speaking using effective gestures to communicate a clear viewpoint and engage listeners and avoid body language or mannerisms that might be distracting to the audience. (A.1), (B.1)
9-10.SL.2.C	Plan and deliver appropriate presentations concisely and logically based on the task, audience and purpose making strategic use of multimedia in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (A.1), (B.1)
Mathematics -	
None	