



**Vertical Articulation of Life Science for the
*South Carolina College- and Career-Ready Science
Standards 2021***

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Purpose and Use

The Life Science (LS) disciplinary core ideas and instructional focus statements describe how students’ understanding of biological phenomena develops across grade bands. These progressions outline how concepts build over time, from early observational experiences to more formal, model-based explanations, and identify key conceptual shifts without prescribing instruction, pedagogy, or assessment.

Educators and leaders may use these progressions to support curriculum design, instructional planning, professional learning, and alignment across courses and grade levels. Classroom teachers can use this document to clarify the intended depth and breadth of content learning at their grade level. The instructional focus statements describe conceptual targets and are intended to help teachers confirm grade-level emphasis, identify content intentionally deferred to later grades, and avoid over-teaching beyond course expectations.

Instructional focus statements organized by full grades or courses can be found in Appendix A of the Performance Targets on the [Science Instructional Resources webpage](#).

Reading this Resource

This resource uses a consistent structure for the progressions:

Grade, Course, or Content	Disciplinary Core Idea Statement with 2021 Performance Expectation Linked	Disciplinary Core Idea-Aligned Instructional Focus
The grade, course, or content is represented here. This also hyperlinks to the Performance Target.	<i>The Disciplinary Core Idea statements from the Performance Expectation (PE) cards are replicated in this section. There are hyperlinks to the appropriate card to view the entire PE.</i>	<i>The Instructional Focus statements are presented in this section. They include statements appropriate for the grade, course, or content, not required activities. They also include “Knowledge Extended Beyond Course Expectations” as a guardrail for depth and breadth of the content. The extended knowledge statements represent a reasonable extension option for students in that grade, course, or content.</i>

Conceptual Vertical Articulation of Life Science Overview

Life Science	K	1	2	3	4	5	6	7	8	B1	B2	AnP
LS1 – From Molecules to Organisms: Structures and Processes												
LS1.A Structure and Function		●			●		●			●	●	●
LS1.B Growth and Development of Organisms		●		●					●	●		
LS1.C Organization for Matter and Energy Flow in Organisms	●					●		●		●		
LS1.D Information Processing		●			●		●					
LS2 – Ecosystems: Interactions, Energy, and Dynamics												
LS2.A Interdependent Relationships in Ecosystems			●			●		●		●	●	
LS2.B Cycles of Matter and Energy Transfer in Ecosystems						●		●		●	●	
LS2.C Ecosystem Dynamics, Functioning, and Resilience				●				●		●	●	
LS2.D Social Interactions and Group Behavior				●							●	
LS3 – Heredity: Inheritance and Variation of Traits												
LS3.A Inheritance of Traits		●		●					●	●	●	
LS3.B Variation of Traits		●		●					●	●	●	
LS4 – Biological Evolution: Unity and Diversity												
LS4.A Evidence of Common Ancestry and Diversity				●					●	●	●	
LS4.B Natural Selection				●					●	●	●	
LS4.C Adaptation				●					●	●	●	
LS4.D Biodiversity and Humans			●	●				●		●	●	

LS1 – From Molecules to Organisms: Structures and Processes

LS1 addresses how organisms are structured, how they grow and develop, how they process information, and how they obtain and use matter and energy to sustain life. Across the grade bands, students move from observing external features and behaviors of organisms to explaining how internal systems, cells, and molecular processes support life functions and coordinated activity. The LS1 progression emphasizes how structure determines function across multiple scales, how organisms grow and reproduce over time, how information from the environment is processed to guide responses, and how matter and energy are transformed and used within living systems to support growth, maintenance, and reproduction.

LS1.A Structure and Function

Students begin by describing observable external structures of plants and animals and explaining how these structures help organisms meet basic needs for survival and growth. In upper elementary grades, students identify internal and external structures and explain how multiple structures work together at the whole-organism level, analyzing how groups of structures interact as systems to support functions such as growth, behavior, and reproduction. In middle school, students explain that all organisms are made of cells with specialized structures that perform specific functions and that cells, tissues, organs, and systems are organized hierarchically to support coordinated function. In high school, students explain how genetic information directs protein production that determines cell and tissue function and how interactions among organized systems maintain stable internal conditions.

Progression of LS1.A

Grade or Course	Disciplinary Core Idea Statement with 2021 Performance Expectation Linked	Disciplinary Core Idea-Aligned Instructional Focus
First Grade	All organisms have external parts. Different animals use their body parts in different ways to see, hear, grasp objects, protect themselves, move from place to place, and seek, find, and take in food, water, and air. Plants also have different parts (roots, stems, leaves, flowers, fruits) that help them survive and grow. (1-LS1-1)	- Describe visible body parts of familiar animals and plants and how each part helps the organism survive or grow. - Identify ways external parts meet basic needs such as protection, movement, or obtaining food or water. - Use observations of plant and animal parts as inspiration for simple designs that solve a human problem. <i>Knowledge Extended Beyond Course Expectations</i> - Recognize that different plants and animals use different external parts to meet similar needs.

Grade or Course	Disciplinary Core Idea Statement with 2021 Performance Expectation Linked	Disciplinary Core Idea-Aligned Instructional Focus
Fourth Grade	Plants and animals have both internal and external structures that serve various functions in growth, survival, behavior, and reproduction. (4-LS1-1)	- Explain how macroscopic internal and external structures enable organisms to meet needs for growth, survival, behavior, or reproduction. - Differentiate structures by the life functions they support using macroscopic evidence. - Analyze how multiple structures work together, at the whole-organism level, to carry out a life function. <i>Knowledge Extended Beyond Course Expectations</i> - Compare structural trade-offs in familiar organisms and defend how form supports function in context (for example, beak or leaf shapes).
Sixth Grade	- 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). (6-LS1-1) - Within cells, special structures are responsible for particular functions, and the cell membrane forms the boundary that controls what enters and leaves the cell. (6-LS1-2) - In multicellular organisms, the body is a system of multiple interacting subsystems. These subsystems are groups of cells that work together to form tissues and organs that are specialized for particular body functions. (6-LS1-3)	- Explain that all living things are made of cells and distinguish living from nonliving things. - Identify organisms as unicellular or multicellular. - Analyze hierarchical organization from cells to tissues, organs, and systems to explain coordinated function. - Evaluate how interactions among organs within body systems support essential life functions. - Interpret the roles and interactions of major cell structures (membrane, wall, nucleus, chloroplasts, mitochondria) in supporting whole-cell function, without describing molecular or chemical mechanisms. <i>Knowledge Extended Beyond Course Expectations</i> - Identify additional cell organelles by name and function. - Contrast prokaryotic and eukaryotic cells at the structural level. - Identify the impact of failure of an organelle or body system on the function of the cell or organism.

Grade or Course	Disciplinary Core Idea Statement with 2021 Performance Expectation Linked	Disciplinary Core Idea-Aligned Instructional Focus
Biology 1	Systems of specialized cells within organisms help them perform the essential functions of life. All cells contain genetic information, in the form of DNA. Genes are specific regions within the extremely large DNA molecules that form the chromosomes. Genes contain the instructions that code for the formation of molecules called proteins, which carry out most of the work of cells to perform the essential functions of life. Proteins provide structural components, serve as signaling devices, regulate cell activities, and determine the performance of cells through their enzymatic actions. (B-LS1-1)	- Describe the structure and functions of DNA. - Describe proteins as the primary functional products of genetic information that enable cells and tissues to perform specialized functions. - Apply the pathway from DNA in the nucleus to protein production by summarizing transcription to mRNA, polypeptide assembly at ribosomes, and protein modification and packaging by the ER and Golgi apparatus. - Explain that all cells in an organism contain the same DNA but can produce different sets of proteins that give rise to specialized cell functions. - Analyze how changes in a gene's information can change a protein and alter cell or tissue function at a conceptual level. <i>Knowledge Extended Beyond Course Expectations</i> - Recognize that not all regions of DNA directly code for proteins. - Understand that gene structure and RNA processing affect how genetic information is used.

Grade or Course	Disciplinary Core Idea Statement with 2021 Performance Expectation Linked	Disciplinary Core Idea-Aligned Instructional Focus
Biology 2	- Systems of specialized cells within organisms help them perform the essential functions of life. All cells contain genetic information, in the form of DNA. Genes are specific regions within the extremely large DNA molecules that form the chromosomes. Genes contain the instructions that code for the formation of molecules called proteins, which carry out most of the work of cells to perform the essential functions of life. Proteins provide structural components, serve as signaling devices, regulate cell activities, and determine the performance of cells through their enzymatic actions. (B-LS1-1) (repeat) - 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) (B-LS3-1)	- Differentiate coding and non-coding DNA and relate non-coding regions to organizational or regulatory roles. - Describe introns and exons in eukaryotic genes and explain how RNA processing produces mature mRNA, allowing a single gene to support multiple functional outcomes. - Outline major stages of transcription and translation and the roles of key cellular structures involved, without reaction mechanisms or kinetics. <i>Knowledge Extended Beyond Course Expectations</i> - Evaluate epigenetic influences, for example methylation, on gene activity conceptually.
Anatomy & Physiology	- 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. (B-LS1-2) - 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. (B-LS1-3)	- Explain the hierarchical organization from cells to tissues, organs, and interacting organ systems as the basis for organism-level structure and function. - Describe that physiological explanations rely on models that simplify complex system interactions and have known limits. - Analyze how interactions among organ systems support coordinated physiological functions (for example, respiratory and circulatory systems in gas exchange; nervous and muscular systems in movement). - Explain how feedback mechanisms maintain internal conditions and differentiate stabilizing (negative) feedback from amplifying (positive) feedback using familiar physiological contexts (for example, thermoregulation, blood glucose, etc.). <i>Knowledge Extended Beyond Course Expectations</i> - Interpret complex system interactions that show the limits of simplified models at a conceptual level.

LS1.B Growth and Development of Organisms

Students begin by recognizing that organisms produce offspring and that behaviors of parents and offspring support the survival of the young. In upper elementary grades, students describe life-cycle stages including growth and reproduction, explain how changes in structure and behavior support stage-specific needs, and compare life cycles across organisms. In middle school, students analyze how reproductive structures and behaviors increase the likelihood of successful reproduction and explain how growth patterns are influenced by both genetic factors and environmental conditions. In high school, students explain how growth, development, and repair are supported by cell division and differentiation and use this understanding to describe how genetic information is maintained and expressed in organisms.

Progression of LS1.B

Grade or Course	Disciplinary Core Idea Statement with 2021 Performance Expectation Linked	Disciplinary Core Idea-Aligned Instructional Focus
First Grade	Adult plants and animals can have young. In many kinds of animals, parents, and the offspring themselves engage in behaviors that help the offspring to survive. (1-LS1-2)	- Describe parent behaviors and how those behaviors help the offspring survive (for example, feeding, protection, keeping warm, etc.). - Identify common offspring signals and related parent responses that support survival (for example, crying or chirping leading to feeding or comfort). - Explain how a visible behavior helps meet an immediate survival need using everyday observations. <i>Knowledge Extended Beyond Course Expectations</i> - Recognize that different animals receive different kinds of help from parents.
Third Grade	Reproduction is essential to the continued existence of every kind of organism. Plants and animals have unique and diverse life cycles. (3-LS1-1)	- Describe that all organisms pass through predictable stages of birth, growth, reproduction, and death, with patterns that differ by species. - Compare life cycles of different plants and animals to identify major similarities and differences at the whole-organism level. - Explain observable changes in appearance or behavior across life-cycle stages and relate those changes to stage-specific needs. <i>Knowledge Extended Beyond Course Expectations</i> - Recognize that changes in the environment can affect an organism's ability to complete a life-cycle stage.

Grade or Course	Disciplinary Core Idea Statement with 2021 Performance Expectation Linked	Disciplinary Core Idea-Aligned Instructional Focus
Eighth Grade	- 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 for reproduction. (8-LS1-4) - Genetic factors as well as local conditions affect the growth 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. (8-LS1-5) - Organisms reproduce, either sexually or asexually, and transfer their genetic information to their offspring. (secondary) (8-LS3-2)	- Analyze how characteristic reproductive behaviors in animals increase the probability of successful reproduction. - Explain how specialized reproductive structures in plants, including interactions with animals, support pollination and seed dispersal. - Explain how genetic factors (without detailing inheritance mechanisms) and local environmental conditions together influence patterns of growth and typical adult size ranges within a species. <i>Knowledge Extended Beyond Course Expectations</i> - Recognize that changes in local environmental conditions can influence growth patterns within a species' typical size range.
Biology 1	In multicellular organisms individual cells grow and then divide via a process called mitosis [sic], thereby allowing the organism to grow (and repair). 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. (B-LS1-4)	- Summarize the outcomes of major stages of the cell cycle and mitosis in terms of how genetic continuity is maintained. - Explain that daughter cells produced by mitosis receive identical genetic information, supporting growth and tissue replacement. - Differentiate general features of mitosis in plant and animal cells. - Explain how mitosis and cell differentiation together support organismal growth, repair, and maintenance by preserving genetic information. - Explain at a conceptual level that cell-cycle regulation helps maintain normal growth and that loss of regulation can result in uncontrolled cell division (for example, cancer). - Evaluate how changes to genetic information or regulation can influence differentiation outcomes and tissue function. <i>Knowledge Extended Beyond Course Expectations</i> - Recognize that additional regulatory processes influence cell division beyond those required to explain normal growth and repair.

LS1.C Organization for Matter and Energy Flow in Organisms

Students begin by recognizing that plants and animals need resources from their environment to live and grow and that animals obtain food from plants or other animals while plants require light and water. In upper elementary grades, students explain how food provides animals with matter for growth and energy for movement and warmth, describe how plants acquire the materials needed for growth primarily from air and water, and distinguish the roles of matter and energy in living systems. In middle school, students explain how organisms transform matter and energy through processes such as photosynthesis and cellular respiration, recognizing that matter is conserved and energy is transferred within and between organisms. In high school, students explain how photosynthesis stores energy in chemical bonds and how cellular respiration releases that energy, using these processes to describe how matter is rearranged and energy flows through living systems.

Progression of LS1.C

Grade or Course	Disciplinary Core Idea Statement with 2021 Performance Expectation Linked	Disciplinary Core Idea-Aligned Instructional Focus
Kindergarten	All animals need food in order to live and grow. They obtain their food from plants or from other animals. Plants need water and light to live and grow. (K-LS1-1)	- Identify what plants need to live and grow. - Identify what animals need to live and grow. - Distinguish where animals obtain food (plants, animals, or both). - Identify simple patterns in what different animals eat. <i>Knowledge Extended Beyond Course Expectations</i> - Recognize that plants in different places may grow differently depending on light or water. - Identify everyday foods as plant- or animal-derived.

Grade or Course	Disciplinary Core Idea Statement with 2021 Performance Expectation Linked	Disciplinary Core Idea-Aligned Instructional Focus
Fifth Grade	- Plants acquire their material for growth chiefly from air and water. (5-LS1-1) - Food provides animals with the materials they need for body repair and growth and the energy they need to maintain body warmth and for motion. (secondary) (5-PS3-1)	- Distinguish materials essential for plant growth from those that provide support, emphasizing that most plant mass comes from air and water rather than soil. - Explain that food provides animals with materials for repair and growth and with energy for body warmth and motion. <i>Knowledge Extended Beyond Course Expectations</i> - Recognize that some plants can grow without soil when air, water, and light are available (for example, hydroponics). - Understand that different environmental conditions can influence how quickly a plant grows. - Recognize that different food types can supply different amounts of matter and energy, without explaining internal processes.
Seventh Grade	- 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. (7-LS1-6) - 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. (7-LS1-7) 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. (7-LS1-6)	- Recognize that plants, algae, and many microorganisms carry out photosynthesis. - Explain that photosynthetic organisms use light energy, carbon dioxide, and water to make sugars and release oxygen. - Describe how sugars made by producers supply matter and energy for producers and consumers. - Explain that food is broken down and rearranged inside organisms to support growth or release energy, with matter conserved and energy transferred during these chemical reactions. <i>Knowledge Extended Beyond Course Expectations</i> - Identify general categories of biological molecules and their roles (for example, carbohydrates for energy, proteins for structure, etc.). - Recognize that some producers carry out chemosynthesis.

Grade or Course	Disciplinary Core Idea Statement with 2021 Performance Expectation Linked	Disciplinary Core Idea-Aligned Instructional Focus
Biology 1	- The process of photosynthesis converts light energy to stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen. (B-LS1-5) - The sugar molecules thus formed contain carbon, hydrogen, and oxygen: the 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 essential life functions. (B-LS1-6) - As matter and energy flow through organizational levels of living systems, chemical elements are recombined to form different products. (B-LS1-6) (B-LS1-7) - 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. Anaerobic cellular respiration follows a different and less efficient chemical pathway to provide energy in cells. (B-LS1-7)	- Explain that chemical reactions within living systems rearrange matter and transfer energy, conserving atoms as energy flows through the system. - Explain how photosynthesis stores light energy as chemical energy in sugars. - Explain that sugars supply both matter and energy for building molecules and supporting life functions. - Describe how major biomolecules, including carbohydrates, lipids, proteins, and nucleic acids, function to store energy, build cellular structures, and support essential life processes. - Describe that cellular respiration rearranges sugars and oxygen to release energy for essential cell functions. - Compare aerobic and anaerobic respiration in terms of inputs, outputs, and relative energy yield. <i>Knowledge Extended Beyond Course Expectations</i> - Recognize that additional biological processes and structures support photosynthesis and cellular respiration beyond those needed to explain matter and energy flow at a system level. - Understand that different biological strategies for acquiring and releasing energy exist, without describing biochemical pathways or reaction mechanisms.

LS1.D Information Processing

Students begin by recognizing that organisms receive information from their environment through their senses and respond with behaviors that support survival. In upper elementary grades, students explain how different senses gather specific types of information, and explain how information is processed following a general pattern of stimulus, receptor, brain processing, and response. In middle school, students explain how sensory receptors respond to specific inputs and transmit signals through nerve cells to the brain, where information is processed and stored within interconnected systems to guide responses. At the high school level, students build on these middle school ideas as background knowledge rather than extending the progression, applying general principles of information processing when relevant while more detailed study of neural systems is reserved for specialized courses.

Progression of LS1.D

Grade or Course	Disciplinary Core Idea Statement with 2021 Performance Expectation Linked	Disciplinary Core Idea-Aligned Instructional Focus
First Grade	Animals have body parts that capture and convey different kinds of information needed for growth and survival. Animals respond to these inputs with behaviors that help them survive. Plants also respond to some external inputs. (1-LS1-1)	- Identify the senses animals use to gather information (sight, hearing, smell, taste, touch). - Describe how animals respond to information with simple behaviors that support survival (for example, moving toward food or away from danger). - Recognize that plants respond in basic ways to external inputs (for example, growing toward light, reacting to touch). <i>Knowledge Extended Beyond Course Expectations</i> - Recognize that animals may use more than one sense before acting (for example, looking and listening before moving).

Grade or Course	Disciplinary Core Idea Statement with 2021 Performance Expectation Linked	Disciplinary Core Idea-Aligned Instructional Focus
Fourth Grade	Different sense receptors are specialized for particular kinds of information, which may be then processed by the animal's brain. Animals are able to use their perceptions and memories to guide their actions. (4-LS1-2)	- Explain that different sense receptors are specialized for particular kinds of information (light, sound, smell, taste, touch). - Describe that the brain as a whole processes information from receptors to guide immediate responses or stored memories. - Interpret familiar examples using the general pattern stimulus → receptor → brain → response, recognizing this as a repeated pattern across animals. <i>Knowledge Extended Beyond Course Expectations</i> - Recognize that memories can influence later responses to similar stimuli.
Sixth Grade	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. (6-LS1-8)	- Differentiate sensory receptors by specific types of stimuli (electromagnetic, mechanical, chemical). - Explain that receptors send information signals along nerve cells to the brain, where signals may produce immediate responses or become memories, without describing electrical or chemical mechanisms. <i>Knowledge Extended Beyond Course Expectations</i> - Describe the basic structure of a neuron (cell body, axon, dendrites), limited to how each part contributes to signal flow. - Recognize that networks within the brain contribute to sensory processing and memory storage.
9-12	<i>LS1.D is not addressed at this grade band.</i>	<i>This grade band does not include LS1.D: Information Processing. Students build understanding of system interactions and organism responses as described in LS1.A and may draw on prior knowledge of sensory processing from middle school as background, while concepts related to neural pathways, synaptic processes, and detailed neuroanatomy are deferred to advanced courses such as Anatomy & Physiology.</i>

LS2 – Ecosystems: Interactions, Energy, and Dynamics

LS2 addresses how organisms interact with one another and with their environment to form ecosystems that support life. Across the grade bands, students move from observing simple relationships among organisms and their environments to explaining how interactions, matter cycling, and system dynamics shape population patterns and ecosystem stability. The LS2 progression emphasizes how interdependent relationships, cycles of matter and energy, and changing environmental conditions influence the structure, function, and resilience of ecosystems, supporting increasingly sophisticated explanations of how ecosystems persist and change over time.

LS2.A Interdependent Relationships in Ecosystems

Students begin by recognizing that organisms depend on resources from their environment and on interactions with other organisms. In upper elementary grades, students explain how organisms are connected in ecosystems through roles such as producers, consumers, and decomposers, describe how these relationships form interconnected food webs, and explain how stable ecosystems support multiple species and how changes, such as the introduction of new species, can disrupt existing relationships. In middle school, students analyze how interactions such as competition, predation, and mutualism influence population patterns and explain how access to limited resources constrains growth and reproduction of organisms and populations. In high school, students explain how resource availability and biotic interactions establish limits on population size, using the concept of carrying capacity to describe how populations are constrained and how disturbances and changing conditions influence ecosystem stability and species abundance over time.

Progression of LS2.A

Grade or Course	Disciplinary Core Idea Statement with 2021 Performance Expectation Linked	Disciplinary Core Idea-Aligned Instructional Focus
Second Grade	- Plants depend on air, water, minerals (in the soil), and light to grow. Different plants survive better in different settings because they have varied needs for water, minerals, and sunlight. (2-LS2-1) - Plants depend on animals for pollination or to move their seeds around. (2-LS2-2)	- Identify that plants need air, water, minerals in soil, and light to grow. - Explain that different plants grow better in different conditions because they have different needs for light and water. - Recognize that changes in light or water availability can affect how well a plant grows. - Recognize that plants depend on animals for pollination or seed movement. - Describe how certain animal structures or behaviors help plants reproduce by pollinating flowers or moving seeds. <i>Knowledge Extended Beyond Course Expectations</i> - Recognize additional pollination types (for example, self pollination, cross pollination, wind, water).
Fifth Grade	The food of almost any kind of animal can be traced back to plants (producers). Organisms are related in food webs in which some animals eat plants for food and other animals eat the animals that eat plants (either way they are consumers). Some organisms, such as fungi and bacteria, break down dead organisms (both plants or plants parts and animals) and therefore operate as “decomposers.” Decomposition eventually restores (recycles) some materials back to the soil. Organisms can survive only in environments in which their particular needs are met. A healthy ecosystem is one in which multiple species of different types are each able to meet their needs in a relatively stable web of life. Newly introduced species can damage the balance of an ecosystem. (5-LS2-1)	- Distinguish producers, consumers, and decomposers by how each obtains matter. - Explain that the food of almost any animal can be traced back to plants, either directly or through other animals using food chains. - Describe a healthy ecosystem as one in which multiple species are able to meet their needs through stable patterns of interactions. - Explain that newly introduced species can alter existing interactions and disrupt ecosystem balance. <i>Knowledge Extended Beyond Course Expectations</i> - Recognize that changes to one group of organisms can affect other organisms’ ability to meet their needs within a food chain.

Grade or Course	Disciplinary Core Idea Statement with 2021 Performance Expectation Linked	Disciplinary Core Idea-Aligned Instructional Focus
Seventh Grade	- Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors. 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. Growth of organisms and population increases are limited by access to resources. (7-LS2-1) - 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. (7-LS2-2)	- Define resources (biotic and abiotic) and explain that access to resources limits organism and population growth and reproduction. - Relate changes in resource availability to changes in organism growth and population size. - Explain how organisms with similar resource requirements compete for limited resources, constraining population size. - Describe common interaction types; competition, predation, and mutualism; and the general population trends each tends to produce. - Explain that similar interaction patterns occur across ecosystems even when the species involved differ. <i>Knowledge Extended Beyond Course Expectations</i> - Understand that competition can lessen when resources become more available.

Grade or Course	Disciplinary Core Idea Statement with 2021 Performance Expectation Linked	Disciplinary Core Idea-Aligned Instructional Focus
Biology 1	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. (B-LS2-1)	- Define carrying capacity as the limit on population size set by finite resources and biotic challenges (predation, competition, disease). - Describe how limits from resources and biotic challenges affect species abundance within defined ecosystem boundaries. - Explain how changes in a limiting factor (for example, decreased prey or increased disease) can shift carrying capacity. - Describe overshoot and subsequent dieback qualitatively, as temporary population increases beyond resource limits followed by reduction toward sustainable levels. <i>Knowledge Extended Beyond Course Expectations</i> - Understand that population responses to limits vary with the nature and timing of environmental changes. - Recognize that ecosystems operate at different spatial and temporal scales, and that populations at one scale can influence resources or conditions at another.
Biology 2	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. (B-LS2-2)	- Describe carrying capacity as a function of finite resources and biotic challenges and explain how this constrains population abundance. - Explain that abundance reflects the tension between potential population growth and environmental limits. - Differentiate outcomes associated with modest versus large disturbances, relating disturbance magnitude to expected population and ecosystem responses. <i>Knowledge Extended Beyond Course Expectations</i> - None identified.

LS2.B Cycles of Matter and Energy Transfer in Ecosystems

Students are not expected to engage directly with cycles of matter and energy transfer in early grades, as these ideas build on foundational understandings of organism needs and interactions. In upper elementary grades, students describe how matter cycles among plants, animals, decomposers, and the environment and explain how decomposers return matter to the system for reuse. In middle school, students use models such as food webs to explain how matter is conserved and cycles between living and nonliving components while energy flows through ecosystems and is released. In high school, students explain how matter cycles at the level of atoms and molecules within ecosystems, including processes such as photosynthesis and cellular respiration, and how energy is transferred through food webs with decreasing availability at higher trophic levels, establishing limits on ecosystem structure and function.

Progression of LS2.B

Grade or Course	Disciplinary Core Idea Statement with 2021 Performance Expectation Linked	Disciplinary Core Idea-Aligned Instructional Focus
K-2	LS2.B is not addressed at this grade band.	<i>This grade band does not include LS2.B Cycles of Matter and Energy in Ecosystems. Students build understanding of organism needs and basic interdependence as described in LS1 and LS2.A, while concepts of matter cycling and energy transfer within ecosystems are deferred to Grade 5.</i>
Fifth Grade	Matter cycles between the air and soil and among plants, animals, and microbes as these organisms live and die. Organisms obtain gases, and water, from the environment, and release waste matter (gas, liquid, or solid) back into the environment. (5-LS2-1)	- Describe that matter cycles among plants, animals, decomposers (microbes and fungi), and the environment as organisms obtain materials and release waste. - Explain that decomposers break down dead organisms and recycle matter to the environment. - Recognize that plants transform matter from air and water into plant matter that can become food for animals. - Describe that consumption moves matter from one part of the system to another. <i>Knowledge Extended Beyond Course Expectations</i> - None identified.

Grade or Course	Disciplinary Core Idea Statement with 2021 Performance Expectation Linked	Disciplinary Core Idea-Aligned Instructional Focus
Seventh Grade	Food webs are models that demonstrate how matter and energy is transferred between producers, consumers, and decomposers as the three groups interact within an ecosystem. Transfers of matter into and out of the physical environment occur at every level. 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 cycled repeatedly between the living and nonliving parts of the ecosystem. (7-LS2-3)	- Explain how matter and energy move through food webs in ecosystems. - Explain that matter and atoms cycle between living organisms and nonliving parts of ecosystems, including transfers to and from the physical environment. - Explain that decomposers recycle materials from dead organisms back to soil or water for reuse by other organisms. <i>Knowledge Extended Beyond Course Expectations</i> - Describe that energy flows through ecosystems and is released to the environment, while matter (atoms) is conserved as it is rearranged and recycled. - Recognize the difference between cycling of matter and one-way flow of energy through and out of ecosystems. - Understand that microbial decomposers operate in both terrestrial and aquatic systems, supporting ongoing recycling of materials.
Biology 1	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-LS2-5)	- Describe the carbon cycle as the movement of carbon among organisms and between the biosphere, atmosphere, hydrosphere, and geosphere. - Explain how photosynthesis, cellular respiration, decomposition, and combustion connect organisms and environments through carbon exchange. <i>Knowledge Extended Beyond Course Expectations</i> - Recognize that carbon cycling can occur over different time scales, without analyzing rates or residence times. - Understand that carbon cycling is one example within broader biogeochemical cycles (e.g., water, nitrogen, phosphorus).

Grade or Course	Disciplinary Core Idea Statement with 2021 Performance Expectation Linked	Disciplinary Core Idea-Aligned Instructional Focus
Biology 2	- Photosynthesis and cellular respiration (including anaerobic processes) provide most of the energy for life processes. (B-LS2-3) - 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 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-LS2-4)	- Explain that photosynthesis provides stored chemical energy that fuels cellular respiration and supports ecosystem-level energy flow. - Describe that all organisms carry out cellular respiration (aerobic or anaerobic) to release chemical energy for life processes and return matter to the environment. - Explain that as matter and energy move through food webs, only a fraction becomes biomass at each successive trophic level, and this inefficiency limits the number of trophic levels in ecosystems. - Recognize that matter (atoms) is conserved as it moves through food webs and is recombined into different molecules, while energy flows through ecosystems and is released to the environment. <i>Knowledge Extended Beyond Course Expectations</i> - Understand that limits on energy transfer help explain common food-web patterns.

LS2.C Ecosystem Dynamics, Functioning, and Resilience

Students are not expected to engage directly with ecosystem dynamics and resilience in early grades, as these ideas build on foundational understandings of organism needs and interactions. In upper elementary grades, students explain how changes in habitat conditions, including the availability of resources, influence which organisms persist in an environment and describe outcomes such as migration, population shifts, or death. In middle school, students analyze ecosystems as dynamic systems that change over time, explaining how disruptions to physical or biological components can shift populations and how biodiversity reflects ecosystem health. In high school, students explain how interactions within ecosystems can maintain relative stability under consistent conditions, how disturbances, including human activities, can alter those interactions, and how the magnitude of change influences whether ecosystems recover or shift to new states over time.

Progression of LS2.C

Grade or Course	Disciplinary Core Idea Statement with 2021 Performance Expectation Linked	Disciplinary Core Idea-Aligned Instructional Focus
K-2	LS2.C is not addressed at this grade level.	<i>This grade band does not include LS2.C Ecosystem Dynamics, Functioning, and Resilience. Students build understanding of organism needs and simple plant–animal relationships as described in LS1 and LS2.A, while concepts related to ecosystem change, population shifts, biodiversity, and resilience are deferred to Grade 3 and later.</i>
Third Grade	When the environment changes in ways that affect a place’s physical characteristics, temperature, or availability of resources, some organisms survive and reproduce, others move to new locations, yet others move into the transformed environment, and some die. (secondary) (3-LS4-4)	- Identify that habitats meet organism needs to different degrees, resulting in different survival outcomes. - Describe how habitat features; such as food, water, shelter, and temperature; affect whether organisms can survive in a place. - Explain that when environments change, some organisms remain, some leave, some move in, and some do not survive. <i>Knowledge Extended Beyond Course Expectations</i> - Recognize that environmental changes can vary in size and impact, leading to different survival outcomes for organisms. - Understand that helping organisms survive typically involves improving access to basic needs.

Grade or Course	Disciplinary Core Idea Statement with 2021 Performance Expectation Linked	Disciplinary Core Idea-Aligned Instructional Focus
Seventh Grade	- 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 its populations. (7-LS2-4) - 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. (7-LS2-5)	- Explain that changes to physical or biological components can shift multiple populations within an ecosystem. - Define biodiversity as the variety of species in ecosystems and recognize it as a commonly used indicator of ecosystem health. - Describe examples of ecosystem services that benefit people (for example, water purification, nutrient recycling, pollination, erosion prevention, climate regulation). <i>Knowledge Extended Beyond Course Expectations</i> - Recognize that disturbances can differ in duration and severity, and that population responses can vary accordingly.
Biology 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. (B-LS2-7)	- Identify human activities that disrupt ecosystems, including habitat destruction, pollution, introduction of invasive species, overexploitation, and long-term changes in climate patterns. - Describe how these activities alter environmental conditions or resource availability within ecosystems. - Explain how such changes can limit organism survival or reproduction, threatening the persistence of some species. - Describe that actions such as habitat restoration, invasive-species management, pollution reduction, and sustainable harvest practices can improve conditions that support ecosystem functioning. <i>Knowledge Extended Beyond Course Expectations</i> - Recognize that species with specialized habitat requirements may be more vulnerable to environmental changes. - Understand that ecosystem recovery following disturbance can vary depending on the extent of change.

Grade or Course	Disciplinary Core Idea Statement with 2021 Performance Expectation Linked	Disciplinary Core Idea-Aligned Instructional Focus
Biology 2	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. (B-LS2-2) (B-LS2-6)	- Describe that under relatively stable conditions, complex interactions can keep ecosystem structure and population sizes within identifiable ranges. - Explain that ecosystems may return to prior states following modest disturbances when key species, resources, and interactions remain intact (resilience). - Explain that extreme disturbances or large population changes can disrupt resources and habitat availability, resulting in ecosystems with different structures and interactions. - Describe factors that influence biodiversity, including resource availability, species interactions, and physical environmental conditions. - Explain that ecosystem stability depends on both the magnitude of environmental change and the relationships among organisms and conditions. <i>Knowledge Extended Beyond Course Expectations</i> - Understand that disruptions at one trophic level can have cascading effects on overall ecosystem functioning.

LS2.D Social Interactions and Group Behavior

In upper elementary grades, students describe how these groups vary in size, structure, and stability and explain how group behavior influences survival in different environments. In high school, students explain how group behaviors can increase survival and reproductive success, analyzing how coordinated interactions provide advantages to individuals and their genetic relatives while also involving tradeoffs that depend on environmental conditions.

Progression of LS2.D

Grade or Course	Disciplinary Core Idea Statement with 2021 Performance Expectation Linked	Disciplinary Core Idea-Aligned Instructional Focus
K-2	LS2.D is not addressed at this grade band.	<i>This grade band does not include LS2.D Social Interactions and Group Behavior. Students build understanding of how organisms meet their needs and basic survival behaviors as described in LS1 and LS2.A, while concepts related to group living, group structure, and coordinated behavior are deferred to Grade 3.</i>
Third Grade	Being part of a group helps animals obtain food, defend themselves, and cope with changes. Groups may serve different functions and vary dramatically in size. Groups can be collections of equal individuals, hierarchies with dominant members, small families, groups of single or mixed gender, or groups composed of individuals similar in age. Some groups are stable over long periods of time; others are fluid, with members moving in and out. Some groups assign specialized tasks to each member; in others, all members perform the same or a similar range of functions. (3-LS2-1)	- Describe that some animals form groups that help individuals obtain food, defend themselves, or cope with environmental changes. - Explain that belonging to a group can increase an individual's chance of survival compared with being alone. - Analyze examples of animal groups with different sizes and structures (for example, family groups or groups with dominant members). - Describe that some animal groups remain stable over time, while others change membership. <i>Knowledge Extended Beyond Course Expectations</i> - Understand that losing access to a group may reduce protection or access to resources for an individual.

Grade or Course	Disciplinary Core Idea Statement with 2021 Performance Expectation Linked	Disciplinary Core Idea-Aligned Instructional Focus
6-8	LS2.D is not addressed at this grade band.	<i>This grade band does not include LS2.D: Social Interactions and Group Behavior. Students build understanding of basic interdependence and organism interactions as described in LS2.A and may draw on prior knowledge of group behavior from Grade 3 as background, while concepts related to fitness advantages, evolutionary pressures, and tradeoffs in group behavior are deferred to high school Biology 2.</i>
Biology 2	Group behavior has evolved because membership can increase the chances of survival for individuals and their genetic relatives. (B-LS2-8)	- Define group behavior as coordinated or cooperative actions among individuals of the same species that can increase survival or reproductive success. - Describe common benefits of group behavior, such as predator avoidance, improved foraging, or energy efficiency. - Explain how group behavior can provide relative fitness advantages to individuals and their genetic relatives compared with solitary behavior. <i>Knowledge Extended Beyond Course Expectations</i> - Understand that environmental conditions can influence which group behaviors are advantageous in a given context.

LS3 – Heredity: Inheritance and Variation of Traits

LS3 addresses how traits are passed from parents to offspring and why individuals within a species show variation. Across the grade bands, students move from observing similarities and differences among organisms to explaining how inherited information and environmental influences shape the traits and variation seen within populations. The LS3 progression emphasizes how genetic information is transmitted and expressed, how variation arises from multiple sources, and how patterns of trait similarity and difference support increasingly sophisticated explanations of how traits are inherited, expressed, and distributed within populations over time.

LS3.A Inheritance of Traits

Students begin by recognizing that offspring resemble their parents but are not exactly the same, identifying observable similarities and differences among individuals. In upper elementary grades, students explain that many traits are inherited from parents while others are influenced by the environment and that variation reflects the combined effects of these factors. In middle school, students explain that traits are determined by genes located on chromosomes and that variation arises from different combinations of inherited genes and from mutations that can alter traits. In high school, students explain how genetic information encoded in DNA directs the production and regulation of proteins that determine traits, using this understanding to explain how sequence differences and patterns of gene expression contribute to variation in organism characteristics.

Progression of LS3.A

Grade or Course	Disciplinary Core Idea Statement with 2021 Performance Expectation Linked	Disciplinary Core Idea-Aligned Instructional Focus
First Grade	Young animals are very much, but not exactly, like their parents. Plants also are very much, but not exactly, like their parents. (1-LS3-1)	- Recognize that young animals and plants are similar to their parents but not exactly the same. - Identify one visible similarity and one visible difference between a parent and its offspring. - Describe the “like, but not exactly like” pattern using familiar examples of plants and animals. <i>Knowledge Extended Beyond Course Expectations</i> - None identified.

Grade or Course	Disciplinary Core Idea Statement with 2021 Performance Expectation Linked	Disciplinary Core Idea-Aligned Instructional Focus
Third Grade	Some characteristics result from individuals' interactions with the environment, which can range from diet to learning. Many characteristics involve both inheritance and environment. (3-LS3-1) (3-LS3-2)	- Describe that many characteristics are inherited and that organisms of the same species show variation in traits (for example, height, weight, color, quantity, etc.). - Identify environmental factors (such as water, nutrients, food availability, or activity level) that can influence how a trait appears. <i>Knowledge Extended Beyond Course Expectations</i> - Understand that the same inherited trait can present differently in different environmental conditions.
Eighth Grade	- 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 specific proteins, which in turn affects the traits of the individual. Changes (mutations) to genes can result in changes to proteins, which can affect the structures and functions of the organism and thereby change traits. (8-LS3-1) - Variations of inherited traits between parent and offspring arise from genetic differences that result from the subset of chromosomes (and therefore genes) inherited. (8-LS3-2)	- Describe that genes are located on chromosomes, which occur in pairs carrying two alleles. - Explain that a gene can direct the production of a specific protein and that protein function influences traits, recognizing that many traits involve multiple components. - Describe mutations as changes in genes that can lead to changes in proteins, with effects that may be beneficial, harmful, or neutral. - Explain that inherited trait variation arises from the subset of chromosomes (and alleles) an offspring inherits. <i>Knowledge Extended Beyond Course Expectations</i> - Recognize that different combinations of alleles in siblings can lead to differences in inherited traits.
Biology 1	- The sequence of nucleotides spells out the information in a gene. (B-LS1-1) - DNA controls the expression of proteins by being transcribed into a "messenger" RNA, which is translated in turn by the cellular machinery into a protein. (B-LS1-1)	- Explain that gene's nucleotide sequence is used to make proteins through transcription of DNA into mRNA and translation of mRNA into a polypeptide. - Explain how traits are inherited and expressed, using central dogma reasoning. - Explain that changes in a gene's sequence can result in changes to a protein and lead to differences in traits. <i>Knowledge Extended Beyond Course Expectations</i> - Recognize that not all DNA codes directly for proteins and that some regions influence how genes are used.

Grade or Course	Disciplinary Core Idea Statement with 2021 Performance Expectation Linked	Disciplinary Core Idea-Aligned Instructional Focus
		Understand that some traits are influenced by multiple genes (for example, eye color, height, disease susceptibility, mammal skin tone, etc.) and may show a range of forms.
Biology 2	- The sequence of nucleotides spells out the information in a gene. (B-LS1-1) (repeat) - DNA controls the expression of proteins by being transcribed into a “messenger” RNA, which is translated in turn by the cellular machinery into a protein. (B-LS1-1) (repeat) - 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. (B-LS3-1)	- Explain that a gene’s nucleotide sequence specifies a protein or a functional RNA product. - Explain how changes in DNA sequence can alter proteins or RNAs and thereby influence traits at the organism level. - Identify that some DNA does not code for proteins and plays regulatory or structural roles that influence gene expression. - Describe how regulatory DNA regions can affect when, where, or how much a gene is expressed. - Recognize that epigenetic influences can alter gene expression without changing the nucleotide sequence. - Explain that many traits are polygenic, leading to complex genotype–phenotype relationships. <i>Knowledge Extended Beyond Course Expectations</i> - Understand that similar genetic changes can have different trait effects in different cell types or environmental conditions.

LS3.B Variation of Traits

Students begin by recognizing that individuals of the same kind are similar but show patterns of variation in their visible traits. In upper elementary grades, students explain that variation arises from differences in inherited information and environmental influences and that the same inherited trait may appear differently under different conditions. In middle school, students explain that genetic variation results from different combinations of alleles inherited from parents and from mutations that can alter traits, and compare how sexual and asexual reproduction influence the amount of variation within a population. In high school, students explain how multiple sources of genetic variation, including recombination during reproduction and mutations, together with environmental influences on gene expression, shape the distribution of traits within populations across conditions and over time.

Progression of LS3.B

Grade or Course	Disciplinary Core Idea Statement with 2021 Performance Expectation Linked	Disciplinary Core Idea-Aligned Instructional Focus
First Grade	Individuals of the same kind of plant or animal are recognizable as similar but can also vary in many ways. (1-LS3-1)	- Describe one visible difference (such as size, color or pattern, leaf shape, or body-part length) within a group of the same kind of organisms. - Identify two visible traits that can be used to compare individuals of the same kind of organism and note one difference. - Explain how individuals of the same kind of organism can be grouped as alike or different based on a single visible trait. <i>Knowledge Extended Beyond Course Expectations</i> - Recognize that variation within a single kind of organism can be noticed in more than one visible way.

Grade or Course	Disciplinary Core Idea Statement with 2021 Performance Expectation Linked	Disciplinary Core Idea-Aligned Instructional Focus
Third Grade	- Different organisms vary in how they look and function because they have different inherited information. (3-LS3-1) - The environment affects the traits that an organism develops. (3-LS3-2)	- Describe that organisms of the same species show similarities and differences within a group because inherited information differs. - Distinguish similarities that are broadly shared within a species from differences observed among individuals of the same species using non-human examples. - Identify an environmental condition that could influence how a trait appears in an organism of a given species. - Describe whether a visible trait difference is more closely associated with inherited information or environmental conditions based on familiar examples. <i>Knowledge Extended Beyond Course Expectations</i> - None identified.
Eighth Grade	- 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. (8-LS3-1) - 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 asexual reproduction, an organism's DNA is replicated and passed to its offspring creating a genetic copy of the parent. (8-LS3-2)	- Contrast sexual and asexual reproduction in terms of how genetic information is passed to offspring, including advantages and disadvantages of each reproductive strategy. - Explain that, in sexual reproduction, offspring inherit two alleles per gene (one from each parent), which may be identical or different, contributing to variation among individuals. - Explain that mutations are changes in genetic information that can affect proteins and traits, with effects that may be beneficial, harmful, or neutral. <i>Knowledge Extended Beyond Course Expectations</i> - Recognize that reproductive cells (gametes), such as egg and sperm, carry one copy of each chromosome, allowing offspring to inherit traits from both parents.

Grade or Course	Disciplinary Core Idea Statement with 2021 Performance Expectation Linked	Disciplinary Core Idea-Aligned Instructional Focus
Biology 1	- 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-LS3-2) - 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-LS3-2) (B-LS3-3)	- Explain how independent assortment and crossing over during meiosis contribute to new combinations of alleles. - Explain that mutations can introduce new genetic variants that may be inherited. - Differentiate sources of mutation (replication errors and environmental factors) and explain how the location and type of change can influence trait effects. - Explain that environmental factors can influence how traits are expressed and affect observed patterns of traits in populations. - Explain how combinations of alleles can account for patterns of trait variation and distribution in populations. <i>Knowledge Extended Beyond Course Expectations</i> - Recognize that some traits are influenced by multiple genes and may show a range of forms in a population. - Identify that environmental factors can influence trait expression without changing DNA sequence, including epigenetic influences.
Biology 2	- 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-LS3-2) (repeat) - 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-LS3-2) (B-LS3-3) (repeat)	- Explain how genetic factors (such as multiple loci) and environmental factors (such as resource gradients) together shape the distribution of traits in populations. - Explain how recombination and mutation provide heritable variation, while environmental influences on trait expression (not inheritance) modulate observed traits across time and conditions. <i>Knowledge Extended Beyond Course Expectations</i> - None identified.

LS4 – Biological Evolution: Unity and Diversity

LS4 addresses how evidence supports explanations for the diversity and unity of life and how biological evolution accounts for both change and adaptation over time. Across the grade bands, students move from observing patterns of similarity, difference, and environmental fit among organisms to explaining how evidence, natural selection, and environmental conditions interact to shape populations and biodiversity. The LS4 progression emphasizes how multiple lines of evidence support common ancestry, how natural selection acts on variation to produce adaptation, and how evolutionary and human processes influence biodiversity, ecosystem stability, and the long-term sustainability of life on Earth.

LS4.A Evidence of Common Ancestry and Diversity

Students are not expected to engage directly with evidence of common ancestry and diversity in early grades, as these ideas build on foundational understandings of organism similarities and differences. In upper elementary grades, students use fossils as evidence to compare past and present organisms and infer characteristics of ancient environments. In middle school, students use the fossil record and anatomical comparisons to identify patterns of diversity, extinction, and change and to infer historical relationships among organisms. In high school, students explain how multiple lines of evidence, including fossil, anatomical, and molecular data, support and refine inferences of common ancestry, using comparisons of DNA, proteins, and organismal structures to interpret branching relationships and account for the unity and diversity of life.

Progression of LS4.A

Grade or Course	Disciplinary Core Idea Statement with 2021 Performance Expectation Linked	Disciplinary Core Idea-Aligned Instructional Focus
K-2	LS4.A is not addressed at this grade band.	This grade band does not include LS4.A Evidence of Common Ancestry and Diversity. Students build understanding of observable similarities and differences among organisms and between parents and offspring as described in LS1 and LS3, and simple relationships between organisms and their environments as described in LS2.A, while concepts related to common ancestry, fossil evidence, and explanations for the origin of diversity over time are deferred to Grade 3 and later.

Grade or Course	Disciplinary Core Idea Statement with 2021 Performance Expectation Linked	Disciplinary Core Idea-Aligned Instructional Focus
Third Grade	Some kinds of plants and animals that once lived on Earth are no longer found anywhere. Fossils provide evidence about the types of organisms that lived long ago and also about the nature of their environments. (3-LS4-1)	- Recognize that some kinds of plants and animals that once lived on Earth are no longer found anywhere. - Describe fossils as evidence of organisms that lived long ago. - Compare fossils with living organisms to identify similarities and differences in observable features. - Use fossil evidence to identify observable features of past environments (such as land or water). <i>Knowledge Extended Beyond Course Expectations</i> - Recognize that some fossils resemble organisms living today, while others do not closely match any living organisms. - Identify that fossils can record parts of organisms or evidence of their activity (such as footprints), without explaining how fossils form.
Eighth Grade	- 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. (8-LS4-1) - Anatomical similarities and differences among modern organisms and between modern and fossil organisms in the fossil record enable the reconstruction of the history and the inference of lines of ancestral relationships. (8-LS4-2)	- Describe the fossil record as a chronological collection of fossils. - Use the fossil record to identify patterns of existence, diversity, extinction, and change in life forms over time. - Compare fossils from different time periods to identify similarities and differences among organisms. - Compare anatomical structures among modern organisms and between modern and fossil organisms. - Use anatomical and fossil evidence to describe historical relationships among organisms. <i>Knowledge Extended Beyond Course Expectations</i> - Recognize that fossils from different locations can strengthen interpretations of life's history. - Explain that similarities among organisms support relatedness, while differences reflect diversity through time.

Grade or Course	Disciplinary Core Idea Statement with 2021 Performance Expectation Linked	Disciplinary Core Idea-Aligned Instructional Focus
Biology 1	Genetic information, like the fossil record, provides evidence of evolution. DNA sequences vary among species, but there are many overlaps; notably, the ongoing branching that produces 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. (B-LS4-1)	- Use multiple lines of evidence, including fossils, comparative anatomy, genetics and molecular biology, and embryology, to support claims that species share common ancestry. - Explain how similarities and differences in DNA sequences provide evidence consistent with shared ancestry among organisms. - Explain how similarities and differences in amino acid sequences provide evidence of relatedness among organisms. - Describe how anatomical and embryological features are used as evidence to support common ancestry. - Describe evolutionary relationships as branching patterns that represent lines of common ancestry. <i>Knowledge Extended Beyond Course Expectations</i> - Recognize that different types of evidence contribute different kinds of information about evolutionary relationships.
Biology 2	Genetic information, like the fossil record, provides evidence of evolution. DNA sequences vary among species, but there are many overlaps; notably, the ongoing branching that produces 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. (B-LS4-1) (repeat)	- Explain how multiple lines of evolutionary evidence, including fossil, molecular, anatomical, and embryological data, are compared for their consistency and explanatory power. - Explain how molecular sequence data can indicate degrees of relatedness and resolve relationships among organisms. - Describe branching patterns as models of divergent evolutionary lineages, including the assumptions and limitations of these representations. - Explain how evidence from different sources can be combined to strengthen, refine, or challenge claims about common ancestry. <i>Knowledge Extended Beyond Course Expectations</i> - Recognize that reconstructions of evolutionary relationships are hypotheses that may be revised as new evidence emerges.

LS4.B Natural Selection

Students are not expected to engage directly with natural selection in early grades, as these ideas build on foundational understandings of organism variation and environmental interactions. In upper elementary grades, students explain that variation occurs within populations, that the usefulness of a trait depends on the environment, and that some differences can provide advantages for survival and reproduction under specific conditions. In middle school, students explain how natural selection leads to changes in populations over generations as individuals with advantageous traits are more likely to survive and reproduce, distinguishing this process from human-directed selection. In high school, students explain how natural selection depends on heritable variation and differences in performance among individuals, using patterns of trait distribution to interpret population change and to explain how differential survival and reproduction shape populations over time.

Progression of LS4.B

Grade or Course	Disciplinary Core Idea Statement with 2021 Performance Expectation Linked	Disciplinary Core Idea-Aligned Instructional Focus
K-2	LS4.B is not addressed at this grade band.	<i>This grade band does not include LS4.B Natural Selection. Students build understanding of observable similarities and differences among organisms, basic needs for survival, and relationships between organisms and their environments as described in LS1, LS2.A, and LS3, while concepts related to differential survival, inherited advantages, and population-level change over time are deferred to Grade 3.</i>
Third Grade	Sometimes the differences in characteristics between individuals of the same species provide advantages in surviving, finding mates, and reproducing. (3-LS4-2)	- Recognize that individuals of the same species can differ in their characteristics. - Explain that some differences can increase an individual's chances of surviving, finding mates, or reproducing in certain environments. - Recognize that a trait that is helpful in one environment may not be helpful in another. <i>Knowledge Extended Beyond Course Expectations</i> - Identify that differences among individuals occur naturally within populations, without purpose or intent.

Grade or Course	Disciplinary Core Idea Statement with 2021 Performance Expectation Linked	Disciplinary Core Idea-Aligned Instructional Focus
Eighth Grade	- Natural selection leads to the predominance of certain traits in a population, and the suppression of others. (8-LS4-4) - 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 onto offspring. (8-LS4-5)	- Contrast natural and artificial selection in terms of driving agent (human or environmental conditions), targeted traits, speed of trait change, and impact of genetic diversity. - Explain that natural selection can cause certain traits to become more common in a population over many generations. - Relate changes in trait prevalence to differences in survival and reproductive success under specific environmental conditions. - Explain how environmental factors influence which inherited traits persist in populations. <i>Knowledge Extended Beyond Course Expectations</i> - Recognize that natural and artificial selection act on existing variation within populations.
Biology 1	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-LS4-2)	- Explain that natural selection occurs only when variation exists among individuals within a population. - Explain that inherited differences in traits can lead to differences in survival or reproductive success under specific environmental conditions. - Explain how differential survival and reproduction among individuals provide the conditions necessary for natural selection to operate in populations. <i>Knowledge Extended Beyond Course Expectations</i> - Recognize that not all genetic differences result in observable trait differences.

Grade or Course	Disciplinary Core Idea Statement with 2021 Performance Expectation Linked	Disciplinary Core Idea-Aligned Instructional Focus
Biology 2	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. The traits that positively affect survival are more likely to be reproduced, and thus are more common in the population. (B-LS4-3)	- Explain how inherited variation and environmental pressures interact to shape changes in trait distributions across generations. - Explain how population-level patterns can be interpreted to determine whether observed changes are consistent with natural selection. - Use the Hardy–Weinberg model to explain how stable allele frequencies reflect equilibrium conditions and how deviations from expected frequencies can indicate evolutionary influences such as natural selection. <i>Knowledge Extended Beyond Course Expectations</i> - Explain why natural selection may be weak, absent, or difficult to detect in some populations. - Recognize that selection can act simultaneously on multiple traits with competing outcomes.

LS4.C Adaptation

Students are not expected to engage directly with adaptation in early grades, as these ideas build on foundational understandings of organism needs, variation, and environmental interactions. In upper elementary grades, students explain how environmental conditions influence which organisms persist and describe patterns of trait–environment fit across different situations. In middle school, students explain that adaptation occurs over generations as natural selection increases the frequency of traits that improve survival and reproduction, recognizing this as a population-level process rather than a change within individuals. In high school, students explain how adaptation results from natural selection acting on heritable variation under changing environmental conditions, using this understanding to explain how shifts in selective pressures can alter trait distributions and lead to outcomes such as population persistence, divergence, or extinction over time.

Progression of LS4.C

Grade or Course	Disciplinary Core Idea Statement with 2021 Performance Expectation Linked	Disciplinary Core Idea-Aligned Instructional Focus
K-2	LS4.C is not addressed at this grade band.	<i>This grade band does not include LS4.C Adaptation. Students build understanding of basic needs of organisms, observable similarities and differences, and relationships between organisms and their environments as described in LS1, LS2.A, and LS3, while concepts related to adaptation, differential survival and reproduction, and population-level change in response to environmental conditions over time are deferred to Grade 3.</i>
Third Grade	Adaptation can lead to organisms that are better suited for their environment. For any particular environment, some kinds of organisms survive well, some survive less well, and some cannot survive at all. (3-LS4-3)	- Describe that when environmental conditions change, some organisms survive, some move to new locations, and some do not survive. - Explain how environmental changes can affect an organism’s ability to meet its needs (such as food, water, or shelter). - Use examples to show that different organisms can respond differently to the same environmental change. <i>Knowledge Extended Beyond Course Expectations</i> - Distinguish between short-term responses (such as moving or finding new resources) and longer-term outcomes (such as no longer surviving in an area). - Recognize that environmental changes can be natural or human-caused.

Grade or Course	Disciplinary Core Idea Statement with 2021 Performance Expectation Linked	Disciplinary Core Idea-Aligned Instructional Focus
Eighth Grade	Adaptation by natural selection occurring 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. (8-LS4-6)	- Explain that adaptation occurs over many generations when natural selection favors traits that improve survival and reproduction under specific environmental conditions (fitness). - Describe adaptation as a population-level process rather than a change within an individual organism's lifetime. - Explain that traits supporting successful survival and reproduction tend to become more common in a population over time. - Explain how changes in environmental conditions can shift the distribution of traits within a population across generations. <i>Knowledge Extended Beyond Course Expectations</i> - Recognize that different populations of the same species may adapt differently if they experience different environmental conditions.

Grade or Course	Disciplinary Core Idea Statement with 2021 Performance Expectation Linked	Disciplinary Core Idea-Aligned Instructional Focus
Biology 1	• Evolution is driven by 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-LS4-2) • 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-LS4-4) • 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. (B-LS4-5) • 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. (B-LS4-5)	• Explain that adaptation results from natural selection acting on inherited variation within a population. • Explain that adapted populations are characterized by traits that increase survival and reproduction (fitness) in a specific environment. • Describe adaptation as a population-level outcome that emerges over many generations rather than a change within individuals. • Explain how environmental change can affect population success depending on which traits are present. • Describe adaptation, extinction, and divergence as alternative long-term outcomes of population responses to environmental change. <i>Knowledge Extended Beyond Course Expectations</i> • Identify that adaptation improves average population success in a given environment but does not guarantee survival of all individuals.

Grade or Course	Disciplinary Core Idea Statement with 2021 Performance Expectation Linked	Disciplinary Core Idea-Aligned Instructional Focus
Biology 2	- 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-LS4-3) - Adaptation also means that the distribution of traits in a population can change when conditions change. (B-LS4-3) - 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. (B-LS4-6)	- Explain adaptation as a population-level outcome resulting from differential survival and reproduction under specific environmental conditions. - Explain how changing or conflicting selective pressures can influence adaptive outcomes in populations. - Explain why adaptation does not guarantee population persistence when environmental change is rapid or severe. <i>Knowledge Extended Beyond Course Expectations</i> - Understand that limits on genetic variation, population size, or time can constrain adaptive potential. - Recognize tradeoffs among traits that can limit adaptive success across environments.

LS4.D Biodiversity and Humans

Students begin by recognizing that many different kinds of organisms live in an area and that different environments support different kinds of living things. In upper elementary grades, students explain how populations depend on their habitats, describe how changes in environments influence biodiversity, and explain how populations respond differently to these changes. In middle school, students explain how biodiversity supports ecosystem services that humans rely on and how changes in biodiversity affect the availability of resources such as food, energy, and medicines. In high school, students explain how evolutionary processes and human activities influence biodiversity and ecosystem functioning, using this understanding to describe how changes in biodiversity affect system stability and resource availability and how tradeoffs in human decisions impact sustainability over time.

Progression of LS4.D

Grade or Course	Disciplinary Core Idea Statement with 2021 Performance Expectation Linked	Disciplinary Core Idea-Aligned Instructional Focus
Second Grade	There are many different kinds of living things in any area, and they exist in different places on land and in water. (2-LS4-1)	- Describe that living things are found in different places on land and in water. - Compare where different plants and animals live within the same environment. - Use local examples to show that an area can support many kinds of organisms. <i>Knowledge Extended Beyond Course Expectations</i> - Identify that different places can have different kinds of living things.
Third Grade	Populations live in a variety of habitats, and change in those habitats affects the organisms living there. (3-LS4-4)	- Recognize that populations of organisms live in different habitats. - Explain that when habitats change, some organisms may survive, some may move, and some may not survive. - Identify patterns to explain that populations depend on habitat conditions to meet their needs. <i>Knowledge Extended Beyond Course Expectations</i> - Recognize that habitat changes can be natural or caused by human activities. - Describe that different populations may be affected differently by the same habitat change.

Grade or Course	Disciplinary Core Idea Statement with 2021 Performance Expectation Linked	Disciplinary Core Idea-Aligned Instructional Focus
Seventh Grade	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. (secondary) (7-LS2-5)	- Explain that humans depend on functioning ecosystems to maintain access to natural resources. - Explain that changes in biodiversity can influence the availability of resources humans rely on, including food, energy, and medicines. - Describe how biodiversity supports ecosystem services that benefit humans, such as water purification and nutrient recycling. - Explain how reductions in biodiversity can limit ecosystem services. <i>Knowledge Extended Beyond Course Expectations</i> - Compare ecosystems with higher biodiversity to those with lower biodiversity in terms of stability. - Recognize that the loss of some species can disproportionately affect ecosystem function.
Biology 1	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. Human activity is having adverse impacts on biodiversity through overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change. These problems have the potential to cause biological extinctions which result in decreased biodiversity and the effects may be harmful to humans and other living things. 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) (B-LS2-7)	- Explain that humans depend on biodiversity for resources and benefits provided by living systems. - Describe how human activities such as habitat destruction, overexploitation, pollution, invasive species introduction, and long-term changes in climate patterns can reduce biodiversity. - Explain how reductions in biodiversity can disrupt ecosystem functioning and productivity, affecting humans and other organisms. - Explain why sustaining biodiversity supports continued ecosystem functioning. - Describe tradeoffs between short-term human benefits and long-term impacts on biodiversity and ecosystem functioning. <i>Knowledge Extended Beyond Course Expectations</i> - Recognize that biodiversity can vary across ecosystems and regions.

Grade or Course	Disciplinary Core Idea Statement with 2021 Performance Expectation Linked	Disciplinary Core Idea-Aligned Instructional Focus
Biology 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. (B-LS4-6)	- Explain how evolutionary processes such as adaptation, speciation, and extinction contribute to changes in biodiversity over time. - Explain the consequences of biodiversity loss for ecosystem resilience and stability. <i>Knowledge Extended Beyond Course Expectations</i> - Explain how cumulative human impacts across systems and scales can intensify biodiversity loss. - Recognize that biodiversity recovery depends on the magnitude of disturbance and ecological context.

References

- National Research Council. (2012). *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*. Washington, DC: The National Academies Press.
- NGSS Lead States. (2013). *Next Generation Science Standards: For States, By States (Appendix E: Disciplinary Core Idea Progression)*. Retrieved from <https://www.nextgenscience.org/>