Performance Expectation *and Louisiana Connectors*
HS-LS1-1 Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins which carry out the essential functions of life through systems of specialized cells. ***LC-HS-LS1-1a Relate DNA molecules to the way cells store and use information to guide their functions.*** ***LC-HS-LS1-1b Relate groups of specialized cells (e.g., heart cells, nerve cells, muscle cells, epithelial cells, fat cells, blood cells) within organisms to the performance of essential functions of life.*** ***LC-HS-LS1-1c Identify evidence supporting an explanation of how a substance called DNA carries genetic information in all organisms which codes for the proteins that are essential to an organism.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Constructing explanations and designing solutions: Constructing explanations (science) and designing solutions (engineering) in 9-12 builds on K-8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.	**STRUCTURE AND FUNCTION** Systems of specialized cells within organisms help them perform the essential functions of life. (HS.LS1A.a) ***All living things are made of cells.*** ***In multicellular organisms, the cells are often quite different from each other in size and structure.*** ***The structure of each kind of cell is suited to the unique function it carries out.*** ***Systems of cells, tissues, and organs work together to meet the needs of the whole organism.*** All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins which carry out the essential functions of life. (HS.LS1A.c) ***All cells contain DNA.*** ***DNA contains regions that are called genes.*** ***The sequence of genes contains instructions that code for proteins.*** ***Groups of specialized cells (tissues) use proteins to carry out functions that are essential to the organism.***	**STRUCTURE AND FUNCTION** Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem. ***Designing and/or investigating new structures/systems requires knowledge of the properties (e.g., rigidity and hardness) of the materials needed for specific parts of the***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Construct an explanation based on valid and reliable evidence from a variety of sources. ***Construct an explanation based on valid and reliable evidence from the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.*** ***Revise an explanation based on valid and reliable evidence from a variety of sources.*** ***Revise an explanation based on valid and reliable evidence from the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.***		***structure.*** ***Designing and/or investigating new structures/systems requires knowledge of the structures of different components.*** ***Designing and/or investigating a new structure requires a detailed examination of the connections of components to reveal its function.*** ***Designing and/or investigating a new structure requires a detailed examination of the connections of components to reveal any problems.***

Clarification Statement
Emphasis is on the conceptual understanding that DNA sequences determine the amino acid sequence and thus protein structure. Students can produce scientific writing, or presentations, and/or physical models that communicate constructed explanations.

Performance Expectation *and Louisiana Connectors*
HS-LS1-2 Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms. ***LC-HS-LS1-2a Using model(s), identify that different systems of the body carry out essential functions (e.g., digestive system, respiratory system, circulatory system, nervous system).*** ***LC-HS-LS1-2b Using model(s), identify the hierarchical organization of systems that perform specific functions within multicellular organisms.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Developing and using models: Modeling in 9-12 builds on K-8 experiences and progresses to using synthesizing and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s). • Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system. ***Develop or use a model to identify and describe the components of a system.*** ***Develop or use a model to identify and describe the relationships between the components of a system.*** ***Develop or use a model to predict relationships between systems or within a system.*** ***Identify that models can help***	**STRUCTURE AND FUNCTION** 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. (HS.LS1A.b) ***Cells may be organized into larger structures beginning with tissues and increasing in size and complexity to maintain organs, organ-systems, and eventually an organism.*** ***Multicellular organisms have a hierarchical structural organization in which one system is made of numerous parts.*** ***The hierarchical organization of interacting systems provide specific functions within multicellular organisms.*** ***Models can be used to illustrate how the parts (e.g., organ system, organs, and their component tissues) and processes (e.g., transport of fluids, motion) of body systems in multicellular organisms function.***	**SYSTEMS AND SYSTEM MODELS** Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales. ***Models can be used to simulate systems.*** ***Models can be used to simulate interactions.*** ***Models can be used simulate interactions within systems at different scales.*** ***Models can be used simulate interactions***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
illustrate relationships between systems or within a system.		***between systems at different scales.***

Clarification Statement
Emphasis is on functions at the organism system level such as nutrient uptake, water delivery, or organism movement in response to neural stimuli. An example of an interacting system could be an artery depending on the proper function of elastic tissue and smooth muscle to regulate and deliver the proper amount of blood within the circulatory system.

Performance Expectation *and Louisiana Connectors*
HS-LS1-3 Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis in living organisms. ***LC-HS-LS1-3a Identify how different organisms react (e.g., heart rate, body temperature) to changes in their external environment.*** ***LC-HS-LS1-3b Identify examples of how organisms use feedback mechanisms to maintain dynamic homeostasis.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Planning and carrying out investigations: Planning and carrying out investigations to answer questions or test solutions to problems in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models. • Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. ***Plan an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data***	**STRUCTURE AND FUNCTION** Feedback mechanisms maintain a living system's internal conditions within certain limits and mediate behaviors, allowing the organism to remain alive and functional even as external conditions change within some range. Feedback mechanisms can promote (through positive feedback) or inhibit (through negative feedback) activities within an organism to maintain homeostasis. (HS.LS1A.d) ***Organisms' systems can maintain balance (homeostasis) within an organism to ensure its survival.*** ***Positive and negative feedback mechanisms regulate organisms' systems in order to help an organism maintain homeostasis.*** ***These feedback mechanisms can encourage or discourage physiological responses in living systems.***	**STABILITY AND CHANGE** Feedback (negative or positive) can stabilize or destabilize a system. ***Stability denotes a condition in which a system is in balance.*** ***A feedback loop is any mechanism in which a condition triggers some action that causes a change in that same condition.*** ***The mechanisms of external controls and internal feedback loops are important elements for a stable system.*** ***A change in one part of a system can cause changes to other parts of the system, resulting in positive or negative feedback loops.*** ***The changes (negative***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
needed to produce reliable measurements. ***Revise an investigation individually and collaboratively to produce data to serve as the basis for evidence.*** ***Conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence.***		***or positive) can stabilize or destabilize a system.***

Clarification Statement
Examples of investigations could include heart rate responses to exercise, stomate responses to moisture and temperature, root development in response to water levels, or cell response to hypertonic and hypotonic environments.

Performance Expectation *and Louisiana Connectors*
HS-LS1-4 Use a model to illustrate the role of the cell cycle and differentiation in producing and maintaining complex organisms. ***LC-HS-LS1-4a Identify how growth and/or maintenance (repair/replacement) occurs when cells multiply (i.e., mitosis) using a model.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Developing and using models: Modeling in 9-12 builds on K-8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s). • Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system. ***Develop a model based on evidence to illustrate the relationships between systems.*** ***Develop a model based on evidence to predict the relationships between systems.*** ***Develop a model based on evidence to illustrate the relationships between components of a system.*** ***Develop a model based on evidence to predict the relationships between components of a system.*** ***Revise a model based on evidence***	**GROWTH AND DEVELOPMENT OF ORGANISMS** In multicellular organisms the cell cycle is necessary for growth, maintenance and repair of multicellular organisms. Disruptions in the cell cycles of mitosis and meiosis can lead to diseases such as cancer. (HS.LS1B.a) ***Cells undergo a regular sequence of growth and division called the cell cycle.*** ***The amount of time it takes to complete the cell cycle varies in different cells.*** ***Complex multicellular organisms maintain themselves by growing and developing through cellular divisions (mitosis) and differentiation of cells.*** ***There are times when cell cycles are disrupted.*** ***Cancer is a disease that can occur when control of the cell cycle is lost.*** ***Cancer is caused by uncontrolled cell division.*** 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. (HS.LS1B.b) ***During cell division, the organism's genetic material is copied into each new cell.*** ***Daughter cells receive identical genetic information from a parent cell or a fertilized egg.*** ***Mitotic cell division produces two genetically identical daughter cells from one parent cell.*** ***Differences between different cell types within a multicellular organism are due to differentiated gene expression.*** Cellular division and differentiation (stem cell) produce and maintain a complex organism, composed of systems of tissues and organs that work together to meet the needs of the whole organism. (HS.LS1B.c)	**SYSTEMS AND SYSTEM MODELS** Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales. ***Models can be used to simulate systems.*** ***Models can be used to simulate interactions.*** ***Models can be used simulate interactions within systems at different scales.*** ***Models can be used simulate interactions between systems at different scales.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
to illustrate the relationships between systems. *Revise a model based on evidence to predict the relationships between systems.* *Revise a model based on evidence to illustrate the relationships between components of a system.* *Revise a model based on evidence to predict the relationships between components of a system.* *Use a model based on evidence to illustrate the relationships between systems.* *Use a model based on evidence to predict the relationships between systems.* *Use a model based on evidence to illustrate the relationships between components of a system.* *Use a model based on evidence to predict the relationships between components of a system.*	*Cellular division and differentiation are required to meet the needs of living organisms. Mitotic cell division results in more cells that: 1) allow growth of the organism; 2) can differentiate to create different cell types; and 3) can replace dead or damaged cells to maintain a complex organism.* *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.*	

Clarification Statement
Emphasis is on conceptual understanding that mitosis passes on genetically identical materials via replication, not on the details of each phase in mitosis.

Performance Expectation *and Louisiana Connectors*
HS-LS1-5 Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy. ***LC-HS-LS1-5a Identify model of photosynthesis, which shows the conversion of light energy to stored chemical energy.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Developing and using models: Modeling in 9-12 builds on K-8 experiences and progresses to using synthesizing and developing models to predict and show relationships among variables between systems and their components in the natural and designed world. • Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system. ***Develop or use a model to identify and describe the components of a system.*** ***Develop or use a model to identify and describe the relationships between the components of a system.*** ***Develop or use a model to predict relationships between systems or within a system.*** ***Identify that models can help illustrate relationships between systems or within a system.***	**ORGANIZATION FOR MATTER AND ENERGY FLOW IN ORGANISMS** The process of photosynthesis converts light energy to stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen. (HS.LS1C.a) ***The processes of photosynthesis (making oxygen and sugar) are done in plants, photosynthetic bacteria and protists.*** ***Photosynthesis transforms light energy into stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen.*** ***The energy needed for most life is ultimately derived from the sun through photosynthesis. Plants, algae (including phytoplankton), and other energy fixing microorganisms use sunlight, water, and carbon dioxide to facilitate photosynthesis, which stores energy, forms plant matter, releases oxygen, and maintains plants' activities.***	**ENERGY AND MATTER** Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. ***The processes of energy transformation and energy transfer can be used to understand the changes that take place in physical systems.***

Clarification Statement
Emphasis is on illustrating inputs and outputs of matter, the transfer and transformation of energy in photosynthesis by plants, and other photosynthesizing organisms. Examples of models could include diagrams, chemical equations, conceptual models, and/or laboratory investigations.

Performance Expectation *and Louisiana Connectors*
HS-LS1-6 Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules. ***LC-HS-LS1-6a Using a model(s), identify how organisms take in matter and rearrange the atoms in chemical reactions to form different products allowing for growth and maintenance.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Constructing explanations and designing solutions: Constructing explanations (science) and designing solutions (engineering) in 9-12 builds on K-8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future, and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the	**ORGANIZATION FOR MATTER AND ENERGY FLOW IN ORGANISMS** The process of photosynthesis converts light energy to stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen. (HS.LS1C.a) ***The processes of photosynthesis (making oxygen and sugar) are done in plants, photosynthetic bacteria and protists.*** ***Photosynthesis transforms light energy into stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen.*** ***The energy needed for most life is ultimately derived from the sun through photosynthesis. Plants, algae (including phytoplankton), and other energy fixing microorganisms use sunlight, water, and carbon dioxide to facilitate photosynthesis, which stores energy, forms plant matter, releases oxygen, and maintains plants' activities.*** The sugar molecules thus formed contain carbon, hydrogen, and oxygen: their hydrocarbon backbones are used to make amino acids and other carbon-based molecules that can be assembled into larger molecules (such as proteins or DNA) used, for example, to form new cells. (HS.LS1C.b) ***Molecules combine, break apart, and recombine to form necessary compounds for life.*** ***The carbon, hydrogen, and oxygen atoms from sugar molecules formed in or ingested by an organism are those same atoms found in its amino acids and other large carbon-based molecules.*** ***Sugar molecules are composed of carbon, oxygen, and hydrogen.*** ***Amino acids and other carbon-based molecules are composed of carbon, oxygen, and hydrogen.***	**ENERGY AND MATTER** Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. ***The processes of energy transformation and energy transfer can be used to understand the changes that take place in physical systems.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
future. ***Construct an explanation based on valid and reliable evidence from a variety of sources.*** ***Construct an explanation based on valid and reliable evidence from the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.*** ***Revise an explanation based on valid and reliable evidence from a variety of sources.*** ***Revise an explanation based on valid and reliable evidence from the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.***		

Clarification Statement
Emphasis is on students constructing explanations for how sugar molecules are formed through photosynthesis and the components of the reaction (i.e., carbon, hydrogen, oxygen). This hydrocarbon backbone is used to make amino acids and other carbon-based molecules that can be assembled (anabolism) into larger molecules (such as proteins or DNA). Examples of models could include diagrams, chemical equations, or conceptual models.

Performance Expectation *and Louisiana Connectors*
HS-LS1-7 Use a model to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed, resulting in a net transfer of energy. ***LC-HS-LS1-7a Using a model(s), identify respiration as the transfer of stored energy to the cell to sustain life's processes (i.e., energy to muscles or energy for maintaining body temperature).***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Developing and using models: Modeling in 9-12 builds on K-8 experiences and progresses to using synthesizing and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s). • Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system. ***Develop a model based on evidence to illustrate the relationships between systems.*** ***Develop a model based on evidence to predict the relationships between systems.*** ***Develop a model based on evidence to illustrate the relationships between components of a system.*** ***Develop a model based on evidence to predict the relationships between components of a system.***	**ORGANIZATION FOR MATTER AND ENERGY FLOW IN ORGANISMS** As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products. (HS.LS1C.c) ***Energy drives the cycling of matter within and between systems.*** ***All organisms take in matter and rearrange the atoms in chemical reactions.*** ***The process of creating the compounds needed for life is done by organisms at a cellular level.*** ***Chemical reactions can create products that are more complex than the reactants.*** ***Chemical reactions involve changes in the energies of the molecules involved in the reaction.*** 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. (HS.LS1C.d) ***The process of cellular respiration (making energy from sugar) is done in plants and animals.*** ***Cellular respiration in plants and animals involves chemical reactions with oxygen that release stored energy.*** ***In cellular respiration, complex molecules containing carbon react with oxygen to produce carbon dioxide and other materials.*** ***Cellular respiration also releases the energy needed to maintain body temperature.***	**ENERGY AND MATTER** Energy cannot be created or destroyed—it only moves between one place and another place, between objects and/or fields, or between systems. ***Energy cannot be created or destroyed.*** ***Energy can be transferred from one object to another and can be transformed from one form to another, but the total amount of energy never changes.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Revise a model based on evidence to illustrate the relationships between systems. ***Revise a model based on evidence to predict the relationships between systems.*** ***Revise a model based on evidence to illustrate the relationships between components of a system.*** ***Revise a model based on evidence to predict the relationships between components of a system.*** ***Use a model based on evidence to illustrate the relationships between systems.*** ***Use a model based on evidence to predict the relationships between systems.*** ***Use a model based on evidence to illustrate the relationships between components of a system.*** ***Use a model based on evidence to predict the relationships between components of a system.***		

Clarification Statement
Emphasis is on the conceptual understanding of the inputs and outputs of the processes of aerobic and anaerobic cellular respiration. Examples of models could include diagrams, chemical equations, conceptual models and/or laboratory investigations.

Performance Expectation *and Louisiana Connectors*
HS-LS1-8 Obtain, evaluate, and communicate information about (1) viral and bacterial reproduction and adaptation, (2) the body's primary defenses against infection, and (3) how these features impact the design of effective treatment. ***LC-LS1-8a Identify the process by which a virus uses a host cell's functions to make new viruses.*** ***LC-LS1-8b Recognize that most bacteria reproduce asexually resulting in two cells exactly like the parent cell.*** ***LC-LS1-8c Identify ways to protect against infectious diseases to maintain a body's health (e.g., eat nutritious food, washing hands, rest, exercise, etc.).*** ***LC-LS1-8d Identify treatments and/or prevention of viral and/or bacterial infections (e.g., antibiotics and vaccines).***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Obtaining, evaluating, and communicating information: Obtaining, evaluating, and communicating information in 9-12 builds on K-8 experiences and progresses to evaluating the validity and reliability of the claims, methods, and designs. • Critically read scientific literature adapted for classroom use to determine the central ideas or conclusions and/or to obtain scientific and/or technical information to summarize complex evidence, concepts, processes, or information by presenting them in simpler but still accurate terms. ***Engage in a critical reading of primary scientific literature (adapted for classroom use) to determine the central ideas to summarize complex evidence, concepts, processes, or information***	**PUBLIC HEALTH** Viruses are obligate intracellular parasites that replicate using a cell's protein expression mechanisms. (HS.LS1E.a) ***Viruses are considered nonliving because they are not composed of cells.*** ***Viruses do not use energy to grow or respond to their surroundings.*** ***Obligate intracellular parasites cannot reproduce outside their host cell.*** ***An obligate intracellular parasite is entirely reliant on intracellular resources.*** ***Obligate intracellular parasites of humans include viruses.*** Vaccines provide immunity to infections by exposing the immune system to antigens before infection which decreases the immune system's response time. Some vaccines may require more than one dose. (HS.LS1E.b) ***A vaccine is a substance that stimulates the body to produce chemicals that destroy viruses, bacteria, or other disease-causing organisms.*** ***Vaccines can prevent some viral and bacterial diseases.*** ***Vaccines are important tools to prevent the spread of infectious diseases.*** Antibiotics are effective treatments against most bacterial infections. Some bacteria may develop resistance to these treatments. (HS.LS1E.c) ***An antibiotic is a chemical that can kill bacteria without harming a person's cells.*** ***Bacterial diseases can be treated with antibiotics.***	**SCALE, PROPORTION, AND QUANTITY** The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. ***The size and time scales relevant to various objects, systems, and processes determine the significance of a phenomena.*** ***Specific phenomena correspond to a specific scale (e.g., the size of the nucleus of an atom to the size of the galaxy and beyond).***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
by presenting them in simpler but still accurate terms. ***Engage in a critical reading of primary scientific literature (adapted for classroom use) to determine the conclusions to summarize complex evidence, concepts, processes, or information by presenting them in simpler but still accurate terms.*** ***Engage in a critical reading of primary scientific literature (adapted for classroom use) to obtain scientific information to summarize complex evidence, concepts, processes, or information by presenting them in simpler but still accurate terms.*** ***Engage in a critical reading of primary scientific literature (adapted for classroom use) to obtain technical information to summarize complex evidence, concepts, processes, or information by presenting them in simpler but still accurate terms.***	***Resistant bacteria are able to survive in the presence of an antibiotic.*** ***Those bacteria survive and reproduce.*** ***Today, many resistant bacteria exist.*** Microorganisms can cause diseases and can provide beneficial services. Microorganisms live in a variety of environments as both parasites and free-living organisms. (HS.LS1E.d) ***Parasites are organisms that live on or in a host and causes harm to the host.*** ***Parasites and other microorganisms can cause disease.*** ***Microorganisms can provide beneficial services.*** ***Bacteria are involved in fuel and food production, environmental recycling and cleanup, and the production of medicines.*** ***Microorganisms live in a variety of environments.*** ***Microorganisms can be both parasites and free-living organisms.*** Microorganisms can reproduce quickly. (HS.LS1E.e) ***Microorganisms can reproduce quickly. Some bacteria can reproduce as often as once every 20 minutes.***	

Clarification Statement
Emphasis is on the speed of reproduction which produces many generations in a short time, allowing for rapid adaptation, the role of antibodies in the body's immune response to infection and how vaccination protects an individual from infectious disease.

Performance Expectation *and Louisiana Connectors*
HS-LS2-1 Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity, biodiversity and populations of ecosystems at different scales. ***LC-HS-LS2-1a Recognize that the carrying capacities of ecosystems are related to the availability of living and nonliving resources and challenges (e.g., predation, competition, disease).*** ***LC-HS-LS2-1b Use a graphical representation to identify carrying capacities in ecosystems as limits to the numbers of organisms or populations they can support.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Using mathematics and computational thinking: Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions (e.g., trigonometric, exponential and logarithmic) and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. • Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations. ***Use mathematical or algorithmic forms for scientific modeling of phenomena and/or design***	**INTERDEPENDENT RELATIONSHIPS IN ECOSYSTEMS** Ecosystems have carrying capacities, which are limits to the numbers of organisms and populations they can support. These limits result from such factors as the availability of living and nonliving resources and from such challenges as predation, competition, and disease that affect biodiversity, including genetic diversity within a population and species diversity within an ecosystem. 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. (HS.LS2A.a) ***Carrying capacities are limits to the numbers of organisms and populations an ecosystem can support.*** ***The carrying capacity for a specific population in an ecosystem depends on the resources available.*** ***These limits can be a result of shifting living (predators, competition, and available food) and non-living (shelter, water, and climate) factors within a specific environment.*** ***Given adequate biotic and abiotic resources and no disease or predators, populations increase at rapid rates.*** ***Resources, (limiting factors), predation and climate, limit the growth of populations in specific niches in an ecosystem.*** Human activity directly and indirectly affect biodiversity and ecosystem health (e.g., habitat fragmentation, introduction of nonnative or invasive species, overharvesting, pollution and climate change). (HS.LS2A.b)	**SCALE, PROPORTION, AND QUANTITY** The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. ***The size and time scales relevant to various objects, systems, and processes determine the significance of a phenomena.*** ***Specific phenomena correspond to a specific scale (e.g., the size of the nucleus of an atom to the size of the galaxy and beyond).***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
solutions to describe claims. ***Use mathematical or algorithmic forms for scientific modeling of phenomena and/or design solutions to support claims.*** ***Use mathematical or algorithmic forms for scientific modeling of phenomena and/or design solutions to describe explanations.*** ***Use mathematical or algorithmic forms for scientific modeling of phenomena and/or design solutions to support explanations.***	***Humans are an integral part of the natural system, and human activities can alter the stability of ecosystems.*** ***Human-related changes to one or more of these factors can result in an ecosystem breaking down or the creation of an entirely new ecosystem.*** ***Human activities have a major effect on other species. For example, increased land use reduces habitat available to other species, pollution changes the chemical composition of air, soil, and water, and introduction of non-native species disrupts the ecological balance.***	

Clarification Statement
Emphasis is on quantitative analysis and comparison of the relationships among interdependent factors including boundaries, resources, climate and competition. Examples of mathematical comparisons could include graphs, charts, histograms, or population changes gathered from simulations or historical data sets.

Performance Expectation *and Louisiana Connectors*
HS-LS2-4 Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem. ***LC-HS-LS2-4a Use a graphical or mathematical representation to identify the changes in the amount of matter as it travels through a food web.*** ***LC-HS-LS2-4b Use a graphical or mathematical representation to identify the changes in the amount of energy as it travels through a food web.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Using mathematics and computational thinking: Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions (e.g., trigonometric, exponential and logarithmic) and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. • Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations. ***Use mathematical or algorithmic forms for scientific modeling of phenomena and/or design solutions to describe claims.*** ***Use mathematical or algorithmic forms for scientific modeling of***	**CYCLES OF MATTER AND ENERGY TRANSFER IN ECOSYSTEMS** Energy is inefficiently transferred from one trophic level to another that affect the relative number of organisms that can be supported at each trophic level and necessitates a constant input of energy from sunlight or inorganic compounds from the environment. (HS.LS2B.b) ***Only a fraction of the energy available at the lower level of a food web is transferred up, resulting in fewer organisms at higher levels.*** ***The inefficiency of energy transfer determines the number of trophic levels and affects the relative number of organisms at each trophic level in an ecosystem.*** ***All energy is conserved as it passes from the sun through an ecosystem.*** ***During energy transformations, some energy is converted to unusable heat.*** ***A continual input of energy from the sun keeps the process going.*** ***On average, regardless of scale, 10% of energy is transferred up from one trophic level to another.*** Photosynthesis, cellular respiration, decomposition and combustion are important components of the carbon cycle, in which carbon is exchanged among the biosphere, atmosphere, hydrosphere, and geosphere through chemical, physical, geological, and biological processes. (HS.LS2B.c) ***Carbon is an essential element cycled through all levels of life from cellular to ecosystems and is required for survival of all living organisms.*** ***Photosynthesis (the main way that solar energy is captured and stored on Earth) and cellular respiration are important components of the carbon cycle, in which carbon is exchanged between living and nonliving systems.*** ***Matter needed to sustain life in ecosystems is continually recycled (e.g., carbon cycle, water cycle, nitrogen cycle, mineral cycles) among organisms and between organisms and the environment.***	**ENERGY AND MATTER: FLOWS, CYCLES, AND CONSERVATION** Energy cannot be created or destroyed—it only moves between one place and another place, between objects and/or fields, or between systems. ***Energy cannot be created or destroyed. Energy can be transferred from one object to another and can be transformed from one form to another, but the total amount of energy never changes.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
phenomena and/or design solutions to support claims. Use mathematical or algorithmic forms for scientific modeling of phenomena and/or design solutions to describe explanations. Use mathematical or algorithmic forms for scientific modeling of phenomena and/or design solutions to support explanations.	Photosynthesis, chemosynthesis, aerobic and anaerobic respiration and cellular respiration (including anaerobic processes) provide most of the energy for life processes. Environmental conditions restrict which and when reactions can occur. (HS.LS2B.a) (suggested extension) ***The processes of photosynthesis (making oxygen and sugar) and cellular respiration (making energy from sugar done in plants and animals) provide most of the energy for life on earth. The reactants and products of photosynthesis and cellular respiration (aerobic and anaerobic) can be used to relate the Law of Conservation of Matter and the Law of Conservation of Energy to ecosystems, using the carbon cycle can as a reference.***	

Clarification Statement
Emphasis is on using a mathematical model of stored energy in biomass to describe the transfer of energy from one trophic level to another and that matter and energy are conserved as matter cycles and energy flows through ecosystems. Emphasis is on atoms and molecules such as carbon, oxygen, hydrogen, and nitrogen being conserved as they move through an ecosystem.

Performance Expectation *and Louisiana Connectors*
HS-LS2-6 Evaluate the claims, evidence and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem. ***LC-HS-LS2-6a Use evidence to identify how modest biological or physical changes versus extreme changes affect stability and change (e.g., number and types of organisms) in ecosystems.*** ***LC-HS-LS2-6b Evaluate explanations of how living things in an ecosystem are affected by changes in the environment (e.g., changes to the food supply, climate change, or the introduction of predators).*** ***LC-HS-LS2-6c Evaluate explanations of how interactions in ecosystems maintain relatively stable conditions, but changing conditions may result in a new ecosystem.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Engaging in argument from evidence: Engaging in argument from evidence in 9-12 builds on K-8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science. • Evaluate the claims, evidence, and/or reasoning behind currently accepted explanations or solutions to determine the merits of arguments. ***Evaluate the claims behind currently accepted explanations to determine the merits of arguments.***	**ECOSYSTEM DYNAMICS, FUNCTIONING, AND RESILIENCE** The dynamic 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 and may result in new ecosystems. (HS.LS2C.a) ***Under most circumstances, a natural balance is maintained within an ecosystem.*** ***Organisms both cooperate and compete in ecosystems.*** ***The interrelationships and interdependencies of these organisms may generate complex ecosystems that are stable over long periods of time and tend to have cyclic fluctuations around an equilibrium (i.e., the ecosystem is resilient).*** ***Extreme fluctuations, such as from natural disasters, can challenge the functioning of ecosystems in terms of resources and habitat availability.*** ***These changes can result in an ecosystem breaking down or the creation of an entirely new ecosystem.***	**STABILITY AND CHANGE** Much of science deals with constructing explanations of how things change and how they remain stable. ***Science deals with constructing explanations of how things change.*** ***Science deals with constructing explanations of how things remain stable.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Evaluate the claims behind currently accepted solutions to determine the merits of arguments. Evaluate the evidence behind currently accepted explanations to determine the merits of arguments. Evaluate the evidence behind currently accepted solutions to determine the merits of arguments. Evaluate the reasoning behind currently accepted explanations to determine the merits of arguments. Evaluate the reasoning behind currently accepted solutions to determine the merits of arguments.		

Clarification Statement
Examples of changes in ecosystem conditions could include modest biological or physical changes, such as moderate hunting or a seasonal flood and extreme changes, such as volcanic eruption or sea level rise. Emphasis should be on describing drivers of ecosystem stability and change, not on the organismal mechanisms of responses and interactions.

Performance Expectation *and Louisiana Connectors*
HS-LS2-7 Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity. ***LC-HS-LS2-7a Describe how people can help protect the Earth's environment and biodiversity (e.g., preserving ecosystems) and how a human activity would threaten Earth's environment and biodiversity (e.g., pollution, damaging habitats, over hunting).*** ***LC-HS-LS2-7b Evaluate or refine a solution to changes in an ecosystem (biodiversity) resulting from a human activity.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Constructing explanations and designing solutions: Constructing explanations (science) and designing solutions (engineering) in 9-12 builds on K-8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade-off considerations. ***Design a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade-off considerations.***	**ECOSYSTEM DYNAMICS, FUNCTIONING, AND RESILIENCE** Ecosystems with a greater biodiversity tend to have a greater resistance and resilience to change. 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. (HS.LS2C.b) ***Biodiversity helps maintain stability in ecosystems.*** ***However, factors caused by humans (e.g., habitat destruction, pollution, introduction of invasive species) have negative effects on the environment and biodiversity.*** ***Some system changes are irreversible.*** **BIODIVERSITY AND HUMANS** Biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction). Humans depend on the living world for the resources and other benefits provided by biodiversity. 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. (HS.LS4D.a) ***Humans depend on the living world for resources.*** ***Thus, protecting the environment and biodiversity helps sustain human life.*** ***Ecosystems undergo major changes as a result of such human-related factors as***	**STABILITY AND CHANGE** Much of science deals with constructing explanations of how things change and how they remain stable. ***Science deals with constructing explanations of how things change.*** ***Science deals with constructing explanations of how things remain stable.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Evaluate a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade-off considerations. ***Refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade-off considerations.***	***overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change.*** ***Sustainability of human societies and the biodiversity that supports them require responsible management of natural resources.*** ***Changes in the physical, chemical, or biological conditions of an ecosystem can alter the diversity of species in the system.*** ***Over time, ecosystems change and populations of organisms adapt, move, or become extinct.*** **DEVELOPING POSSIBLE SOLUTIONS** When evaluating solutions it is important to take into account a range of constraints including cost, safety, reliability and aesthetics and to consider social, cultural and environmental impacts. (HS.ETS1B.a) ***It is important to determine the full impact of the advantages and disadvantages when evaluating a solution.*** ***The development of solutions is driven by the following factors: economical, political, cultural, social, safety, and environmental.***	

Clarification Statement
Examples of human activities can include urbanization, building dams, or dissemination of invasive species.

Performance Expectation *and Louisiana Connectors*
HS-LS3-1 Formulate, refine, and evaluate questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring. ***LC-HS-LS3-1a Identify that DNA molecules in all cells contain the instructions for traits passed from parents to offspring.*** ***LC-HS-LS3-1b Identify appropriate questions about the relationships between DNA and chromosomes and how traits are passed from parents to offspring.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Asking questions and defining problems: Asking questions (science) and defining problems (engineering) in 9-12 builds on K-8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations. • Ask questions that arise from examining models or a theory, to clarify and/or seek additional information and relationships. ***Ask questions that arise from examining models to clarify relationships.*** ***Ask questions that arise from examining models to seek additional information.*** ***Ask questions that arise from examining a theory to clarify relationships.*** ***Ask questions that arise from***	**STRUCTURE AND FUNCTION** All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins which carry out the essential functions of life. (HS.LS1A.c) ***All cells contain DNA.*** ***DNA contains regions that are called genes.*** ***The sequence of genes contains instructions that code for proteins.*** ***Groups of specialized cells (tissues) use proteins to carry out functions that are essential to the organism.*** **INHERITANCE OF TRAITS** Each chromosome consists of a single very long DNA molecule, and each gene on the chromosome is a particular segment of that DNA. The instructions for forming species' characteristics are carried in DNA. All cells in an organism have the same genetic content, but the genes used (expressed) by the cell may be regulated in different ways. Not all DNA codes for a protein; some segments of DNA are involved in regulatory or structural functions, and some have no as-yet known function. (HS.LS3A.a) ***All cells contain genetic information in the form of DNA molecules.*** ***DNA molecules contain the instructions for forming species' characteristics.*** ***All cells in an organism have the same genetic content.*** ***There are several types of DNA, including DNA that codes for proteins, DNA that is involved in regulatory or structural functions (cell membrane proteins, cyclins), and DNA that has no known function (introns).***	**CAUSE AND EFFECT** Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. ***Evidence is required when attributing an observed phenomenon to a specific cause.*** ***Evidence is required to explain the causal mechanisms in a system under study.*** ***Evidence is required to support a claim about the causal mechanisms in a system under study.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
examining a theory to seek additional information.	In Mendel's model of inheritance an organism's phenotype is determined by the combined expression of two inherited versions they have for each gene. However, most traits follow more complex patterns of inheritance such as traits that are codominant, incomplete dominant, and polygenic. (HS.LS3A.b) ***One allele is provided by each parent of an offspring. In complete dominance, a recessive trait can be carried by an organism. Following this mode of inheritance, a recessive trait will be masked (or will not be apparent) if the dominant allele is present.***	

Clarification Statement
Emphasis should be on traits including completely dominant, codominant, incompletely dominant, and sex-linked traits (e.g., pedigrees, karyotypes, genetic disorders, Punnett squares). Examples do not need to include dihybrid crosses.

Performance Expectation *and Louisiana Connectors*
HS-LS3-2 Make and defend a claim based on evidence that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors. ***LC-HS-LS3-2a Identify a model showing evidence that parents and offspring may have different traits.*** ***LC-HS-LS3-2b Identify that meiosis is a process which distributes genetic material among the new cells (i.e., gametes) produced, which results in genetic variation.*** ***LC-HS-LS3-2c Identify that when DNA makes a copy of itself, sometimes errors occur that may lead to genetic variations.*** ***LC-HS-LS3-2d Identify examples of mutations in DNA caused by environmental factors.*** ***LC-HS-LS3-2e Use evidence to support a claim about a source of inheritable genetic variations.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Engaging in argument from evidence: Engaging in argument from evidence in 9-12 builds on K-8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science. • Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge and student-generated evidence. ***Make and defend a claim based on evidence about the natural world that reflects scientific knowledge and student-generated evidence.***	**VARIATION OF TRAITS** In sexual reproduction, chromosomes can sometimes swap sections or cross over 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. (HS.LS3B.a) ***New genetic combinations lead to increased genetic variation.*** ***New genetic combinations are the result of:*** ***• sexual reproduction,*** ***• crossing over and random assortment during meiosis,*** ***• mutations due to errors in DNA replication, or*** ***• environmental influences.*** Mutations may occur due to errors during DNA replication and/or environmental factors. In general, only mutations that occur in gametes (sperm and egg) can be passed to offspring. Genes have variations (alleles) that code for specific variants of a protein (or RNA), and therefore specific traits of an individual. (HS.LS3B.b) ***Genes play an important role in shaping how organisms look and act (specific traits of an individual).***	**CAUSE AND EFFECT** Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. ***Evidence is required when attributing an observed phenomenon to a specific cause.*** ***Evidence is required to explain the causal mechanisms in a system under study.*** ***Evidence is required to support a claim about the causal mechanisms in a system under study.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Make and defend a claim based on evidence about the effectiveness of a design solution that reflects scientific knowledge and student-generated evidence.	***Mutations can be passed to offspring from parents (i.e., mutations that occur in gametes).*** ***Common changes in genes are responsible for many of the normal variations between people such as eye color, hair color, and blood type.*** ***Many common mutations have no negative effects on a person's health.*** 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. (HS.LS3B.c) ***Environmental factors (climate, diet, pollution, lifestyle) have influence on gene expression.*** ***Mutations can also occur when cells are aging or have been exposed to certain chemicals or radiation.*** ***Inheritable genetic variations may result from new genetic combinations through meiosis, viable errors occurring during replication, and/or mutations caused by environmental factors.***	

Clarification Statement
Emphasis is on using data to support arguments for the way variation occurs. Claims should not include the phases of meiosis or the biochemical mechanisms of specific steps in the process.

Performance Expectation *and Louisiana Connectors*
HS-LS3-3 Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population. ***LC-HS-LS3-3a Calculate the probability (e.g., two out of four) of a particular trait in an offspring based on a completed Punnett square.*** ***LC-HS-LS3-3b Identify examples, using data, of environmental factors which affect the expression of traits, and so then affect the probability of occurrences of traits in a population.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Analyzing and interpreting data: Analyzing data in 9-12 builds on K-8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data. • Apply concepts of statistics and probability (e.g., determining function fits to data and correlation coefficient for linear or nonlinear fits) to scientific and engineering questions and problems, using digital tools when feasible. ***Apply concepts of statistics and probability (e.g., determining function fits to data and correlation coefficient for linear or nonlinear fits) to scientific questions and problems, using digital tools when feasible.*** ***Apply concepts of statistics and probability (e.g., determining***	**VARIATION OF TRAITS** In sexual reproduction, chromosomes can sometimes swap sections or cross over 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. (HS.LS3B.a) ***New genetic combinations lead to increased genetic variation.*** ***New genetic combinations are the result of:*** ***• sexual reproduction,*** ***• crossing over and random assortment during meiosis,*** ***• mutations due to errors in DNA replication, or*** ***• environmental influences.*** Mutations may occur due to errors during DNA replication and/or caused by environmental factors. In general, only mutations that occur in gametes (sperm and egg) can be passed to offspring. Genes have variations (alleles) that code for specific variants of a protein (or RNA), and therefore specific traits of an individual. (HS.LS3B.b) ***Genes play an important role in shaping how organisms look and act (specific traits of an individual).*** ***Mutations can be passed to offspring from parents (i.e., mutations that occur in gametes).*** ***Common changes in genes are responsible for many of the normal variations between***	**SCALE, PROPORTION, AND QUANTITY** Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth). ***Examine scientific data to predict the effect of a change in one variable on another.*** ***Algebraic thinking can be used to explore complex mathematical relationships in science (e.g., the difference between linear growth and exponential growth).***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
function fits to data and correlation coefficient for linear or nonlinear fits) to engineering questions and problems, using digital tools when feasible.	***people such as eye color, hair color, and blood type.*** ***Many common mutations have no negative effects on a person's health.***	

Clarification Statement
Emphasis is on distribution and variation of traits in a population and the use of mathematics (e.g., calculations of frequencies in Punnett squares, graphical representations) to describe the distribution.

Performance Expectation *and Louisiana Connectors*
HS-LS4-1 Analyze and interpret scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence. ***LC-HS-LS4-1a Identify patterns (e.g., DNA sequences, fossil records) as evidence to a claim of common ancestry.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Analyzing and interpreting data: Analyzing data in 9-12 builds on K-8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data. • Compare and contrast various types of data sets (e.g., self-generated, archival) to examine consistency of measurements and observations. ***Compare and contrast various types of data sets (e.g., self-generated, archival) to examine consistency of measurements.*** ***Compare and contrast various types of data sets (e.g., self-generated, archival) to examine consistency of observations.***	**EVIDENCE OF COMMON ANCESTRY AND DIVERSITY** Genetic information provides evidence of evolution. DNA sequences vary among species, but there are many overlaps; in fact, the ongoing branching that produces multiple lines of descent 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 observable anatomical and embryological evidence. (HS.LS4A.a) ***Evolution is a change in allelic frequencies of a population over time.*** ***Highly similar DNA sequences among species leads to anatomical similarities and provides evidence of evolution.*** ***Organisms are classified into a hierarchy of groups and subgroups based on similarities in structure, comparisons in DNA and protein and evolutionary relationships.*** ***Differences in DNA sequences among species contributes to the diversity of living things.*** ***The theory of evolution is supported by extensive biochemical, structural, embryological, and fossil evidence.***	**PATTERNS** Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. ***Patterns can be used to explain phenomena.*** ***Different patterns can be observed at different scales (micro and macro) in a system.*** ***Classifications used at one scale may fail or need revision when information from smaller or larger scales is introduced.***

Clarification Statement
Emphasis is on a conceptual understanding of the role each line of evidence (e.g., similarities in DNA sequences, order of appearance of structure during embryological development, cladograms, homologous and vestigial structures, fossil records) demonstrates as related to common ancestry and biological evolution.

Performance Expectation *and Louisiana Connectors*
HS-LS4-2 Construct an explanation based on evidence that biological diversity is influenced by (1) the potential for a species to increase in number, (2) the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment. ***LC-HS-LS4-2a Recognize that as a species grows in number, competition for limited resources also increases.*** ***LC-HS-LS4-2b Recognize that different individuals have specific traits that give advantages (e.g., survive and reproduce at higher rates) over other individuals in the species.*** ***LC-HS-LS4-2c Identify how evolution may be a result of genetic variation through mutations and sexual reproduction in a species that is passed on to their offspring.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Constructing explanations and designing solutions: Constructing explanations (science) and designing solutions (engineering) in 9-12 builds on K-8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do in the future.	**NATURAL SELECTION** Natural selection occurs only if there is both (1) variation in the genetic information between organisms in a population (e.g., mutations and sexual reproduction), and (2) variation in the expression of that genetic information—that is, trait variation—that leads to differences in performance among individuals. Natural selection leads to populations that have more individuals with behavioral, anatomical, and physiological adaptations. (HS.LS4B.a) ***Biological traits become either more or less common in a population through the process of natural selection.*** ***Different factors (including mutations and sexual reproduction) contribute to variation in a population and that natural selection can influence frequencies of heritable traits by providing survival advantages to some individuals.*** ***Four factors primarily influence evolution: (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.*** The traits that positively affect survival are more likely to be reproduced, and thus are more common in the population. (HS.LS4B.c) ***Offspring with advantageous adaptations are more likely to survive and reproduce, thus***	**CAUSE AND EFFECT** Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. ***Evidence is required when attributing an observed phenomenon to a specific cause.*** ***Evidence is required to explain the causal mechanisms in a system under study.*** ***Evidence is required to support a claim about the causal mechanisms in a system under study.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Construct an explanation based on valid and reliable evidence from a variety of sources. ***Construct an explanation based on valid and reliable evidence from the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.*** ***Revise an explanation based on valid and reliable evidence from a variety of sources.*** ***Revise an explanation based on valid and reliable evidence from the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.***	***increasing the proportion of individuals within a population with advantageous characteristics.***	

Clarification Statement
Emphasis is on using evidence to explain the influence each of the four factors has on number of organisms, behaviors, morphology, or physiology in terms of ability to compete for limited resources and subsequent survival of individuals and adaptation of species. Examples of evidence could include mathematical models such as simple distribution graphs or proportional reasoning.

Performance Expectation *and Louisiana Connectors*
HS-LS4-3 Apply concepts of statistics and probability to support explanations that populations of organisms adapt when an advantageous heritable trait increases in proportion to organisms lacking this trait. ***LC-HS-LS4-3a Use patterns in data to identify how heritable variations in a trait may lead to an increasing proportion of individuals within a population with that trait (i.e., an advantageous characteristic).***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Analyzing and interpreting data: Analyzing data in 9-12 builds on K-8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data. • Apply concepts of statistics and probability (e.g., determining function fits to data and correlation coefficient for linear or nonlinear fits) to scientific and engineering questions and problems, using digital tools when feasible. ***Apply concepts of statistics and probability (e.g., determining function fits to data and correlation coefficient for linear or nonlinear fits) to scientific questions and problems, using digital tools when feasible.*** ***Apply concepts of statistics and probability (e.g., determining function fits to data and correlation***	**NATURAL SELECTION** Natural selection occurs only if there is both (1) variation in the genetic information between organisms in a population (e.g., mutations and sexual reproduction), and (2) variation in the expression of that genetic information—that is, trait variation—that leads to differences in performance among individuals. Natural selection leads to populations that have more individuals with behavioral, anatomical, and physiological adaptations. (HS.LS4B.a) ***Biological traits become either more or less common in a population through the process of natural selection.*** ***Different factors (including mutations and sexual reproduction) contribute to variation in a population and that natural selection can influence frequencies of heritable traits by providing survival advantages to some individuals.*** ***Four factors primarily influence evolution: (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.*** The traits that positively affect survival are more likely to be reproduced, and thus are more common in the population. (HS.LS4B.c) ***Offspring with advantageous adaptations are more likely to survive and reproduce, thus increasing the proportion of individuals within a population with advantageous characteristics.*** **ADAPTATION** Natural selection leads to adaptation that is, to a population dominated by organisms that are	**PATTERNS** Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. ***Patterns can be used to explain phenomena.*** ***Different patterns can be observed at different scales (micro and macro) in a system.*** ***Classifications used at one scale may fail or need revision when information from smaller or larger scales is introduced.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
coefficient for linear or nonlinear fits) to engineering questions and problems, using digital tools when feasible.	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. (HS.LS4C.a) ***The inheritance of certain traits can lead to a competitive advantage for certain organisms in a population.*** ***Advantages lead to increased survival and/or reproductive rates within the population.*** ***Natural selection leads to adaptation in a population dominated by organisms that are anatomically, behaviorally, and physiologically well suited to survive and reproduce in a specific environment.*** Adaptation also means that the distribution of traits in a population can change when conditions change. (HS.LS4C.b) ***Natural selection causes shifts in the frequency of traits within a population over time.*** ***Relationships between biotic and abiotic differences in ecosystems and their contributions to a change in gene frequency over time, leads to adaptation of populations, and thus, proportional increases in organisms with advantageous heritable traits.***	

Clarification Statement
Emphasis is on analyzing shifts in numerical distribution of traits and using these shifts as evidence to support explanations for adaptations. Explanations could include basic statistical or graphical analysis.

Performance Expectation *and Louisiana Connectors*
HS-LS4-4 Construct an explanation based on evidence for how natural selection and other mechanisms lead to genetic changes in populations. ***LC-HS-LS4-4a Use data to provide evidence for how specific biotic or abiotic differences in ecosystems (e.g., ranges of seasonal temperature, acidity, light, geographic barriers) support the claim that organisms with an advantageous heritable trait are better able to survive over time.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Constructing explanations and designing solutions: Constructing explanations (science) and designing solutions (engineering) in 9-12 builds on K-8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. ***Construct an explanation based on valid and reliable evidence from a variety of sources.***	**NATURAL SELECTION** Natural selection occurs only if there is both (1) variation in the genetic information between organisms in a population (e.g., mutations and sexual reproduction), and (2) variation in the expression of that genetic information—that is, trait variation—that leads to differences in performance among individuals. Natural selection leads to populations that have more individuals with behavioral, anatomical, and physiological adaptations. (HS.LS4B.a) ***Biological traits become either more or less common in a population through the process of natural selection.*** ***Different factors (including mutations and sexual reproduction) contribute to variation in a population and that natural selection can influence frequencies of heritable traits by providing survival advantages to some individuals.*** ***Four factors primarily influence evolution: (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.*** Genetic drift and gene flow can lead to genetic changes in populations, not adaptations. (HS.LS4B.b) ***Other factors that influence evolution include: sexual selection, mutation, genetic drift, and genetic modification.*** ***Genetic drift is a mechanism of evolution that affects the genetic makeup of the population through a random process. It does not produce adaptations.*** ***Gene flow moves alleles between populations. Migration is a common way gene flow***	**CAUSE AND EFFECT** Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. ***Evidence is required when attributing an observed phenomenon to a specific cause.*** ***Evidence is required to explain the causal mechanisms in a system under study.*** ***Evidence is required to support a claim about the causal mechanisms in a system under study.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Construct an explanation based on valid and reliable evidence from the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. ***Revise an explanation based on valid and reliable evidence from a variety of sources.*** ***Revise an explanation based on valid and reliable evidence from the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.***	***occurs.*** **ADAPTATION** 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. (HS.LS4C.a) ***The inheritance of certain traits can lead to a competitive advantage for certain organisms in a population.*** ***Advantages lead to increased survival and/or reproductive rates within the population.*** ***Natural selection leads to adaptation in a population dominated by organisms that are anatomically, behaviorally, and physiologically well suited to survive and reproduce in a specific environment.*** 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. (HS.LS4C.c) ***Environmental changes have a strong influence on the evolutionary process.*** ***Changes in the physical environment, naturally occurring or human induced, contribute to changes in biodiversity. Changes may include species expansion, invasive species, and extinction.*** ***Possible outcomes of human interactions include changes in the number of individuals of some species, emergence of new species over time, and the extinction of other species.***	

Clarification Statement
Emphasis is on using data to provide evidence for how specific biotic and abiotic differences in ecosystems (such as ranges of seasonal temperature, long-term climate change, acidity, light, geographic barriers, or evolution of other organisms) contribute to a change in gene frequency over time, leading to adaptation of populations.

Performance Expectation *and Louisiana Connectors*
HS-LS4-5 Evaluate evidence supporting claims that changes in environmental conditions can affect the distribution of traits in a population causing: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species. ***LC-HS-LS4-5a Identify the relationship between naturally occurring or human-induced changes in the environment (e.g., drought, flood, deforestation, fishing, application of fertilizers) and the expression of traits in a species (e.g., peppered moth studies).*** ***LC-HS-LS4-5b Identify the relationship between naturally occurring or human-induced changes in the environment (e.g., drought, flood, deforestation, fishing, application of fertilizers) and the emergence of new species over time.*** ***LC-HS-LS4-5c Identify that species become extinct because they can no longer survive and reproduce given changes in the environment.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Engaging in argument from evidence: Engaging in argument from evidence in 9-12 builds on K-8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science. • Evaluate the claims, evidence, and/or reasoning behind currently accepted explanations or solutions to determine the merits of arguments. ***Evaluate the claims behind currently accepted explanations to determine the merits of arguments.*** ***Evaluate the claims behind currently accepted solutions to***	**ADAPTATION** Changes in the physical environment, whether naturally occurring or human-induced, have thus contributed to the expansion of some species, the emergence of new distinct species as populations diverge under different conditions, and the decline–and sometimes the extinction–of some species. (HS.LS4C.c) ***Environmental changes have a strong influence on the evolutionary process.*** ***Changes in the physical environment, naturally occurring or human-induced, contribute to changes in biodiversity. Changes may include species expansion, invasive species, and extinction.*** ***Possible outcomes of human interactions include changes in the number of individuals of some species, emergence of new species over time, and the extinction of other species.*** 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. (HS.LS4C.d) ***When a physical change to an organism's environment is sudden and/or extreme, a species becomes extinct when they are no longer able to survive and reproduce.*** ***Thus, drastic changes to an environment limits the possibilities of species' evolution.***	**CAUSE AND EFFECT** Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. ***Evidence is required when attributing an observed phenomenon to a specific cause.*** ***Evidence is required to explain the causal mechanisms in a system under study.*** ***Evidence is required to support a claim about the causal mechanisms in a system under study.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
determine the merits of arguments. Evaluate the evidence behind currently accepted explanations to determine the merits of arguments. Evaluate the evidence behind currently accepted solutions to determine the merits of arguments. Evaluate the reasoning behind currently accepted explanations to determine the merits of arguments. Evaluate the reasoning behind currently accepted solutions to determine the merits of arguments.		

Clarification Statement
Emphasis is on determining cause and effect relationships for how changes to the environment such as deforestation, overfishing, application of fertilizers, drought, flood, and the rate of change of the environment affect distribution or disappearance of traits in species.