

FROM MOLECULES TO ORGANISMS: STRUCTURES AND PROCESSES

Performance Expectation	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.
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.

Science & Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
<ol style="list-style-type: none"> Asking questions and defining problems Developing and using models Planning and carrying out investigations Analyzing and interpreting data Using mathematics and computational thinking 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. <ul style="list-style-type: none"> 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. Engaging in argument from evidence Obtaining, evaluating, and communicating information 	<p>STRUCTURE AND FUNCTION</p> <p>Systems of specialized cells within organisms help them perform the essential functions of life. (HS.LS1A.a)</p> <p>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)</p>	<p>STRUCTURE AND FUNCTION</p> <p>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.</p>

FROM MOLECULES TO ORGANISMS: STRUCTURES AND PROCESSES

Performance Expectation	Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.
Clarification Statement	Emphasis is on functions at the organism system level such as nutrient uptake, water delivery, 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.

Science & Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
<ol style="list-style-type: none"> Asking questions and defining problems 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). <ul style="list-style-type: none"> 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. Planning and carrying out investigations Analyzing and interpreting data Using mathematics and computational thinking Constructing explanations and designing solutions Engaging in argument from evidence Obtaining, evaluating, and communicating information 	<p>STRUCTURE AND FUNCTION</p> <p>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)</p>	<p>SYSTEMS AND SYSTEM MODELS</p> <p>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.</p>

FROM MOLECULES TO ORGANISMS: STRUCTURES AND PROCESSES

Performance Expectation	Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis in living organisms.
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.

Science & Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
<ol style="list-style-type: none"> Asking questions and defining problems Developing and using models 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. <ul style="list-style-type: none"> 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. Analyzing and interpreting data Using mathematics and computational thinking Constructing explanations and designing solutions Engaging in argument from evidence Obtaining, evaluating, and communicating information 	<p>STRUCTURE AND FUNCTION</p> <p>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)</p>	<p>STABILITY AND CHANGE</p> <p>Feedback (negative or positive) can stabilize or destabilize a system.</p>

FROM MOLECULES TO ORGANISMS: STRUCTURES AND PROCESSES

Performance Expectation	Use a model to illustrate the role of the cell cycle and differentiation in producing and maintaining complex organisms.
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.

Science & Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
<ol style="list-style-type: none"> Asking questions and defining problems 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). <ul style="list-style-type: none"> 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. Planning and carrying out investigations Analyzing and interpreting data Using mathematics and computational thinking Constructing explanations and designing solutions Engaging in argument from evidence Obtaining, evaluating, and communicating information 	<p>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)</p> <p>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)</p> <p>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)</p>	<p>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.</p>

FROM MOLECULES TO ORGANISMS: STRUCTURES AND PROCESSES

Performance Expectation	Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy.
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.

Science & Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
<ol style="list-style-type: none"> Asking questions and defining problems 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 <ul style="list-style-type: none"> 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. Planning and carrying out investigations Analyzing and interpreting data Using mathematics and computational thinking Constructing explanations and designing solutions Engaging in argument from evidence Obtaining, evaluating, and communicating information 	<p>ORGANIZATION FOR MATTER AND ENERGY FLOW IN ORGANISMS</p> <p>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)</p>	<p>ENERGY AND MATTER</p> <p>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.</p>

FROM MOLECULES TO ORGANISMS: STRUCTURES AND PROCESSES

Performance Expectation	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.
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.

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FROM MOLECULES TO ORGANISMS: STRUCTURES AND PROCESSES

Performance Expectation	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.
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.

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<ol style="list-style-type: none"> Asking questions and defining problems 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). <ul style="list-style-type: none"> 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. Planning and carrying out investigations Analyzing and interpreting data Using mathematics and computational thinking Constructing explanations and designing solutions Engaging in argument from evidence Obtaining, evaluating, and communicating information 	<p>ORGANIZATION FOR MATTER AND ENERGY FLOW IN ORGANISMS</p> <p>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)</p> <p>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)</p>	<p>ENERGY AND MATTER</p> <p>Energy cannot be created or destroyed—it only moves between one place and another place, between objects and/or fields, or between systems.</p>

FROM MOLECULES TO ORGANISMS: STRUCTURES AND PROCESSES

Performance Expectation	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.
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.

Science & Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
<ol style="list-style-type: none"> Asking questions and defining problems Developing and using models Planning and carrying out investigations Analyzing and interpreting data Using mathematics and computational thinking Constructing explanations and designing solutions Engaging in argument from evidence 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. <ul style="list-style-type: none"> 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. 	<p>PUBLIC HEALTH</p> <p>Viruses are obligate intracellular parasites that replicate using a cell's protein expression mechanisms. (HS.LS1E.a)</p> <p>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)</p> <p>Antibiotics are effective treatments against most bacterial infections. Some bacteria may develop resistance to these treatments. (HS.LS1E.c)</p> <p>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)</p> <p>Microorganisms can reproduce quickly. (HS.LS1E.e)</p>	<p>SCALE, PROPORTION, AND QUANTITY</p> <p>The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs.</p>

ECOSYSTEMS: INTERACTIONS, ENERGY AND DYNAMICS

Performance Expectation	Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity, biodiversity and populations of ecosystems at different scales.
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.

Science & Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
<ol style="list-style-type: none"> Asking questions and defining problems Developing and using models Planning and carrying out investigations Analyzing and interpreting data 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. <ul style="list-style-type: none"> Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations. Constructing explanations and designing solutions Engaging in argument from evidence Obtaining, evaluating, and communicating information 	<p>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)</p> <p>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)</p>	<p>SCALE, PROPORTION, AND QUANTITY The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs.</p>

ECOSYSTEMS: INTERACTIONS, ENERGY AND DYNAMICS

Performance Expectation	Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem.
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.

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<ol style="list-style-type: none"> Asking questions and defining problems Developing and using models Planning and carrying out investigations Analyzing and interpreting data 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. <ul style="list-style-type: none"> Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations. Constructing explanations and designing solutions Engaging in argument from evidence Obtaining, evaluating, and communicating information 	<p>CYCLES OF MATTER AND ENERGY TRANSFER IN ECOSYSTEMS</p> <p>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)</p> <p>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)</p> <p>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)</p>	<p>ENERGY AND MATTER: FLOWS, CYCLES, AND CONSERVATION</p> <p>Energy cannot be created or destroyed—it only moves between one place and another place, between objects and/or fields, or between systems.</p>

ECOSYSTEMS: INTERACTIONS, ENERGY AND DYNAMICS

Performance Expectation	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.
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.

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<ol style="list-style-type: none"> Asking questions and defining problems Developing and using models Planning and carrying out investigations Analyzing and interpreting data Using mathematics and computational thinking Constructing explanations and designing solutions 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. <ul style="list-style-type: none"> Evaluate the claims, evidence, and/or reasoning behind currently accepted explanations or solutions to determine the merits of arguments. Obtaining, evaluating, and communicating information 	<p>ECOSYSTEM DYNAMICS, FUNCTIONING, AND RESILIENCE</p> <p>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)</p>	<p>STABILITY AND CHANGE</p> <p>Much of science deals with constructing explanations of how things change and how they remain stable.</p>

ECOSYSTEMS: INTERACTIONS, ENERGY AND DYNAMICS

Performance Expectation	Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.
Clarification Statement	Examples of human activities can include urbanization, building dams, or dissemination of invasive species.

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HEREDITY: INHERITANCE AND VARIATION OF TRAITS

Performance Expectation	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.
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.

Science & Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
<ol style="list-style-type: none"> 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. <ul style="list-style-type: none"> Ask questions that arise from examining models or a theory, to clarify and/or seek additional information and relationships. Developing and using models Planning and carrying out investigations Analyzing and interpreting data Using mathematics and computational thinking Constructing explanations and designing solutions Engaging in argument from evidence Obtaining, evaluating, and communicating information 	<p>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)</p> <p>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)</p> <p>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)</p>	<p>CAUSE AND EFFECT Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.</p>

HEREDITY: INHERITANCE AND VARIATION OF TRAITS

Performance Expectation	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.
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.

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HEREDITY: INHERITANCE AND VARIATION OF TRAITS

Performance Expectation	Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.
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.

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<ol style="list-style-type: none"> Asking questions and defining problems Developing and using models Planning and carrying out investigations 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. <ul style="list-style-type: none"> 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. Using mathematics and computational thinking Constructing explanations and designing solutions Engaging in argument from evidence Obtaining, evaluating, and communicating information 	<p>VARIATION OF TRAITS</p> <p>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)</p> <p>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)</p>	<p>SCALE, PROPORTION AND QUANTITY</p> <p>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).</p>

BIOLOGICAL EVOLUTION: UNITY AND DIVERSITY

Performance Expectation	Analyze and interpret scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence.
Clarification Statement	Emphasis is on a conceptual understanding of the role each line of evidence (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.

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BIOLOGICAL EVOLUTION: UNITY AND DIVERSITY

Performance Expectation	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.
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.

Science & Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
<ol style="list-style-type: none"> Asking questions and defining problems Developing and using models Planning and carrying out investigations Analyzing and interpreting data Using mathematics and computational thinking 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. <ul style="list-style-type: none"> 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. Engaging in argument from evidence Obtaining, evaluating, and communicating information 	<p>NATURAL SELECTION</p> <p>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)</p> <p>The traits that positively affect survival are more likely to be reproduced, and thus are more common in the population. (HS.LS4B.c)</p>	<p>CAUSE AND EFFECT</p> <p>Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.</p>

BIOLOGICAL EVOLUTION: UNITY AND DIVERSITY

Performance Expectation	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.
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.

Science & Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
<ol style="list-style-type: none"> Asking questions and defining problems Developing and using models Planning and carrying out investigations 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. <ul style="list-style-type: none"> 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. Using mathematics and computational thinking Constructing explanations and designing solutions Engaging in argument from evidence Obtaining, evaluating, and communicating information 	<p>NATURAL SELECTION</p> <p>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)</p> <p>The traits that positively affect survival are more likely to be reproduced, and thus are more common in the population. (HS.LS4B.c)</p> <p>ADAPTATION</p> <p>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)</p> <p>Adaptation also means that the distribution of traits in a population can change when conditions change. (HS.LS4C.b)</p>	<p>PATTERNS</p> <p>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.</p>

BIOLOGICAL EVOLUTION: UNITY AND DIVERSITY

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

Science & Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
<ol style="list-style-type: none"> Asking questions and defining problems Developing and using models Planning and carrying out investigations Analyzing and interpreting data Using mathematics and computational thinking 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. <ul style="list-style-type: none"> 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. Engaging in argument from evidence Obtaining, evaluating, and communicating information 	<p>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)</p> <p>Genetic drift and gene flow can lead to genetic changes in populations, not adaptations. (HS.LS4B.b)</p> <p>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)</p> <p>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)</p>	<p>CAUSE AND EFFECT Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.</p>

BIOLOGICAL EVOLUTION: UNITY AND DIVERSITY

Performance Expectation	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.
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.

Science & Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
<ol style="list-style-type: none"> Asking questions and defining problems Developing and using models Planning and carrying out investigations Analyzing and interpreting data Using mathematics and computational thinking Constructing explanations and designing solutions 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. <ul style="list-style-type: none"> Evaluate the claims, evidence, and/or reasoning behind currently accepted explanations or solutions to determine the merits of arguments. Obtaining, evaluating, and communicating information 	<p>ADAPTATION</p> <p>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)</p> <p>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)</p>	<p>CAUSE AND EFFECT</p> <p>Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.</p>