COLORADO
Department of Education

Prepared Graduates:

5. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how individual organisms are configured and how these structures function to support life, growth, behavior and reproduction.

Grade Level Expectation:

1. DNA codes for the complex hierarchical organization of systems that enable life's functions.

Evidence Outcomes

Students Can:

a. 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. (HS-LS1-1) *(Boundary Statement: Does not include identification of specific cell or tissue types, whole body systems, specific protein structures and functions, or the biochemistry of protein synthesis.)*

b. Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms. (HS-LS1-2) *(Clarification Statement: Emphasis is on functions at the organism system level such as nutrient uptake, water delivery, and 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.) (Boundary Statement: Does not include interactions and functions at the molecular or chemical reaction level.)*

c. Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis. (HS-LS1-3) *(Clarification Statement: Examples of investigations could include heart rate response to exercise, stomate response to moisture and temperature, and root development in response to water levels.) (Boundary Statement: Does not include the cellular processes involved in the feedback mechanism.)*

Academic Context and Connections

Colorado Essential Skills and Science and Engineering Practices:

1. Develop and use a model based on evidence to illustrate the relationship between systems or between components of a system. (Developing and Using Models) (Personal: Initiative/Self-direction)
2. 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 traits, cost, risk, time), and refine the design accordingly. (Planning and Carrying Out Investigations) (Entrepreneurial: Inquiry/Analysis)
3. Construct an explanation based on valid and reliable evidence obtained from a variety 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. (Constructing Explanations and Designing Solutions) (Civic/Interpersonal: Global/Cultural awareness)

Elaboration on the GLE:

1. Students can answer the question: How do the structures of organisms enable life's functions?
2. LS1:A Structure and Function: Systems of specialized cells within organisms help them perform the essential functions of life. All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins, which carry out most of the work of cells. 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. Feedback mechanisms maintain a living system's internal conditions within certain limits and mediate behaviors, allowing it to remain alive and functional even as external conditions change within some range. Feedback mechanisms can encourage (through positive feedback) or discourage (negative feedback) what is going on inside the living system.

Cross Cutting Concepts:

1. Systems and System Models: Models (e.g., physical, mathematical, computer) can be used to simulate systems and interactions – including energy, matter, and information flows – within and between systems at different scales.
2. Structure and Function: Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components to reveal the structure's function and/or to solve a problem.
3. Stability and Change: Feedback (negative or positive) can stabilize or destabilize a system.

COLORADO
Department of Education

Prepared Graduates:

5. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how individual organisms are configured and how these structures function to support life, growth, behavior and reproduction.

Grade Level Expectation:

2. Growth and division of cells in complex organisms occurs by mitosis, which differentiates specific cell types.

Evidence Outcomes

Students Can:

a. Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms. (HS-LS1-4) *(Boundary Statement: Does not include specific gene control mechanisms or rote memorization of the steps of mitosis.)*

Academic Context and Connections

Colorado Essential Skills and Science and Engineering Practices:

1. Use a model based on evidence to illustrate the relationships between systems or between components of systems. (Developing and Using Models) (Professional: Information/Communication technologies)

Elaboration on the GLE:

1. Students can answer the question: How do organisms grow and develop?
2. LS1:B Growth and Development of Organisms: In multicellular organisms individual cells grow and then divide via a process called mitosis, thereby allowing the organism to grow. The organism begins as a single cell (fertilized egg) that divides successively to produce many cells, with each parent cell passing identical genetic material (two variants of each chromosome pair) to both daughter cells. Cellular division and differentiation produce and maintain a complex organism, composed of systems of tissues and organs that work together to meet the needs of the whole organism.

Cross Cutting Concepts:

1. Systems and System Models: Models (e.g., physical, mathematical, computer) can be used to stimulate systems and interactions – including energy, matter, and information flows – within and between systems at different scales.
2. Structure and Function: Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components to reveal the structure's function and/or to solve a problem.
3. Stability and Change: Feedback (negative or positive) can stabilize or destabilize a system.

COLORADO
Department of Education

Prepared Graduates:

5. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how individual organisms are configured and how these structures function to support life, growth, behavior and reproduction.

Grade Level Expectation:

3. Organisms use matter and energy to live and grow.

Evidence Outcomes

Students Can:

a. Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy. (HS-LS1-5) *(Clarification Statement: Emphasis is on illustrating inputs and outputs of matter and the transfer and transformation of energy in photosynthesis by plants and other photosynthesizing organisms. Examples of models could include diagrams, chemical equations, and conceptual models.) (Boundary Statement: Does not include specific biochemical steps.)*
b. 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. (HS-LS1-6) *(Clarification Statement: Emphasis is on using evidence from models and simulations to support explanations.) (Boundary Statement: Does not include the details of the specific chemical reactions or identification of macromolecules.)*
c. 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. (HS-LS1-7) *(Clarification Statement: Emphasis is on the conceptual understanding of the inputs and outputs of the process of cellular respiration.)*

Academic Context and Connections

Colorado Essential Skills and Science and Engineering Practices:

1. Use a model based on evidence to illustrate the relationships between systems or between components of systems. (Developing and Using Models) (Personal: Initiative/Self-direction)
2. 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 would operate today as they did the past and will continue to do so in the future. (Constructing Explanations and Designing Solutions) (Entrepreneurial: Creativity/Innovation)

Elaboration on the GLE:

1. Students can answer the question: How do organisms obtain and use the matter and energy they need to live and grow?

2. LS1:C Organization for Matter and Energy Flow in Organisms: The process of photosynthesis converts light energy to stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen. 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. As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products. As a result of these chemical reactions, energy is transferred from one system of interacting molecules to another and release energy to the surrounding environment and to maintain body temperature. Cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and new compounds are formed that can transport energy to muscles.

Cross Cutting Concepts:

1. 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.

COLORADO
Department of Education

Prepared Graduates:

6. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how living systems interact with the biotic and abiotic environment.

Grade Level Expectation:

4. Organisms interact with the living and nonliving components of the environment to obtain matter and energy.

Evidence Outcomes

Students Can:

a. Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales. (HS-LS2-1) *(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, and population changes gathered from simulations or historical data sets.)*

b. Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales. (HS-LS2-2) *(Clarification Statement: Examples of mathematical representations include finding the average, determining trends, and using graphical comparisons of multiple sets of data.)*

Academic Context and Connections

Colorado Essential Skills and Science and Engineering Practices:

1. Use mathematical and/or computational representations of phenomena or design solutions to support explanations. (Using Mathematical and Computational Thinking) (Entrepreneurial: Critical thinking/Problem solving)
2. Connections to Nature of Science: Scientific Knowledge is open to revision in light of new evidence. Most scientific knowledge is quite durable, but is, in principle, subject to change based on new evidence and/or reinterpretation of existing evidence.

Elaboration on the GLE:

1. Students can answer the question: How do organisms interact with the living and nonliving environments to obtain matter and energy?
2. LS2:A Interdependent Relationships in Ecosystems: Ecosystems have carrying capacities, which are limits to the numbers of organisms and populations they can support. These limits result from such factors as the availability of living and nonliving resources and from such challenges such as predation, competition, and disease. Organisms would have the capacity to produce populations of great size were it not for the fact that environments and resources are finite. This fundamental tension affects the abundance (number of individuals) of species in any given ecosystem.

3. LS2:C Ecosystem Dynamics, Functioning, and Resilience: A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions. If a modest biological or physical disturbance to an ecosystem occurs, it may return to its more or less original status (i.e., the ecosystem is resilient), as opposed to becoming a very different ecosystem. Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of ecosystems in terms of resources and habitat availability.

Cross Cutting Concepts:

1. Scale, Proportion, and Quantity: The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. Using the concept of orders of magnitude allows one to understand how a model at one scale relates to a model at another scale.

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Prepared Graduates:

6. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how living systems interact with the biotic and abiotic environment.

Grade Level Expectation:

5. Matter and energy necessary for life are conserved as they move through ecosystems.

Evidence Outcomes

Students Can:

a. Construct and revise an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions. (HS-LS2-3) *(Clarification Statement: Emphasis is on conceptual understanding of the role of aerobic and anaerobic respiration in different environments.)*
b. Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem. (HS-LS2-4) *(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.)*
c. Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere. (HS-LS2-5) *(Clarification Statement: Examples of models could include simulations and mathematical models.)*

Academic Context and Connections

Colorado Essential Skills and Science and Engineering Practices:

1. 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. (Constructing Explanations and Revising Solution) (Entrepreneurial: Creativity/Innovation)
2. Use mathematical representations of phenomena or design solutions to support claims. (Using Mathematics and Computational Thinking) (Entrepreneurial: Critical thinking/Problem solving)
3. Develop a model based on evidence to illustrate the relationships between systems or components of a system. (Developing and Using Models) (Personal: Initiative/Self-direction)
4. Connections to Nature of Science: Scientific Knowledge is open to revision in light of new evidence. Most scientific knowledge is quite durable, but is, in principle, subject to change based on new evidence and/or reinterpretation of existing evidence.

Elaboration on the GLE:

1. Students can answer the question: How do matter and energy move through an ecosystem?
2. LS2:B Cycles of Matter and Energy Transfer in Ecosystems: Photosynthesis and cellular respiration (including anaerobic processes) provide most of the energy for life processes.
3. LS2:B Cycles of Matter and Energy Transfer in Ecosystems: Plants or algae form the lowest level of the food web. At each link upward in a food web, only a small fraction of the matter consumed at the lower level is transferred upward, to produce growth and release energy in cellular respiration at the higher level. Given this inefficiency, there are generally fewer organisms at higher levels of a food web. Some matter reacts to release energy for life functions, some matter is stored in newly made structures, and much is discarded. The chemical elements that make up the molecules of organisms pass through food webs and into and out of the atmosphere and soil, and they are combined and recombined in different ways. At each link in an ecosystem, matter and energy are conserved.
4. PS3:D Energy in Chemical Processes: The main way that solar energy is captured and stored on Earth is through the complex chemical process known as photosynthesis.

Cross Cutting Concepts:

1. 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.
2. Energy and Matter: Energy drives the cycling of matter within and between systems. Energy cannot be created or destroyed—it only moves between one place and another place, between objects and/or fields, or between systems.

COLORADO
Department of Education

Prepared Graduates:

6. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how living systems interact with the biotic and abiotic environment.

Grade Level Expectation:

6. A complex set of interactions determine how ecosystems respond to disturbances.

Evidence Outcomes

Students Can:

a. Evaluate 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. (HS-LS2-6) *(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.)*
b. Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity. (HS-LS2-7) *(Clarification Statement: Examples of human activities can include urbanization, building dams, and dissemination of invasive species.)*

Academic Context and Connections

Colorado Essential Skills and Science and Engineering Practices:

1. Design, evaluate, and refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade-off considerations. (Constructing Explanations and Designing Solutions) (Civic/Interpersonal: Civic Engagement)
2. Arguments may also come from current scientific or historical episodes in science.-Evaluate the claims, evidence, and reasoning behind currently accepted explanations or solutions to determine the merits of arguments. (Engaging in Argument from Evidence) (Personal: Initiative/Self-direction)
3. Connections to Nature of Science: Scientific Knowledge is open to revision in light of new evidence. Scientific argumentation is a mode of logical discourse used to clarify the strength of relationships between ideas and evidence that may result in revision of an explanation.

Elaboration on the GLE:

1. Students can answer the question: What happens to ecosystems when the environment changes?
2. LS2:C Ecosystem Dynamics, Functioning, and Resilience: Anthropogenic changes (induced by human activity) in the environment — including habitat destruction, pollution, introduction of invasive species, over-exploitation, and climate change — can disrupt an ecosystem and threaten the survival of some species.
3. LS4:D 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. But human activity is also having adverse impacts on biodiversity through overpopulation, over-exploitation, 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.

Cross Cutting Concepts:

1. Stability and Change: Much of science deals with constructing explanations of how things change and how they remain stable.

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Prepared Graduates:

6. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how living systems interact with the biotic and abiotic environment.

Grade Level Expectation:

7. Organisms interact in groups to benefit the species.

Evidence Outcomes

Students Can:

a. Evaluate evidence for the role of group behavior on individual and species' chances to survive and reproduce. (HS-LS2-8) *(Clarification Statement: Emphasis is on: (1) distinguishing between group and individual behavior, (2) identifying evidence supporting the outcomes of group behavior, and (3) developing logical and reasonable arguments based on evidence. Examples of group behaviors could include flocking, schooling, herding, and cooperative behaviors such as hunting, migrating, and swarming.)*

Academic Context and Connections

Colorado Essential Skills and Science and Engineering Practices:

1. Evaluate the evidence behind currently accepted explanations to determine the merits of arguments. (Engaging in Arguments from Evidence) (Personal: Initiative/Self-direction)
2. Connections to Nature of Science: Scientific knowledge is open to revision in light of new evidence. Scientific argumentation is a mode of logical discourse used to clarify the strength of relationships between ideas and evidence that may result in revision of an explanation.

Elaboration on the GLE:

1. Students can answer the question: How do organisms interact in groups so as to benefit individuals?
2. LS2:D Social Interactions and Group Behavior: Group behavior has evolved because membership can increase the chances of survival for individuals and their genetic relatives.

Cross Cutting Concepts:

1. Cause and Effect: Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects

COLORADO
Department of Education

Prepared Graduates:

7. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how genetic and environmental factors influence variation of organisms across generations.

Grade Level Expectation:

8. The characteristics of one generation are dependent upon the genetic information inherited from previous generations.

Evidence Outcomes

Students Can:

a. Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring. (HS-LS3-1) *(Clarification Statement: Does not include the phases of meiosis or the biochemical mechanism of specific steps in the process.)*

Academic Context and Connections

Colorado Essential Skills and Science and Engineering Practices:

1. Ask questions that arise from examining models or a theory to clarify relationships. (Asking Questions and Defining Problems) (Entrepreneurial: Inquiry/Analysis)

Elaboration on the GLE:

1. Students can answer the question: How are the characteristics of one generation related to the previous generation?
2. LS1:A Structure and Function: All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins.
3. LS3:A Inheritance of Traits: Each chromosome consists of a single very long DNA molecule, and each gene on the chromosome is a particular segment of that DNA. The instructions for forming species' characteristics are carried in DNA. All cells in an organism have the same genetic content, but the genes used (expressed) by the cell may be regulated in different ways. Not all DNA codes for a protein; some segments of DNA are involved in regulatory or structural functions, and some have no as-yet known function.

Cross Cutting Concepts:

1. Cause and Effect: Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

COLORADO
Department of Education

Prepared Graduates:

8. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how natural selection drives biological evolution accounting for the unity and diversity of organisms.

Grade Level Expectation:

9. Variation between individuals results from genetic and environmental factors.

Evidence Outcomes

Students Can:

a. Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population. (HS-LS3-3) *(Clarification Statement: Emphasis is on the use of mathematics to describe the probability of traits as it relates to genetic and environmental factors in the expression of traits.)*
b. 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. (HS-LS3-2) *(Clarification Statement: Emphasis is on using data to support arguments for the way variation occurs.)*

Academic Context and Connections

Colorado Essential Skills and Science and Engineering Practices:

1. Make and defend a claim based on evidence about the natural world that reflects scientific knowledge, and student-generated evidence. (Engaging in Argument from Evidence) (Civic/Interpersonal: Collaboration/Teamwork)
2. Apply concepts of statistics and probability (including determining function fits to data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible. (Analyzing and Interpreting Data) (Entrepreneurial: Critical thinking/Problem solving)
3. Connections to Nature of Science: Science is a human endeavor. Technological advances have influenced the progress of science and science has influenced advances in technology. Science and engineering are influenced by society and society is influenced by science and engineering.

Elaboration on the GLE:

1. Students can answer the question: Why do individuals of the same species vary in how they look, function, and behave?
2. LS3:B Variation of Traits: In sexual reproduction, chromosomes can sometimes swap sections during the process of meiosis (cell division), thereby creating new genetic combinations and thus more genetic variation. Although DNA replication is tightly regulated and remarkably accurate, errors do occur and result in mutations, which are also a source of genetic variation. Environmental factors can also cause mutations in genes, and viable mutations are inherited. 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.

Cross Cutting Concepts:

1. Cause and Effect: Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

COLORADO
Department of Education

Prepared Graduates:

8. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how natural selection drives biological evolution accounting for the unity and diversity of organisms.

Grade Level Expectation:

10. Evidence of common ancestry and diversity between species can be determined by examining variations including genetic, anatomical and physiological differences.

Evidence Outcomes

Students Can:

a. Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence. (HS-LS4-1) *(Clarification Statement: Emphasis is on a conceptual understanding of the role each line of evidence has relating to common ancestry and biological evolution. Examples of evidence could include similarities in DNA sequences, anatomical structures, and order of appearance of structures in embryological development.)*

Academic Context and Connections

Colorado Essential Skills and Science and Engineering Practices:

1. Communicate scientific information (e.g., about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).(Analyzing and Interpreting Data) (Entrepreneurial: Critical thinking/Problem solving)
2. Connections to Nature of Science: Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena. A scientific theory is a substantiated explanation of some aspect of the natural world, based on a body of facts that have been repeatedly confirmed through observation and experiment and the science community validates each theory before it is accepted. If new evidence is discovered that the theory does not accommodate, the theory is generally modified in light of this new evidence.

Elaboration on the GLE:

1. Students can answer the question: Why do individuals of the same species vary in how they look, function, and behave?
2. LS4:A Evidence of Common Ancestry and Diversity: Genetic information, like the fossil record, 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 anatomical and embryological evidence.

Cross Cutting Concepts:

1. 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.
2. Connections to Nature of Science: Scientific Knowledge Assumes an Order and Consistency in Natural Systems. Scientific knowledge is based on the assumption that natural laws operate today as they did in the past and they will continue to do so in the future.

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Prepared Graduates:

8. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how natural selection drives biological evolution accounting for the unity and diversity of organisms.

Grade Level Expectation:

11. Genetic variation among organisms affects survival and reproduction.

Evidence Outcomes

Students Can:

a. Construct an explanation based on evidence that the process of evolution primarily results from four factors: (1) the potential for a species to increase in number, (2) the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment. (HS-LS4-2) *(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 and proportional reasoning.) (Boundary Statement: Does not include other mechanisms of evolution, such as genetic drift, gene flow through migration, and co-evolution.)*

b. Apply concepts of statistics and probability to support explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait. (HS-LS4-3) *(Clarification Statement: Emphasis is on analyzing shifts in numerical distribution of traits and using these shifts as evidence to support explanations.) (Boundary Statement: Limited to basic statistical and graphical analysis. Assessment does not include allele frequency calculations.)*

Academic Context and Connections

Colorado Essential Skills and Science and Engineering Practices:

1. Apply concepts of statistics and probability (including determining function fits to data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible. (Analyzing and Interpreting Data) (Entrepreneurial: Inquiry/Analysis)
2. Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (Constructing Explanations and Designing Solutions) (Entrepreneurial: Critical thinking/Problem solving)

Elaboration on the GLE:

1. Students can answer the question: How does genetic variation among organisms affect survival and reproduction?
2. LS4:B Natural Selection: Natural selection occurs only if there is both (1) variation in the genetic information between organisms in a population and (2) variation in the expression of that genetic information — that is, trait variation — that leads to differences in performance among individuals. The traits that positively affect survival are more likely to be reproduced, and thus are more common in the population.

Cross Cutting Concepts:

1. 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.
2. Cause and Effect: Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

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Prepared Graduates:

8. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how natural selection drives biological evolution accounting for the unity and diversity of organisms.

Grade Level Expectation:

12. The environment influences survival and reproduction of organisms over multiple generations.

Evidence Outcomes

Students Can:

a. Construct an explanation based on evidence for how natural selection leads to adaptation of populations. (HS-LS4-4) *(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.)*

b. Evaluate the evidence supporting claims that changes in environmental conditions may result in (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species. (HS-LS4-5) *(Clarification Statement: Emphasis is on determining cause and effect relationships for how changes to the environment such as deforestation, fishing, application of fertilizers, drought, flood, and the rate of change of the environment affect distribution or disappearance of traits in species.)*

Academic Context and Connections

Colorado Essential Skills and Science and Engineering Practices:

1. Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (Constructing Explanations and Designing Solutions) (Entrepreneurial: Creativity/Innovation)
2. Arguments may also come from current or historical episodes in science. Evaluate the evidence behind currently accepted explanations or solutions to determine the merits of arguments. (Engaging in Argument from Evidence) (Entrepreneurial: Critical thinking/Problem solving)

Elaboration on the GLE:

1. Students can answer the question: How does the environment influence populations of organisms over multiple generations?

2. LS4:C Adaptation: Evolution is a consequence of the interaction of four factors: (1) the potential for a species to increase in number, (2) the genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for an environment's limited supply of the resources that individuals need in order to survive and reproduce, and (4) the ensuing proliferation of those organisms that are better able to survive and reproduce in that environment. 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. Adaptation also means that the distribution of traits in a population can change when conditions change. 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. 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.

Cross Cutting Concepts:

1. Cause and Effect: Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.
2. Connections to Nature of Science: Scientific Knowledge Assumes an Order and Consistency in Natural Systems. Scientific knowledge is based on the assumption that natural laws operate today as they did in the past and they will continue to do so in the future.

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Department of Education

Prepared Graduates:

8. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how natural selection drives biological evolution accounting for the unity and diversity of organisms.

Grade Level Expectation:

13. Humans have complex interactions with ecosystems and have the ability to influence biodiversity on the planet.

Evidence Outcomes

Students Can:

a. Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity. (HS-LS4-6) *(Clarification Statement: Emphasis is on testing solutions for a proposed problem related to threatened or endangered species, or to genetic variation of organisms for multiple species.)*

Academic Context and Connections

Colorado Essential Skills and Science and Engineering Practices:

1. Create or revise a simulation of a phenomenon, designed device, process, or system. (Using Mathematics and Computational Thinking) (Entrepreneurial: Critical thinking/Problem solving)

Elaboration on the GLE:

1. Students can answer the question: What is biodiversity, how do humans affect it, and how does it affect humans?
2. LS4:D Biodiversity and Humans: Humans depend on the living world for the resources and other benefits provided by biodiversity. But human activity is also having adverse impacts on biodiversity through overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change. Thus sustaining biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth. Sustaining biodiversity also aids humanity by preserving landscapes of recreational or inspirational value.

Cross Cutting Concepts:

1. Cause and Effect: Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.