ILLINOIS
STATE BOARD OF
EDUCATION

Theory of Action: Academic standards represent a collective commitment around what students should learn each year. The state assessment asks students to demonstrate their knowledge, skills, and understanding related to these standards using a common measure. The resulting data allows us to see patterns in performance that should guide school and district improvement, helping identify areas of strength and opportunity.

Role of Performance Level Descriptors in Defining Proficiency: Performance level descriptors bridge the state assessment to classroom instruction and the systems of formative assessments that guide local instruction and choices about individual students. ***Academic proficiency represents a <u>range</u> of observable student performance characteristics***. There are multiple pathways to proficiency, and students rely upon their strengths differently within that range of performance.

Proficiency and Difficulty: A student's ability to demonstrate proficiency is influenced by the complexity of the texts or stimuli presented, tasks they're asked to complete, and the contexts in which they are engaged. As student performance improves, students are typically able to handle more challenging texts/stimuli, tasks, and contexts, and are able to demonstrate their skills and knowledge more accurately and consistently.

SCIENCE HIGH SCHOOL LIFE SCIENCES

Life Sciences *Student performance indicates the ability to…*

HS-LS1-1	Below Proficient	Approaching Proficient	Proficient	Above Proficient
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.	**Identify** basic cell structures (e.g., nucleus, cell membrane) and recognize DNA as genetic material without connecting **structure to function** at the molecular level.	**Construct** simple explanations showing that DNA contains genetic information that relates to protein production, but with **incomplete connections** between molecular structure and cellular function.	**Construct** detailed explanations showing how the **structure of DNA** enables it to encode genetic information that determines protein structure and function.	**Develop** comprehensive explanations that integrate **structure-function relationships** across **multiple scales**, from DNA base-pairing to protein folding to organism-level traits.
DCI: LS1.A: Structure and Function	**Describe** simplified versions of protein synthesis that lack accurate details about the **information flow** from genes to proteins.	**Outline** the general process of gene expression with some awareness of the **cause-effect relationship** between DNA sequence and protein structure.	**Explain** the mechanisms of **gene expression** from DNA to RNA to protein, including how nucleotide sequences correspond to amino acid sequences.	**Analyze** how changes in DNA structure can affect protein structure and function and **predict** resulting effects on cellular systems and organism phenotype.
SEP: Constructing Explanations	**Recognize** that DNA contains information but show limited understanding of how this relates to **cellular systems** or protein function.	**Recognize** that proteins have specific shapes related to their functions but provide limited explanation of how DNA **determines** these structures.	**Connect** protein structure to **specific cellular functions** and explain how specialized cells utilize different proteins to perform their roles in multicellular organisms.	**Evaluate** how the **molecular mechanisms** of gene expression contribute to cell differentiation and the emergence of complex traits in multicellular organisms.
CCC: Structure and Function **ACT Integrations**: Scientific Investigation, Interpretation of Data	*For example, state that "DNA is in the nucleus and contains genes" without explaining how DNA structure encodes information or how this determines protein structure and cellular function.*	*For example, describe that "DNA has genes that code for proteins that do different jobs in the cell" but explain the mechanisms of transcription, translation, or protein folding with partial accuracy.*	*For example, explain how the nucleotide sequence in DNA codes for a specific sequence of amino acids in a protein that folds to form a functional enzyme that catalyzes a metabolic reaction within a specialized cell type.*	*For example, analyze how a point mutation in a DNA sequence alters amino acid sequence in a protein, changing its binding affinity in a signaling pathway, which affects cellular response and ultimately influences an organism-level trait like antibiotic resistance in bacteria.*

HS-LS1-2	Below Proficient	Approaching Proficient	Proficient	Above Proficient
Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.	**Identify** basic body systems and recognize some components like organs or tissues without representing their **hierarchical organization** or interactions.	**Develop** basic models showing some connections between body systems but with limited detail about how **smaller subsystems** contribute to larger system function.	**Develop** detailed models illustrating the **hierarchical organization** from cells to tissues to organs to organ systems, with clear representation of their interactions.	**Create** sophisticated models that demonstrate the **emergent properties** of biological systems, showing how interactions among components result in functions that cannot be predicted from individual parts.
DCI: LS1.A – Structure and Function	**Create** simple diagrams showing isolated body parts without connecting them to **system function** or illustrating how they work together.	**Represent** general relationships between cells, tissues, and organs with some awareness of **hierarchical organization** but incomplete representation of interactions.	**Explain** how structural organization at different levels contributes to **system function** and how multiple systems coordinate to maintain homeostasis.	**Analyze** how disruption at one organizational level cascades across multiple scales, affecting **system stability** and organism function.
SEP: Developing and Using Models **CCC**: Systems and System Models	**Recognize** that organisms contain different structures but show limited understanding of how these structures form **functional systems**.	**Describe** how major organ systems serve different functions but show partial understanding of how these systems **interact** to maintain organism homeostasis.	**Analyze** the relationships between structure and function across scales, showing how specialized cells contribute to tissue function and how tissues enable organ function.	**Integrate** molecular, cellular, and physiological mechanisms to explain how **feedback loops** maintain system function despite changing conditions.
ACT Integrations: Interpretation of Data, Scientific Investigation	*For example, label organs in a diagram but represent them as isolated parts rather than as components of interacting systems that together maintain organism function.*	*For example, create a model showing that the heart pumps blood through vessels and lungs add oxygen, but incompletely explain how these processes connect to cellular respiration or how multiple systems coordinate their activities.*	*For example, model how the circulatory and respiratory systems work together to deliver oxygen to tissues and remove carbon dioxide, showing how specialized cells in each organ contribute to these functions and how these processes support cellular metabolism throughout the body.*	*For example, model how changes in cellular ion channels affect cardiac muscle contraction, heart rhythm, blood pressure regulation, and ultimately tissue perfusion throughout the body, demonstrating how molecular changes cascade through multiple levels of organization and how regulatory mechanisms compensate for disruptions.*

HS-LS1-3	Below Proficient	Approaching Proficient	Proficient	Above Proficient
Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis. **DCI**: LS1.A – Structure and Function **SEP**: Planning and Carrying Out Investigations **CCC**: Stability and Change **ACT Integrations**: Scientific Investigation, Evaluation of Models	**Design** simple investigations related to biological responses but with limited consideration of variables, controls, or data collection methods needed to study feedback mechanisms. **Collect** observational data about organism responses without connecting these to homeostatic processes or regulatory systems. **Identify** basic physiological changes without recognizing the underlying feedback systems that regulate these changes. *For example, observe that plants grow toward light and record this directional growth, but not investigate the sensors, hormones, or response mechanisms involved in maintaining optimal light exposure.*	**Plan** basic investigations exploring processes like osmosis, diffusion, or temperature regulation with some attention to system responses and methodological controls. **Recognize** that organisms maintain internal stability but show incomplete understanding of how feedback mechanisms achieve this regulation. **Collect** relevant data about environmental changes and organism responses, but provide limited analysis of the cause-effect relationships in feedback loops. *For example, measure changes in body temperature after exercise and during recovery, but incompletely explain the sensors, effectors, or negative feedback loops that regulate this process to maintain homeostasis.*	**Design and implement** well-controlled investigations that test how **feedback mechanisms** maintain **dynamic equilibrium** in biological systems under changing conditions. **Analyze** experimental data to explain how positive and negative feedback loops respond to disruptions and return systems to set points or establish new equilibrium states. **Evaluate** the effectiveness of experimental designs, including appropriate controls, reliable measurements, and adequate sample sizes to draw valid conclusions about **regulatory mechanisms**. *For example, design an experiment testing how plants respond to changes in light direction, measuring growth rates, hormone concentrations, and cellular elongation to demonstrate how phototropism maintains optimal light exposure through negative feedback.*	**Design and execute** sophisticated investigations that integrate **multiple variables** and analyze their interactions in maintaining **system stability** across different organizational levels. **Apply** systems thinking to predict how perturbations affect interconnected feedback mechanisms and develop hypotheses about compensatory responses. **Evaluate** the limitations of experimental models and propose refinements that would more accurately capture the **complexity of biological regulation**. *For example, investigate how blood glucose regulation involves multiple hormones (insulin, glucagon), tissues (pancreas, liver, muscle), and signaling pathways, analyzing how disruptions in one component cascade through the system to affect cellular metabolism, tissue function, and whole-body energy balance.*

HS-LS1-4	Below Proficient	Approaching Proficient	Proficient	Above Proficient
Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms. **DCI**: LS1.B – Growth and Development of Organisms **SEP**: Developing and Using Models **CCC**: Systems and System Models **ACT Integrations**: Data Representation, Interpretation of Data	**Identify** basic cellular structures involved in energy processing without showing how energy **flows and transforms** through biological systems.	**Develop** basic models showing some aspects of cellular energy processes with partial representation of **energy transformation** stages.	**Construct** detailed models that illustrate how **chemical energy** stored in carbon-based molecules is transferred through cellular respiration to support cellular work.	**Create** sophisticated models that integrate energy transformations across **multiple scales**, from molecular interactions to ecosystem energy flows.
	Create simple representations of cells that identify some organelles but show limited understanding of their **functional relationships** or energy conversion roles.	**Trace** the general flow of energy through photosynthesis and cellular respiration but with incomplete details about intermediate molecules or reaction pathways.	**Explain** how ATP functions as the primary **energy currency** of cells, coupling energy-releasing reactions to energy-requiring processes.	**Analyze** thermodynamic constraints on biological systems and explain how **energy efficiency** varies across different metabolic pathways and trophic levels.
	Recognize that cells use food for energy without accurately representing the molecular processes of **energy transformation**.	**Describe** ATP as an energy carrier but show limited understanding of how its **molecular structure** relates to energy storage and transfer.	**Apply** principles of **energy conservation** to track how energy transforms from one form to another while supporting cellular functions and organismal processes.	**Evaluate** how environmental conditions influence energy transformation processes and how organisms have evolved optimal **energy capture and utilization** strategies.
	For example, identify chloroplasts and mitochondria in cell diagrams but represent energy conversion simply as "plants make food with sunlight" and "cells use food for energy" without showing the biochemical pathways involved.	*For example, create a flow diagram showing glucose breaking down to release energy in cells, but missing key processes like the electron transport chain or not accounting for the conservation of matter and energy.*	*For example, model how light energy is converted to chemical energy during photosynthesis, stored in glucose molecules, and then systematically released through cellular respiration to generate ATP that powers cellular work, with all energy transformations obeying thermodynamic principles.*	*For example, develop quantitative models that track energy from photosynthetic capture through food web transfers, analyzing efficiency losses at each step, explaining how cellular respiration pathways differ in efficiency, and connecting these processes to ecosystem productivity and resilience.*

HS-LS1-5	Below Proficient	Approaching Proficient	Proficient	Above Proficient
Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy.	**Identify** basic components of photosynthesis like sunlight, plants, and oxygen production without accurately representing **energy transformations** or molecular processes.	**Identify** basic components of photosynthesis like sunlight, plants, and oxygen production without accurately representing **energy transformations** or molecular processes.	**Construct** detailed models showing how **light energy** is converted to chemical energy during photosynthesis through a series of molecular interactions and chemical reactions.	**Create** sophisticated models that integrate **atomic/molecular interactions** with cellular structures and ecological energy flows in photosynthesis.
DCI: LS1.C – Organization for Matter and Energy Flow in Organisms SEP: Developing and Using Models CCC: Energy and Matter ACT Integrations: Evaluation of Models, Scientific Investigations	**Create** simple representations showing that plants use sunlight but lacking detail about reactants, products, or the **conservation of matter and energy**.	**Create** simple representations showing that plants use sunlight but lacking detail about reactants, products, or the **conservation of matter and energy**.	**Explain** how chlorophyll molecules capture photons, energizing electrons that power the splitting of water, generation of ATP and NADPH, and ultimately the fixation of carbon into glucose.	**Analyze** limiting factors in photosynthetic efficiency and predict how changing environmental conditions (light intensity, carbon dioxide levels, temperature) would affect energy capture and carbon fixation.
	Recognize that plants produce their own food but show limited understanding of the **molecular interactions** that convert light energy to chemical energy.	**Recognize** that plants produce their own food but show limited understanding of the **molecular interactions** that convert light energy to chemical energy.	**Track** both energy and matter through the light-dependent and light-independent reactions, demonstrating how **energy is transformed** and **matter is conserved** throughout the process.	**Evaluate** evolutionary adaptations in photosynthetic processes (C3, C4, CAM pathways) in terms of their **structural and functional advantages** in different environments.
	For example, draw plants in sunlight with arrows indicating "making food" without specifying the carbon dioxide and water inputs, glucose outputs, or the chemical processes that trap light energy in chemical bonds.	*For example, draw plants in sunlight with arrows indicating "making food" without specifying the carbon dioxide and water inputs, glucose outputs, or the chemical processes that trap light energy in chemical bonds.*	*For example, develop a model showing how light absorption by chlorophyll initiates electron transport chains that generate ATP and NADPH, which then power the Calvin cycle where carbon dioxide is fixed into carbohydrates, storing the energy in chemical bonds.*	*For example, develop models comparing how C3 and C4 plants differ in their carbon fixation mechanisms, analyzing how these structural and biochemical adaptations affect photosynthetic efficiency under varying CO_2 concentrations, temperatures, and water availability, with implications for agricultural productivity under climate change scenarios.*

HS-LS1-6	Below Proficient	Approaching Proficient	Proficient	Above Proficient
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.	**Identify** glucose as an energy source for cells without explaining the **molecular transformations** that release this energy or how atoms are rearranged.	**Construct** basic explanations describing how glucose is metabolized in cells, with some understanding of the **molecular rearrangements** but incomplete details about reaction pathways.	**Construct** detailed explanations of how cells systematically break down **carbon-based molecules** through a series of chemical reactions that transfer electrons and release energy.	**Develop** comprehensive explanations that integrate **atomic/molecular transformations** with cellular metabolism and broader ecosystem processes.
DCI: LS1.C – Organization for Matter and Energy Flow in Organisms	**Recognize** that cells break down sugar but show limited understanding of how the **atoms and energy** in glucose are transferred to other molecules.	**Trace** carbon compounds through simple metabolic pathways but show partial understanding of how electrons are transferred or how energy is captured in ATP.	**Explain** how the carbon, hydrogen, and oxygen atoms in glucose can be tracked through metabolic pathways, demonstrating that **matter is conserved** while energy is transformed.	**Analyze** how variations in metabolic pathways (aerobic respiration, anaerobic respiration, fermentation) reflect evolutionary adaptations to different environmental conditions.
SEP: Constructing Explanations and Designing Solutions **CCC**: Energy and Matter	**Describe** cellular processes in general terms without accurately representing the **chemical reactions** involved or the conservation of matter.	**Describe** how atoms from food molecules can become part of other biological molecules but with limited explanation of **specific biochemical transformations**.	**Analyze** how cellular respiration and biosynthetic pathways are connected, showing how organic molecules can be broken down for energy or used as building blocks for new molecules.	**Evaluate** the thermodynamic efficiency of different metabolic strategies and explain how **energy transformations** constrain biological systems across scales.
ACT Integrations: Scientific Explanation, Interpretation of Data	*For example, explain that "cells break down sugar for energy" without tracing the carbon atoms through metabolic pathways or explaining how energy is extracted step-by-step from chemical bonds.*	*For example, explain that glucose is broken down into carbon dioxide in mitochondria to release energy, but incompletely describe intermediate compounds, electron carriers, or how energy is systematically extracted and captured.*	*For example, trace how glucose enters glycolysis, producing pyruvate that enters the mitochondria for the citric acid cycle, releasing carbon dioxide while transferring electrons to carriers that power ATP synthesis in the electron transport chain, with clear accounting of carbon atoms throughout the process.*	*For example, compare how different fermentation pathways in yeast, bacteria, and muscle cells rearrange carbon compounds differently, affecting ATP yield and waste product formation, and analyze how these molecular adaptations provide selective advantages in specific ecological niches, connecting biochemistry to evolutionary fitness.*

HS-LS1-7	Below Proficient	Approaching Proficient	Proficient	Above Proficient
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. **DCI**: LS1.C – Organization for Matter and Energy Flow in Organisms **SEP**: Developing and Using Models **CCC**: Energy and Matter **ACT Integrations**: Evaluation of Models, Scientific Explanation	**Identify** that cells divide and multiply but show limited understanding of how this process maintains **genetic continuity** or contributes to organism growth. **Create** simple diagrams of dividing cells without accurate representation of chromosomes, DNA replication, or the **stages of mitosis**. **Recognize** that organisms have specialized cells but show limited understanding of how **cell differentiation** occurs from identical genetic material. *For example, draw cell division as simple splitting without addressing chromosome duplication, segregation, or the mechanisms that ensure each daughter cell receives identical genetic material.*	**Develop** basic models showing the main phases of mitosis with some understanding of chromosome behavior but incomplete details about **DNA replication** or nuclear division. **Describe** that specialized cells develop from stem cells but provide limited explanation of the **regulatory mechanisms** that control differentiation. **Explain** that cell division contributes to growth and repair with some awareness of the **cell cycle** but incomplete representation of checkpoints or control mechanisms. *For example, create models showing chromosomes separating during mitosis but incompletely explain centromere function, spindle apparatus, or how the cell cycle ensures accurate DNA replication before division begins.*	**Construct** detailed models showing how **chromosomes** are replicated, aligned, and distributed during mitosis, ensuring genetic continuity across cell generations. **Explain** how cell division contributes to growth, development, and tissue repair in multicellular organisms through regulated cycles of DNA replication and cytoplasmic division. **Model** how cellular differentiation produces specialized cells with distinct structures and functions despite containing identical genetic material, through selective gene expression. *For example, model how stem cells in bone marrow undergo controlled cell division and differentiation to produce specialized blood cells (erythrocytes, leukocytes, platelets) with distinct functions, while maintaining a population of undifferentiated cells for future divisions.*	**Develop** sophisticated models that integrate **molecular mechanisms** of cell cycle regulation with tissue development and organism-level growth patterns. **Analyze** how disruptions in cell cycle control or differentiation pathways contribute to diseases such as cancer, connecting molecular events to **system dysfunction**. **Evaluate** how signaling pathways, transcription factors, and epigenetic modifications interact to regulate **stem cell maintenance** and differentiation in complex tissues. *For example, model how signaling networks like Wnt and Notch pathways regulate stem cell division and fate determination, how epigenetic changes establish and maintain differentiated cell states, and how failures in these regulatory systems can lead to developmental disorders or cancerous growth.*

HS-LS2-1	Below Proficient	Approaching Proficient	Proficient	Above Proficient
Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales.	**Identify** that ecosystems have limited resources but show limited understanding of how this relates to **population size** or carrying capacity.	**Create** simple mathematical representations showing how one or two factors affect population size, with basic understanding of **carrying capacity** but limited consideration of multiple variables.	**Develop** mathematical and computational models that incorporate multiple factors affecting carrying capacity, clearly showing how these factors **interact** in ecosystem dynamics.	**Create** sophisticated mathematical models that integrate multiple variables across **different scales** to predict carrying capacity under various scenarios.
DCI: LS2.A – Interdependent Relationships in Ecosystems	**Recognize** basic factors like food and space that affect organisms but provide minimal **mathematical representation** of these relationships.	**Calculate** population changes using provided formulas but show partial understanding of how different factors **interact** to determine ecosystem carrying capacity.	**Analyze** quantitative relationships between population size, resource availability, and environmental factors to explain how carrying capacity is determined.	**Evaluate** how changes in one factor can have cascading effects through ecosystems due to complex **feedback mechanisms** and interdependent relationships.
SEP: Using Mathematics and Computational Thinking	**Describe** population changes in general terms without incorporating **quantitative analysis** or ecosystem-level interactions.	**Describe** how resources limit population growth with some quantitative support but incomplete analysis of how these limitations operate across **different scales**.	**Apply** principles of **scale** to explain how carrying capacity factors operate differently at the microhabitat, ecosystem, and biome levels.	**Analyze** how time scales affect carrying capacity, differentiating between short-term fluctuations and long-term ecosystem changes.
CCC: Scale, Proportion, and Quantity **ACT Integrations**: Interpretation of Data, Scientific Investigation	*For example, state that "an ecosystem can only support so many animals" without using mathematical representations to explain the specific limiting factors or how these operate at different scales.*	*For example, graph how a population increases until it reaches a carrying capacity plateau, but incompletely explain how this carrying capacity is determined by the interaction of multiple environmental factors or how these relationships change at different spatial or temporal scales.*	*For example, create a computational model showing how carrying capacity for a deer population is determined by the interaction of available forage, predator numbers, disease, and habitat area, with mathematical representations of how these factors operate differently at local and regional scales.*	*For example, develop a computational simulation that models how climate change alters multiple environmental variables (precipitation patterns, temperature, growing season) and predicts resulting changes in carrying capacity for several interacting species across local, regional, and global scales, incorporating feedback loops and time-dependent factors.*

HS-LS2-2	Below Proficient	Approaching Proficient	Proficient	Above Proficient
Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.	**Identify** that ecosystems contain different species but show limited understanding of **biodiversity measures** or mathematical representations of population dynamics.	**Apply** basic mathematical calculations to describe biodiversity (e.g., species richness) but show partial understanding of how multiple factors interact to affect **ecosystem stability**.	**Develop** mathematical representations that analyze biodiversity patterns across **different ecosystem scales**, showing relationships between species richness, habitat area, and environmental factors.	**Create** sophisticated mathematical models that predict biodiversity responses to environmental changes across multiple scales, incorporating **complex interactions** among biotic and abiotic factors.
DCIs: LS2.A – Interdependent Relationships in Ecosystems, LS2.C – Ecosystem Dynamics, Functioning, and Resilience	**Recognize** that populations change over time but provide minimal quantitative analysis of how various factors affect these changes.	**Create** simple graphs or equations showing population changes over time with some consideration of factors like reproduction and mortality rates.	**Use** quantitative models to explain how factors such as resource availability, habitat connectivity, and disturbance regimes affect population dynamics and community structure.	**Analyze** how factors affecting biodiversity operate differently across temporal and spatial scales, with quantitative evaluation of **threshold effects** and tipping points.
SEP: Using Mathematics and Computational Thinking **CCC**: Scale, Proportion, and Quantity **ACT Integrations**: Interpretation of Data, Drawing Conclusions	**Describe** ecosystem diversity in general terms without incorporating **scale considerations** or mathematical relationships. *For example, list different species in an ecosystem but not use mathematical indices to measure biodiversity or to explain how diversity changes with ecosystem area or other variables.*	**Explain** how some environmental factors affect biodiversity with limited quantitative support and incomplete analysis across **different spatial scales**. *For example, calculate a simple biodiversity index for different areas but incompletely explain how area size, habitat fragmentation, or disturbance history quantitatively affect these measurements or how biodiversity patterns change from local to regional scales.*	**Revise** explanations based on mathematical evidence, demonstrating how biodiversity contributes to **ecosystem resilience** and stability. *For example, use species-area curves and diversity indices to analyze how habitat fragmentation affects biodiversity at different spatial scales, and model how greater species diversity increases ecosystem resilience to environmental disturbances through redundancy in functional roles.*	**Integrate** multiple mathematical approaches to evaluate ecosystem functioning, evolutionary processes, and human impacts on biodiversity. *For example, develop computational models that integrate island biogeography theory, metapopulation dynamics, and species interaction networks to predict how habitat fragmentation and climate change will affect biodiversity at genetic, species, and ecosystem levels, with distinct predictions for different ecosystem types and geographic regions.*

HS-LS2-3	Below Proficient	Approaching Proficient	Proficient	Above Proficient
Construct and revise an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions.	**Identify** that organisms need energy but show limited understanding of how matter cycles or energy flows through **biological systems**.	**Construct** basic explanations of how matter cycles and energy flows through ecosystems with some understanding of the processes involved but incomplete details about **aerobic and anaerobic pathways**.	**Construct** detailed explanations of how **matter cycles** and **energy flows** through ecosystems, comparing and contrasting aerobic and anaerobic processes at the molecular level.	**Develop** comprehensive explanations that integrate **molecular transformations** in metabolic pathways with ecosystem-level matter cycling and energy flow across diverse environmental conditions.
DCI: LS2.B – Cycles of Matter and Energy Transfer in Ecosystems **SEP**: Constructing Explanations and Designing Solutions	**Recognize** basic processes like photosynthesis and cellular respiration without accurately explaining the **molecular transformations** involved.	**Describe** differences between photosynthesis and cellular respiration with some recognition of how they are linked in **ecosystem functioning**.	**Explain** how carbon, nitrogen, and other elements move through biogeochemical cycles, with clear distinction between the fate of matter (cycled) and energy (flows and dissipates).	**Analyze** how evolutionary adaptations in metabolic pathways optimize energy capture under different environmental constraints, with quantitative assessment of **energy efficiency** and matter transformation.
CCC: Energy and Matter **ACT Integrations**: Scientific Explanation, Understanding Concepts	**Describe** that decomposition breaks down dead organisms without connecting this to **matter cycling** or energy transfer.	**Explain** decomposition's role in matter cycling with partial understanding of how microorganisms function in **aerobic versus anaerobic conditions**.	**Analyze** evidence showing how organisms use different metabolic pathways depending on environmental conditions, with accurate representations of the molecular transformations and energy yields.	**Evaluate** how disruptions to biogeochemical cycles affect ecosystem function and stability, with evidence-based predictions about system responses.
	For example, state that "plants make food and animals eat plants for energy" without explaining how carbon and other elements cycle between organisms and the environment or how energy flows through and is transformed within ecosystems.	*For example, describe how carbon moves from the atmosphere to plants through photosynthesis and then to animals through feeding, but incompletely explain how fermentation and anaerobic respiration differ from aerobic respiration differ from aerobic processes in terms of energy yield and end products.*	*For example, explain how bacteria in oxygen-depleted environments use alternative electron acceptors like nitrate or sulfate in anaerobic respiration, comparing the ATP yield to aerobic respiration and explaining the different end products that result, with implications for biogeochemical cycling in diverse environments like wetlands or deep ocean sediments.*	*For example, construct explanations for how methane-producing archaea in anaerobic environments like wetlands and landfills use unique metabolic pathways that contribute to carbon cycling while producing greenhouse gases and analyze how climate change might alter the balance between aerobic and anaerobic decomposition processes in thawing permafrost, with cascading effects on global carbon and nitrogen cycles.*

HS-LS2-4	Below Proficient	Approaching Proficient	Proficient	Above Proficient
Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem.	**Identify** that energy moves through ecosystems but show limited ability to represent this movement **mathematically** or distinguish between energy and matter.	**Create** basic mathematical representations of energy pyramids or food webs with some understanding of **energy transfer efficiency** but incomplete quantitative analysis.	**Develop** mathematical models that quantitatively represent both **matter cycling** and **energy flow** through ecosystems, clearly distinguishing between their different fates.	**Create** sophisticated mathematical models that integrate multiple biogeochemical cycles with energy flow, analyzing **system dynamics** under different scenarios.
DCI: LS2.B – Cycles of Matter and Energy Transfer in Ecosystems	**Recognize** that organisms can be classified as producers or consumers without quantitatively analyzing energy transfer between **trophic levels**.	**Calculate** simple energy flows between trophic levels but show partial understanding of why energy decreases at each level.	**Calculate** efficiency of energy transfer between trophic levels and use these calculations to support claims about ecosystem structure and carrying capacity.	**Evaluate** ecosystem energy budgets across different biomes, using quantitative comparisons to explain variations in **productivity** and trophic structure.
SEP: Using Mathematics and Computational Thinking **CCC**: Energy and Matter	**Describe** food chains in general terms without incorporating **mathematical representations** of matter cycling or energy flow.	**Represent** matter cycling with limited mathematical support or incomplete distinction between the **different fates** of matter and energy in ecosystems.	**Analyze** quantitative data showing how matter is transformed and recycled while energy flows through ecosystems and is ultimately dissipated as heat.	**Predict** how changes in one part of an ecosystem will affect matter cycling and energy flow throughout the system using mathematical relationships and feedback analysis.
ACT Integrations: Interpretation of Data, Scientific Explanation	*For example, draw a simple food chain showing that plants are eaten by herbivores which are eaten by carnivores, but without mathematical calculations of energy transfer efficiency or representation of how matter is recycled.*	*For example, construct a pyramid of energy showing decreasing energy at higher trophic levels and calculate that approximately 10% of energy transfers between levels, but incompletely explain the thermodynamic principles behind this pattern or how matter behaves differently from energy.*	*For example, use mathematical representations to calculate productivity and biomass at different trophic levels, analyze carbon and nitrogen cycling through biogeochemical processes, and explain how the laws of thermodynamics constrain energy flow through food webs, with implications for ecosystem structure and sustainable harvest levels.*	*For example, develop computational models that integrate carbon, nitrogen, and phosphorus cycles with energy flow to predict how climate change or nutrient pollution might alter ecosystem productivity, trophic efficiency, and biogeochemical cycling rates across different ecosystems, with quantitative assessment of threshold effects and resilience.*

HS-LS2-5	Below Proficient	Approaching Proficient	Proficient	Above Proficient
Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere.	**Identify** that carbon exists in different Earth systems but show limited understanding of how it **cycles** between these systems.	**Develop** basic models showing carbon movement between organisms and the atmosphere through photosynthesis and respiration, with some understanding of **carbon reservoirs** but incomplete representation of all Earth systems.	**Develop** comprehensive models illustrating how carbon cycles among all four Earth spheres, with clear representation of the **chemical transformations** involved in biological processes.	**Create** sophisticated models that integrate carbon cycling across multiple temporal and spatial scales, with quantitative representation of **flux rates** and reservoir sizes under changing conditions
DCI: LS2.B – Cycles of Matter and Energy Transfer in Ecosystems **SEP**: Developing and Using Models	**Recognize** that photosynthesis and respiration involve carbon dioxide but provide minimal explanation of their role in the **global carbon cycle**.	**Describe** how carbon dioxide is fixed by plants and released through respiration with partial modeling of carbon's **chemical transformations**.	**Explain** how photosynthesis converts atmospheric carbon dioxide into organic molecules while respiration oxidizes these molecules, returning carbon to the atmosphere and completing the biological carbon cycle.	**Analyze** how human activities have altered natural carbon cycles, using models to illustrate changes in carbon distribution among Earth systems and potential **feedback mechanisms**.
CCC: Systems and System Models	**Create** simple representations showing some carbon-containing components without accurately modeling the **movement of carbon** between Earth's spheres.	**Represent** some carbon pathways but show limited understanding of **timescales** or the quantitative aspects of carbon storage in different reservoirs.	**Analyze** the relative sizes of carbon reservoirs and **flux rates** between them, including both short-term biological cycles and long-term geological processes.	**Evaluate** how perturbations to the carbon cycle interact with other biogeochemical cycles and Earth systems, modeling complex **system interactions**.
ACT Integrations: Evaluation of Models, Scientific Investigation	*For example, draw plants taking in carbon dioxide and animals breathing it out, but without connecting these processes to the broader carbon cycle involving the atmosphere, oceans, sediments, and fossil fuels.*	*For example, create a diagram showing how carbon moves through photosynthesis, food webs, and respiration, but incompletely represent carbon movement through the hydrosphere and geosphere or the different timescales of these processes.*	*For example, create models showing how carbon moves through multiple pathways: from atmospheric CO_2 to plant biomass through photosynthesis, through food webs via consumption, back to the atmosphere through respiration, into the hydrosphere through dissolution, into the geosphere through sedimentation and fossil fuel formation, and back to the atmosphere through combustion and volcanic activity.*	*For example, develop dynamic models that integrate carbon flux through fast biological processes (photosynthesis, respiration), medium-term ecological processes (decomposition, soil carbon storage), and slow geological processes (fossil fuel formation, rock weathering), with quantitative analysis of how human activities have altered these fluxes and created imbalances, including potential climate feedback loops such as permafrost thawing, ocean acidification, and changing terrestrial productivity.*

HS-LS2-6	Below Proficient	Approaching Proficient	Proficient	Above Proficient
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.	**Identify** that ecosystems contain different organisms but show limited understanding of the **interactions** that maintain ecosystem stability.	**Describe** some interactions among organisms in ecosystems with partial understanding of how these contribute to **system stability**.	**Evaluate** scientific claims about **ecosystem stability** by analyzing the quality of evidence and reasoning about how complex interactions like competition, predation, and mutualism maintain biodiversity.	**Construct** sophisticated evaluations of scientific claims that integrate multiple lines of evidence across different ecosystems to analyze factors affecting **stability, resilience, and transformation**.
DCI: LS2.C – Ecosystem Dynamics, Functioning, and Resilience	**Recognize** that ecosystems can change over time without accurately explaining the factors that contribute to **resilience** or vulnerability.	**Explain** that ecosystems can respond to disturbances but show incomplete analysis of the evidence for factors affecting **resilience** versus fundamental change.	**Analyze** evidence demonstrating how feedback mechanisms regulate ecosystem dynamics under stable conditions and how exceeding resilience thresholds can lead to **alternative stable states**.	**Differentiate** between correlation and causation in ecological studies, critically evaluating experimental design, data quality, and logical reasoning in arguments about ecosystem dynamics.
SEP: Engaging in Argument from Evidence **CCC**: Stability and Change	**Describe** ecological disturbances in general terms without evaluating evidence about how ecosystems respond to or recover from these changes.	**Evaluate** simple claims about ecosystem changes with limited assessment of the quality and sufficiency of evidence or the validity of reasoning.	**Assess** the strength of scientific arguments about how different types and magnitudes of disturbance affect ecosystem responses, distinguishing between resistance, resilience, and fundamental transformation.	**Synthesize** evidence from observational studies, experiments, and modeling to develop nuanced explanations of how **complex adaptive systems** respond to various perturbations.
ACT Integrations: Evaluation of Models, Drawing Conclusions	*For example, state that "ecosystems can change when something disturbs them" without analyzing specific evidence about feedback mechanisms, population dynamics, or factors that maintain stability under normal conditions.*	*For example, explain that predator-prey relationships help keep populations in check, but provide limited evaluation of scientific evidence showing how multiple interactions and feedback mechanisms maintain ecosystem balance or how exceeding certain thresholds can cause regime shifts.*	*For example, evaluate scientific arguments about how complex interactions in a coral reef ecosystem (competition for space, predator-prey relationships, symbiotic partnerships) maintain diversity and function under stable conditions, while analyzing evidence that multiple stressors like warming, acidification, and pollution can push the system past a tipping point, resulting in a fundamentally different ecosystem state dominated by algae.*	*For example, critically evaluate competing scientific explanations for observed ecosystem shifts in multiple biomes, analyzing strengths and weaknesses in experimental evidence about keystone species, trophic cascades, and alternative stable states, and developing a coherent explanation for why some ecosystems demonstrate high resilience to major disturbances while others undergo catastrophic shifts when certain thresholds are exceeded.*

HS-LS2-7	Below Proficient	Approaching Proficient	Proficient	Above Proficient
Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity. **DCIs**: LS2.C – Ecosystem Dynamics, Functioning, and Resilience, LS4.D – Biodiversity and Humans **SEP**: Constructing Explanations and Designing Solutions **CCC**: Stability and Change ACT **Integrations**: Experimental Design, Scientific Investigation	**Identify** some human impacts on the environment but show limited ability to design solutions that address these impacts. **Propose** simple, general solutions without sufficient consideration of their **effectiveness** or feasibility in addressing specific environmental problems. **Recognize** that biodiversity is important but provide minimal evaluation of how proposed solutions would specifically protect or enhance it. *For example, suggest "planting more trees" to address deforestation without analyzing what species to plant, where to plant them, how to ensure their survival, or how this solution addresses the root causes of the problem.*	**Design** basic solutions to environmental problems with some consideration of scientific principles but incomplete analysis of potential **consequences** or limitations. **Evaluate** proposed solutions using some relevant criteria but show partial consideration of the complex **trade-offs** involved. **Describe** how solutions might reduce human impacts on biodiversity with limited analysis of evidence for effectiveness or insufficient refinement based on constraints. *For example, design a habitat corridor to connect fragmented forests, but provide limited evaluation of its optimal location, width, or composition based on scientific evidence, or incompletely analyze potential unintended consequences like increased disease transmission or predator access.*	**Design** detailed solutions for reducing human environmental impacts based on scientific understanding of **ecosystem dynamics** and biodiversity. **Evaluate** proposed solutions using multiple criteria including effectiveness, feasibility, cost, and potential **unintended consequences**. **Refine** solutions based on scientific evidence, addressing limitations and optimizing for both environmental protection and human needs. *For example, design a comprehensive watershed management plan to reduce agricultural runoff impacts on aquatic biodiversity, evaluate its effectiveness using models of nutrient cycling and aquatic ecosystem dynamics, and refine the solution by optimizing buffer zone width, farming practices, and incentive structures based on evidence from similar implemented solutions.*	**Develop** innovative solutions that address complex environmental challenges by integrating **multiple approaches** and considering interactions across different scales. **Evaluate** proposed solutions using sophisticated analysis of **system dynamics**, incorporating feedback mechanisms, threshold effects, and resilience considerations. **Refine** solutions through iterative testing and modeling, optimizing for long-term effectiveness and adaptability to changing conditions. *For example, design an integrated urban development approach that combines green infrastructure, habitat restoration, policy changes, and community engagement to enhance biodiversity while addressing climate resilience, evaluate it using complex systems modeling that incorporates multiple ecological and social variables, and refine the solution by developing adaptive management strategies that can respond to monitoring data and changing conditions over time.*

HS-LS2-8	Below Proficient	Approaching Proficient	Proficient	Above Proficient
Evaluate the evidence for the role of group behavior on individual and species' chances to survive and reproduce.	**Identify** examples of group behaviors in animals without evaluating how these behaviors affect **survival or reproduction**.	**Describe** various group behaviors with some explanation of their potential benefits to individuals or species but limited evaluation of **scientific evidence**.	**Evaluate** scientific evidence demonstrating how specific group behaviors affect individual **fitness** and species persistence.	**Construct** sophisticated evaluations of research on group behavior that integrate evidence from **multiple methodologies** (field studies, controlled experiments, comparative analyses) across diverse taxa.
DCI: LS2.D – Social Interactions and Group Behavior **SEP**: Engaging in Argument from Evidence	**Recognize** basic group structures like flocks or herds but show limited understanding of the **evolutionary advantages** of group living.	**Explain** that group living can provide advantages like protection from predators or improved resource acquisition with partial analysis of **cause-effect relationships**.	**Analyze** the strength of evidence for **causal relationships** between group behaviors and survival or reproductive advantages in diverse species.	**Differentiate** between proximate and ultimate causes of group behavior, evaluating evidence for the **evolutionary mechanisms** that have shaped social adaptations.
CCC: Cause and Effect **ACT Integrations**: Drawing Conclusions, Scientific Investigation	**Describe** social behaviors in general terms without analyzing evidence for their adaptive significance.	**Evaluate** simple claims about group behavior with limited assessment of the quality and sufficiency of evidence or the strength of logical reasoning.	**Assess** research studies investigating the evolutionary benefits and costs of cooperative behavior, division of labor, territorial defense, and other group interactions.	**Synthesize** evidence to explain how group behaviors represent trade-offs between individual and group interests, with nuanced analysis of how these behaviors have evolved under different ecological contexts.
	For example, note that birds migrate in flocks but not evaluate scientific evidence for how this group behavior increases navigation accuracy, reduces predation risk, or enhances energy efficiency compared to solitary migration.	*For example, explain that wolves hunt in packs to take down larger prey, but provide limited evaluation of evidence showing how this cooperative behavior affects survival rates, reproductive success, or the evolution of specialized roles within the pack structure.*	*For example, critically evaluate experimental and observational evidence showing how honeybee communication about food sources increases colony food acquisition efficiency, how division of labor enhances overall colony productivity, and how these collective behaviors increase survival and reproductive success compared to solitary strategies.*	*For example, critically analyze research on cooperative breeding in birds, evaluating evidence from long-term field studies, genetic analyses, and behavioral experiments to explain how helpers enhance offspring survival, how kinship influences cooperation, and how ecological constraints shape the evolution of these complex social systems, while identifying limitations in current evidence and proposing testable hypotheses for further investigation.*

HS-LS3-1	Below Proficient	Approaching Proficient	Proficient	Above Proficient
Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring.	**Recognize** that traits are passed from parents to offspring without formulating questions about the **molecular mechanisms** involved in inheritance.	**Formulate** basic questions about how traits are passed from parents to offspring with some understanding of DNA's role but limited precision about **genetic mechanisms**.	**Develop** precise questions that clarify the **molecular relationships** between DNA, genes, chromosomes, and the expression of traits.	**Generate** sophisticated questions that integrate multiple levels of biological organization to explore how **genetic information** is maintained, expressed, and transmitted between generations.
DCI: LS3.A – Inheritance of Traits	**Identify** DNA and chromosomes as related to heredity but ask questions that show limited understanding of how they **code for traits**.	**Ask** questions that connect DNA to traits but show incomplete understanding of how DNA sequences **code for proteins** that influence characteristics.	**Formulate** questions that address how the **genetic code** in DNA is translated into proteins that influence an organism's characteristics.	**Formulate** questions that explore complex inheritance patterns, addressing how **gene interactions**, epigenetic factors, and environmental influences affect trait expression.
SEP: Asking Questions and Defining Problems **CCC**: Structure and Function	**Ask** general questions about inheritance that don't address the **cause-effect relationships** between genes and characteristics.	**Generate** questions about inheritance patterns with partial consideration of how chromosomal structures affect the **transmission of genetic information**.	**Ask** questions that explore the **cause-effect connections** between chromosomal behavior during meiosis and patterns of inheritance observed in offspring.	**Develop** questions that challenge existing models or address gaps in scientific understanding of **genetic mechanisms** and inheritance patterns.
ACT Integrations: Scientific Investigation, Understanding Concepts	*For example, ask "Do children look like their parents because of genes?" without formulating more specific questions about how DNA sequences determine protein structure or how chromosomal arrangement affects trait inheritance.*	*For example, ask "How do genes on chromosomes determine eye color?" showing some understanding of the connection between genes and traits, but without questions addressing how specific DNA sequences are transcribed and translated into proteins that produce pigmentation.*	*For example, ask "How do specific nucleotide sequences in DNA determine the amino acid sequence in proteins that affect skin pigmentation, and how does the segregation of chromosomes during meiosis explain why siblings can have different skin tones even with the same parents?"*	*For example, formulate questions like "How do interactions between multiple genes, epigenetic modifications, and environmental factors together determine complex traits like height or disease susceptibility, and why do some genetic conditions show variable expressivity or incomplete penetrance across individuals with the same genotype?"*

HS-LS3-2	Below Proficient	Approaching Proficient	Proficient	Above Proficient
Make and defend a claim based on evidence that inheritable genetic variations may result from (1) new genetic combinations through meiosis, (2) viable errors during replication, and/or (3) mutations caused by environmental factors.	**Identify** that genetic variations exist without making claims about their specific **sources or mechanisms**.	**Make** general claims about sources of genetic variation with some supporting evidence but incomplete defense of how these mechanisms generate **heritable changes**.	**Construct** well-reasoned claims about multiple sources of genetic variation, defending each with appropriate **scientific evidence**.	**Develop** sophisticated claims that integrate multiple lines of evidence about various sources of genetic variation and their **differential impacts** on phenotype and fitness.
DCI: LS3.B – Variation of Traits	**Recognize** that mutations can occur but show limited understanding of the different processes that generate **genetic diversity**.	**Describe** processes like meiosis or mutation with partial understanding of how they contribute to **genetic diversity** in populations.	**Defend** claims by explaining how specific mechanisms of variation—meiotic recombination, replication errors, and environmentally induced mutations—lead to **different types** of heritable changes.	**Analyze** the molecular mechanisms underlying different types of variation, defending claims about their relative evolutionary significance using diverse **experimental evidence**.
SEP: Engaging in Argument from Evidence	**Present** basic statements about inheritance without defending them with relevant evidence or explaining **cause-effect relationships**.	**Present** evidence related to genetic variation but show limited ability to connect specific mechanisms to **observable phenotypic differences**.	**Evaluate** the relative significance of different sources of variation, using evidence to support **cause-effect relationships** between genetic mechanisms and evolutionary potential.	**Synthesize** information across scales to connect specific molecular processes to population-level genetic diversity and **adaptive potential**.
CCC: Cause and Effect **ACT Integrations**: Interpretation of Data, Scientific Investigation	*For example, state that "mutations can change DNA" without making specific claims about the mechanisms of meiotic recombination, replication errors, or environmental mutagens, or providing evidence to support the relative importance of these sources of variation.*	*For example, claim that "crossing over during meiosis creates new combinations of genes" with some supporting evidence about the process, but without thoroughly defending how this, along with other mechanisms, explains patterns of variation observed in populations.*	*For example, make and defend the claim that "sexual reproduction generates extensive genetic diversity primarily through independent assortment and crossing over during meiosis" by citing evidence from genetic mapping studies, explaining the molecular mechanisms involved, and comparing the scale of variation produced through these processes versus spontaneous or induced mutations.*	*For example, construct and defend nuanced claims about how different mechanisms of generating variation (recombination, point mutations, chromosomal rearrangements, horizontal gene transfer) contribute differentially to evolutionary adaptation in various contexts, using evidence from molecular genetics, experimental evolution studies, and comparative genomics to support the arguments.*

HS-LS3-3	Below Proficient	Approaching Proficient	Proficient	Above Proficient
Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.	**Recognize** that traits vary in populations without applying statistical concepts to analyze **patterns of distribution**.	**Calculate** basic probabilities for simple inheritance patterns but show partial understanding of how these relate to **trait distribution** in populations.	**Apply** statistical concepts (mean, variance, standard deviation) to analyze the **distribution** of traits within populations.	**Integrate** advanced statistical and probability concepts to analyze complex patterns of trait **distribution** across different populations and environmental factors
DCI: LS3.B – Variation of Traits	**Identify** basic inheritance patterns but show limited ability to use probability to predict or explain **trait frequencies**.	**Apply** elementary statistics to describe variation for single traits with limited analysis of how multiple factors contribute to **population-level patterns**.	**Use** probability principles to predict and explain patterns of inheritance, connecting theoretical predictions to **observed frequencies** of traits.	**Model** how various factors—including epistasis, pleiotropy, polygenic inheritance, and gene-environment interactions—contribute to **quantitative variation** in traits.
SEP: Analyzing and Interpreting Data **CCC**: Patterns; Scale, Proportion, and Quantity	**Describe** trait variations in qualitative terms without quantitative analysis of **population distributions**.	**Use** Punnett squares or simple probability rules with some ability to connect genotypic ratios to **phenotypic frequencies**.	**Analyze** how various factors—including multiple alleles, gene interactions, and environmental influences—affect the **scale and pattern** of variation in expressed traits.	**Evaluate** how selection, drift, and other evolutionary processes shape the **statistical properties** of trait distributions over generations.
ACT Integrations: Probability and Statistics, Data Analysis	*For example, observe that "human height varies" without applying statistical measures like mean, range, or standard deviation to describe the distribution, or without using probability to explain how genotypic ratios relate to phenotypic frequencies.*	*For example, calculate the probability of specific genotypes from a monohybrid cross and describe the expected phenotypic ratio, but show limited ability to apply these concepts to explain continuous trait variation or the effects of multiple genes and environmental factors on population distributions.*	*For example, analyze a population dataset showing the distribution of a trait like height, calculate statistical measures of central tendency and variation, and explain how this distribution reflects both genetic factors (multiple genes, dominant/recessive relationships) and environmental influences, using probability concepts to explain why certain phenotypes appear at specific frequencies.*	*For example, analyze datasets showing the distribution of a complex trait across different populations, apply statistical tests to compare means and variances, model how the trait's heritability affects response to selection, and predict how the distribution would change under different scenarios of selection intensity, population size, and environmental variation.*

HS-LS4-1	Below Proficient	Approaching Proficient	Proficient	Above Proficient
Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence. **DCI**: LS4.A – Evidence of Common Ancestry and Diversity **SEP**: Obtaining, Evaluating, and Communicating Information **CCC**: Patterns **ACT Integrations**: Interpretation of Data, Scientific Explanation	**Identify** some evidence related to evolution without effectively communicating how multiple lines of evidence support **common ancestry**. **Recognize** basic concepts like fossils or anatomical similarities but show limited ability to connect these to **evolutionary relationships**. **Present** information about biological diversity without clearly communicating the **patterns** that indicate evolutionary history. *For example, mention that "fossils show ancient organisms" without effectively communicating how the fossil record, along with other evidence, demonstrates patterns of change over time and supports the concept of common ancestry.*	**Describe** several types of evidence for evolution with some explanation of how they support **common ancestry**. **Communicate** information about comparative anatomy or embryology with partial connections to **evolutionary relationships**. **Present** some patterns in molecular or fossil evidence but show incomplete integration of **multiple lines** of supporting data. *For example, communicate that homologous structures in vertebrate limbs suggest common ancestry, but provide limited explanation of how this evidence is strengthened when combined with molecular, embryological, and fossil evidence to form a coherent scientific explanation.*	**Communicate** clearly how multiple, independent lines of evidence collectively support **common ancestry** and biological evolution. **Integrate** information from different fields—including paleontology, comparative anatomy, embryology, molecular biology, and biogeography—to explain **convergent patterns** that support evolutionary theory. **Evaluate** the strength of various forms of evidence and explain how they provide a coherent scientific explanation for the **diversity** of life. *For example, systematically communicate how patterns in the fossil record show transitional forms, how homologous structures and embryological similarities indicate shared ancestry, how molecular evidence (DNA and protein sequences) provides quantifiable measures of relationship, and how biogeographical patterns reflect evolutionary history—all converging to support common ancestry despite being derived from different methodologies.*	**Synthesize** complex scientific information to explain how diverse evidence forms an interconnected web of support for **evolutionary theory**. **Analyze** how new technologies and discoveries continue to strengthen the case for common ancestry, while explaining how science has addressed historical **challenges** to evolutionary theory. **Communicate** effectively about the nature of science and how the multiple lines of evidence for evolution exemplify the **process of building scientific knowledge**. *For example, construct a sophisticated scientific explanation that not only integrates traditional evidence from comparative anatomy, fossils, and embryology with modern genomic data, but also analyzes how predictions made by evolutionary theory have been repeatedly confirmed by new discoveries (such as transitional fossils like Tiktaalik or the evolution of antibiotic resistance), discusses how apparent contradictions have been resolved, and explains why evolution represents a powerful unifying theory in biology.*

HS-LS4-2	Below Proficient	Approaching Proficient	Proficient	Above Proficient
Construct an explanation based on evidence that the process of evolution primarily results from four factors: (1) potential for species to increase in number, (2) heritable genetic variation, (3) competition for limited resources, and (4) proliferation of better-adapted organisms.	**Identify** some factors related to evolution without constructing a coherent explanation of how they drive **evolutionary change**.	**Construct** basic explanations that include some evolutionary factors but show incomplete integration of all four key components or limited use of **supporting evidence**.	**Construct** a comprehensive explanation that integrates all four factors of evolution, supported by relevant **scientific evidence**.	**Develop** sophisticated explanations that integrate the four evolutionary factors across multiple scales, from molecular to ecological, with robust **supporting evidence**.
	Recognize concepts like natural selection but show limited understanding of the **necessary conditions** that make evolution possible.	**Explain** natural selection with some understanding of how variation and differential survival contribute to **adaptive change** but partial connection to reproductive potential or resource limitation.	**Explain** how reproductive potential, heritable variation, resource competition, and differential survival and reproduction together cause **adaptive change** in populations over time.	**Analyze** how these factors interact in different contexts, explaining how variations in their relative importance can lead to different **evolutionary outcomes**.
DCI: LS4.B – Natural Selection **SEP**: Constructing Explanations **CCC**: Cause and Effect **ACT Integrations**: Scientific Explanation, Understanding Concepts	**Describe** competition or adaptation in general terms without connecting these to the **mechanisms** of evolutionary change. *For example, state that "organisms compete for resources" without constructing an explanation of how this competition, combined with heritable variation, reproductive potential, and differential survival, drives evolutionary change in populations.*	**Describe** evolutionary processes with some supporting evidence but limited analysis of the **causal relationships** among the four factors. *For example, explain that "organisms with advantageous traits survive better and pass these traits to offspring," but provide an incomplete explanation of how this process relates to reproductive potential, the sources of heritable variation, and competition for limited resources.*	**Analyze** the evidence supporting each factor, demonstrating how they work together as a **causal mechanism** for evolutionary change. *For example, develop an explanation of how a bacterial population evolves antibiotic resistance by citing evidence for: (1) the rapid reproductive potential of bacteria, (2) the random mutations and genetic recombination that create heritable variation in resistance, (3) the competition for resources intensified by antibiotic presence, and (4) the selective survival and reproduction of bacteria with mutations conferring resistance.*	**Evaluate** how additional factors—such as genetic drift, gene flow, and sexual selection—interact with the four primary factors to shape **evolutionary trajectories**. *For example, construct an explanation of adaptive radiation in cichlid fishes by analyzing evidence for how: (1) high reproductive rates allow rapid population growth, (2) specific genetic mechanisms and sexual reproduction create tremendous variation in feeding structures and coloration, (3) specialized competition for different food resources creates divergent selection pressures, and (4) differential survival and reproductive success in different microhabitats leads to speciation—while also evaluating how factors like genetic drift in isolated populations and sexual selection for mate recognition further influence the evolutionary outcome.*

HS-LS4-3	Below Proficient	Approaching Proficient	Proficient	Above Proficient
Apply concepts of statistics and probability to support explanations that organisms with advantageous heritable traits tend to increase in proportion to those lacking the traits. **DCI**: LS4.C – Adaptation **SEP**: Analyzing and Interpreting Data **CCC**: Patterns **ACT Integrations**: Data Interpretation, Probability and Statistics	**Recognize** that advantageous traits can become more common without applying statistical or probability concepts to analyze this **pattern**. **Identify** examples of natural selection but show limited ability to use quantitative approaches to explain changes in **trait frequencies**. **Describe** adaptations in qualitative terms without applying mathematical reasoning to support explanations of **proportional changes**. *For example, state that "giraffes with longer necks survived better" without applying statistical concepts to explain how this advantage would change the distribution of neck lengths in the population over generations.*	**Apply** basic probability concepts to predict inheritance patterns with some understanding of how these relate to **changes in trait frequency**. **Calculate** simple proportions or percentages to describe trait distributions but show partial ability to use these to explain **patterns of change** over generations. **Use** statistical terms with some accuracy but incomplete application to support explanations of how **selection pressures** alter trait distributions. *For example, calculate the proportion of a trait in a population and describe how it might increase, but with limited application of probability concepts to model the multi-generational effects of selection or to predict how the strength of selection affects the rate of change.*	**Apply** appropriate statistical and probability concepts to analyze data showing how **advantageous traits** increase in frequency over generations. **Use** mathematical models to support explanations of how selection pressures alter the **distribution** of traits in a population. **Calculate** changes in allele and genotype frequencies to demonstrate how heritable variation and differential reproduction create **predictable patterns** in trait distributions. *For example, analyze a dataset showing the frequency distribution of beak sizes in a bird population before and after a drought, apply statistical tests to demonstrate significant changes, and use probability models to explain how stronger selection for larger beaks leads to predictable shifts in the trait distribution over multiple generations.*	**Integrate** advanced statistical methods and probability models to analyze complex patterns of **selection** acting on multiple traits simultaneously. **Model** how various factors—including selection intensity, heritability, and population size—quantitatively affect the **rate and direction** of evolutionary change. **Evaluate** how statistics and probability help distinguish between changes due to selection versus random processes, supporting sophisticated explanations of **evolutionary dynamics**. *For example, apply statistical analyses to complex datasets showing changes in multiple correlated traits, model how selection gradients influence the evolution of trait combinations, calculate how heritability affects response to selection, and predict population trajectories under different selection scenarios while accounting for factors like genetic drift and gene flow that introduce stochastic elements.*

HS-LS4-4	Below Proficient	Approaching Proficient	Proficient	Above Proficient
Construct an explanation based on evidence for how natural selection leads to adaptation of populations. **DCI**: LS4.C – Adaptation **SEP**: Constructing Explanations **CCC**: Cause and Effect **ACT Integrations**: Scientific Investigation, Interpretation of Data	**Identify** examples of adaptations without constructing explanations for how they developed through **natural selection**. **Recognize** that organisms are suited to their environments but show limited understanding of the **causal processes** that lead to population-level adaptation. **Describe** adaptive traits in general terms without connecting them to the selection pressures that shaped them. *For example, describe the camouflage coloration of an arctic fox without constructing an explanation of how predation pressure, heritable variation in coat color, and differential survival led to the adaptation of white fur in the population.*	**Construct** basic explanations linking natural selection to adaptations with some supporting evidence but incomplete analysis of the **mechanism** by which populations change. **Explain** that favorable traits become more common through differential survival with partial understanding of how this process leads to **population-level adaptation** over time. **Use** some evidence to support explanations but show limited ability to connect specific selection pressures to observed **adaptive traits**. *For example, explain that "faster cheetahs catch more prey and reproduce more" but provide limited evidence about the variation in speed within the population, the heritability of traits affecting speed, or how the proportion of genes for speed changed over generations.*	**Construct** detailed explanations based on evidence for how specific **selection pressures** acting on heritable variation lead to adaptation of populations. **Analyze** the relationship between environmental challenges, variation within populations, differential survival and reproduction, and the resulting **adaptive changes**. **Use** multiple lines of evidence—including field observations, experimental results, and molecular data—to support explanations of how **natural selection** has shaped particular adaptations. *For example, construct an explanation for bacterial antibiotic resistance using evidence that shows: random mutations created variation in resistance, antibiotic exposure created strong selection pressure, bacteria with resistance genes survived and reproduced at higher rates, and the frequency of resistance genes increased over generations until the population became adapted to the presence of antibiotics.*	**Develop** sophisticated, multi-causal explanations that integrate various forms of evidence to explain how **complex adaptations** evolve through natural selection. **Analyze** how multiple selection pressures interact to shape adaptations, explaining trade-offs and constraints that influence the **evolutionary outcome**. **Evaluate** alternative explanations for adaptive traits, using evidence to distinguish between traits shaped by selection and those resulting from other **evolutionary processes**. *For example, construct a comprehensive explanation for the evolution of C4 photosynthesis in plants by analyzing paleoclimatic evidence for changing CO2 levels, comparative physiological data showing advantages in hot/dry conditions, molecular evidence revealing the stepwise evolution of the pathway, and experimental studies demonstrating selection under different conditions—while also explaining why certain plant lineages evolved this adaptation while others did not due to developmental constraints and historical contingency.*

HS-LS4-5	Below Proficient	Approaching Proficient	Proficient	Above Proficient
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, and/or (3) the extinction of other species.	**Identify** that environmental changes affect species without evaluating evidence for specific **population responses**.	**Examine** some evidence for how environmental changes affect species with partial evaluation of the **strength and relevance** of the data.	**Evaluate** the quality, quantity, and consistency of evidence supporting claims about how environmental changes affect **biodiversity patterns**.	**Construct** sophisticated evaluations of competing scientific claims about how environmental changes affect biodiversity, analyzing methodological strengths and limitations of supporting studies.
DCI: LS4.C – Adaptation	**Recognize** concepts like extinction or adaptation but show limited ability to assess the **evidence** supporting claims about these processes.	**Describe** examples of population changes, speciation, or extinction with some assessment of supporting evidence but limited analysis of the **causal mechanisms** involved.	**Analyze** scientific studies that demonstrate causal links between specific environmental changes and their effects on population sizes, speciation rates, and extinction risks.	**Synthesize** evidence across multiple time scales and research approaches to assess complex **causal pathways** from environmental change to biodiversity impacts.
SEP: Engaging in Argument from Evidence **CCC**: Stability and Change	**Describe** general relationships between environment and species survival without critically examining the **causal links** or strength of supporting data.	**Evaluate** basic claims about species responses to environmental change with incomplete consideration of alternative explanations or evidence quality.	**Assess** the strength of evidence for different mechanisms by which environmental change drives **ecological and evolutionary responses**, distinguishing between well-supported and weakly supported claims.	**Identify** gaps in current evidence and evaluate how uncertainty affects confidence in predictions about **future biodiversity responses** to environmental change.
ACT Integrations: Scientific Investigation, Drawing Conclusions	*For example, state that "climate change can cause extinctions" without evaluating specific evidence demonstrating how particular environmental changes affect population dynamics, speciation rates, or extinction risk for different species.*	*For example, examine evidence that warming temperatures are affecting butterfly ranges and phenology, but provide limited evaluation of how well this evidence demonstrates causal relationships, how comprehensive the data collection was, or how it connects to broader patterns of biodiversity change.*	*For example, systematically evaluate multiple lines of evidence—including fossil records, experimental studies, and field observations—that demonstrate how ocean acidification affects marine invertebrate populations, how geographic isolation due to changing sea levels has facilitated speciation in island systems, and how narrow temperature tolerance has increased extinction risk for specialized coral reef species.*	*For example, critically analyze competing explanations for the Permian-Triassic mass extinction by evaluating the strength of evidence from geochemical proxies, fossil assemblages, and comparative physiological studies; synthesize evidence of how current climate change affects species across different taxonomic groups and ecosystems; and assess limitations in current understanding of how interaction effects between multiple stressors influence extinction vulnerability.*

HS-LS4-6	Below Proficient	Approaching Proficient	Proficient	Above Proficient
Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.	**Identify** some human impacts on biodiversity without creating or revising simulations to test potential **solutions**.	**Create** basic simulations that test simple solutions with limited variables or incomplete consideration of how they address the **complexity** of biodiversity threats.	**Create** detailed simulations that test proposed solutions to biodiversity loss, incorporating multiple variables and clearly defined **cause-effect relationships**.	**Design** sophisticated simulations that integrate multiple ecological processes and human activities to test comprehensive solutions addressing **interacting threats** to biodiversity.
DCI: LS4.D – Biodiversity and Humans **SEP**: Using Mathematics and Computational Thinking	**Describe** general conservation approaches but show limited ability to develop **computational representations** of how these approaches would work.	**Develop** rudimentary models showing cause-effect relationships between conservation actions and biodiversity outcomes but with partial analysis of effectiveness.	**Develop** computational models that represent how specific conservation actions would mitigate identified human impacts on biodiversity at appropriate **spatial and temporal scales**.	**Create** models that represent complex adaptive systems, allowing for emergent properties and feedback loops when testing the **effectiveness** of proposed conservation strategies.
CCC: Systems and System Models	**Recognize** that biodiversity loss is a problem without developing testable models of how proposed solutions would affect **ecological systems**.	**Revise** simulations in limited ways that don't fully address the **interactions** between different factors affecting biodiversity conservation.	**Revise** simulations based on initial results or new evidence, improving the models to better represent the **complex interactions** in ecological systems.	**Systematically** revise simulations using sensitivity analysis and scenario testing to optimize solutions for multiple **conservation objectives** while accounting for socioeconomic constraints.
ACT Integrations: Experimental Design, Interpretation of Simulations	*For example, suggest creating wildlife preserves to protect endangered species but not develop a simulation to test how preserve size, location, or connectivity would affect population viability or ecosystem function.*	*For example, create a simple population model showing how reducing harvesting affects a single species' abundance, but with limited incorporation of habitat requirements, species interactions, or how the proposed solution addresses multiple human impacts across different scales.*	*For example, develop an agent-based model that simulates how a proposed wildlife corridor system would affect population connectivity, genetic diversity, and species persistence in a fragmented landscape, and then revise the model based on testing results to optimize corridor placement, width, and habitat composition for multiple species.*	*For example, develop a complex socio-ecological system model that integrates climate change projections, land-use change, species interactions, and human economic activities to test a multi-faceted conservation strategy combining protected area expansion, sustainable harvest practices, and economic incentives, then use systematic model revision to identify robust solutions that maintain biodiversity while balancing competing demands across different future scenarios.*