

Biology

UNIT 4 Ecosystems: Interactions, Energy, and Dynamics

Big Ideas:

- How do living and nonliving parts of the Earth interact and affect the survival of organisms
- How do abiotic and biotic factors shape ecosystems?
- What factors contribute changes in populations?
- How have human activities shaped local and global ecology?
- How have animals descended from earlier forms through the process of evolution?
- How do the structures of animals allow them to obtain essential materials and eliminate wastes?

Essential Questions:

What is ecology?

What are biotic and abiotic factors?

What methods are used in ecological studies?

What are primary producers?

How do consumers obtain energy and nutrients?

How does energy flow through ecosystems?

What do the three types of ecological pyramids illustrate?

How does matter move through the biosphere?

How does water cycle through the biosphere?

What is the importance of the main nutrient cycles?

How does nutrient availability relate to the primary productivity of an ecosystem?

What is climate?

What factors determine global climate?

What is a niche?

How does competition shape communities?

How do predation and herbivory shape communities?

What are the three primary ways that organisms depend on each other?

How do communities change over time?

Do ecosystems return to “normal” following a disturbance?

What abiotic and biotic factors characterize biomes?

What areas are not easily classified into major biomes?

What factors affect life in aquatic environments?

What are the major categories of freshwater ecosystems?

Why are estuaries important?
How do ecologists usually classify marine ecosystems?
How do ecologists study populations?
What factors affect population growth?
What happens during exponential growth?
What is logistic growth?
What factors determine the carrying capacity?
What limiting factors depend on population density?
What limiting factors do not typically depend on population density?
How has human population size changed over time?
Why do population growth rates differ among countries?
How do our daily activities affect the environment?
What is the relationship between resource use and sustainable development?
What is soil important and how do we protect it
What are the primary sources of water pollution?
What are the major forms of air pollution?
Why is biodiversity important?
What are the most significant threats to biodiversity?
How do we preserve biodiversity?
How does the average ecological footprint in America compare to the world's average?
How can ecology guide us to a sustainable future?
When did the first animals evolve?
What does the cladogram of invertebrates illustrate?
What are the most ancient chordates?
What can we learn about studying the cladogram of chordates?
What is the significance of behavior in the evolution of animal species?
What is an innate behavior?
What are the major types of learning?
How do many complex behaviors arise?
How do environmental changes affect animal behavior?
How do social behaviors increase an animal's evolutionary fitness?
How do animals communicate with others in their environment?
How is the human body organized?

What is homeostasis?

What are the structures and functions of the eleven human body systems?

Vocabulary:

LS2-4, LS2-5: biosphere, species, population, community, ecology, ecosystem, biome, biotic factor, abiotic factor, autotroph, primary producer, photosynthesis, chemosynthesis, heterotroph, consumer, carnivore, herbivore, scavenger, omnivore, decomposer, detritivore, food chain, phytoplankton, food web, zooplankton, trophic level, ecological pyramid, biomass, biogeochemical cycles, nutrient, nitrogen fixation, denitrification, limiting nutrients.

LS2-3, LS2-6: weather, climate, microclimate, greenhouse effect, tolerance, habitat, niche, resource, competitive exclusion principle, predation, herbivory, keystone species, symbiosis, mutualism, parasitism, commensalism, ecological succession, primary succession, pioneer species, secondary succession canopy, understory, deciduous, coniferous, humus, taiga, permafrost, photic zone, aphotic zone, benthos, plankton, wetland, estuary

LS2.1: populations density, age structure, immigration, emigration, exponential growth, logistic growth carrying capacity, limiting factor, density-dependent limiting factor, density-independent limiting factor, demography, demography transition,

LS2.2, LS2-7: monoculture, renewable resource, nonrenewable resource, sustainable development, desertification, deforestation, pollutant, biological magnification, smog, acid rain, biodiversity, ecosystem diversity, species diversity, genetic diversity, habitat fragmentation, ecological hot spot, ecological footprint, ozone layer, aquaculture, global warming, appendage, larva, trochophore, cartilage, tetrapod

LS2-8 behavior, innate behavior, learning, habituation, classical conditioning, operant conditioning, insight learning, imprinting, circadian rhythm, migration, courtship, territory, aggression, society, kin selection, communication, language
epithelial tissue, connective tissue, nervous tissue, muscle tissue, homeostasis, feedback inhibition, nervous system, integumentary system, lymphatic/immune system, muscular system, skeletal system, circulatory system, respiratory system, digestive system, excretory system, endocrine system, reproductive system.

Students who demonstrate understanding can:

HS-LS2-1. Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales.[Clarification Statement: Emphasis is on quantitative analysis and comparison of the relationships among interdependent factors including boundaries, resources, climate, and competition. Examples of mathematical comparisons could include graphs, charts, histograms, and population changes gathered from simulations or historical data sets.] [Assessment Boundary: Assessment does not include deriving mathematical equations to make comparisons.]

HS-LS2-2. Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.[Clarification Statement: Examples of mathematical representations include finding the average, determining trends, and using graphical comparisons of multiple sets of data.] [Assessment Boundary: Assessment is limited to provided data.]

HS-LS2-3. Construct and revise an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions.[Clarification Statement: Emphasis is on conceptual understanding of the role of aerobic and anaerobic respiration in different environments.] [Assessment Boundary: Assessment does not include the specific chemical processes of either aerobic or anaerobic respiration.]

- HS-LS2-4. Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem.**[Clarification Statement: Emphasis is on using a mathematical model of stored energy in biomass to describe the transfer of energy from one trophic level to another and that matter and energy are conserved as matter cycles and energy flows through ecosystems. Emphasis is on atoms and molecules such as carbon, oxygen, hydrogen and nitrogen being conserved as they move through an ecosystem.] [Assessment Boundary: Assessment is limited to proportional reasoning to describe the cycling of matter and flow of energy.]
- HS-LS2-5. Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere.**[Clarification Statement: Examples of models could include simulations and mathematical models.] [Assessment Boundary: Assessment does not include the specific chemical steps of photosynthesis and respiration.]
- HS-LS2-6. Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.**[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.]
- HS-LS2-7. Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.***[Clarification Statement: Examples of human activities can include urbanization, building dams, and dissemination of invasive species.]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
<p>Developing and Using Models Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show how relationships among variables between systems and their components in the natural and designed worlds.</p> <ul style="list-style-type: none"> Develop a model based on evidence to illustrate the relationships between systems or components of a system. (HS-LS2-5) <p>Using Mathematics and Computational Thinking Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.</p> <ul style="list-style-type: none"> Use mathematical and/or computational representations of phenomena or design solutions to support explanations. (HS-LS2-1) Use mathematical representations of phenomena or design solutions to support and revise explanations. (HS-LS2-2) Use mathematical representations of phenomena or design solutions to support claims. (HS-LS2-4) 	<p>LS2.A: Interdependent Relationships in Ecosystems</p> <ul style="list-style-type: none"> 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. (HS-LS2-1),(HS-LS2-2) <p>LS2.B: Cycles of Matter and Energy Transfer in Ecosystems</p> <ul style="list-style-type: none"> Photosynthesis and cellular respiration (including anaerobic processes) provide most of the energy for life processes. (HS-LS2-3) Plants or algae form the lowest level of the food web. At each link upward in a food web, only a small fraction of the matter consumed at the lower level is transferred upward, to produce growth and release energy in cellular respiration at the higher level. Given this inefficiency, there are generally fewer organisms at higher levels of a food web. Some matter reacts to release energy for life functions, some matter is stored in newly made structures, and much is discarded. The chemical elements that make up the molecules of organisms pass through food webs and into and out of the atmosphere and soil, and they are combined and recombined in 	<p>Cause and Effect</p> <ul style="list-style-type: none"> Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-LS2-8) <p>Scale, Proportion, and Quantity</p> <ul style="list-style-type: none"> The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. (HS-LS2-1) Using the concept of orders of magnitude allows one to understand how a model at one scale relates to a model at another scale. (HS-LS2-2) <p>Systems and System Models</p> <ul style="list-style-type: none"> 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. (HS-LS2-5) <p>Energy and Matter</p> <ul style="list-style-type: none"> Energy cannot be created or destroyed—it only moves between one place and another place, between objects and/or fields, or between systems. (HS-LS2-4) Energy drives the cycling of matter within and between systems. (HS-LS2-3) <p>Stability and Change</p> <ul style="list-style-type: none"> Much of science deals with constructing explanations of how things change and how they remain stable. (HS-LS2-6),(HS-LS2-7)

Constructing Explanations and Designing Solutions

Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.

- Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (HS-LS2-3)
- Design, evaluate, and refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-LS2-7)

Engaging in Argument from Evidence

Engaging in argument from evidence in 9–12 builds on K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science.

- Evaluate the claims, evidence, and reasoning behind currently accepted explanations or solutions to determine the merits of arguments. (HS-LS2-6)
- Evaluate the evidence behind currently accepted explanations to determine the merits of arguments. (HS-LS2-8)

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. (HS-LS2-2),(HS-LS2-3)
- 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. (HS-LS2-6),(HS-LS2-8)

different ways. At each link in an ecosystem, matter and energy are conserved. (HS-LS2-4)

- Photosynthesis and cellular respiration are important components of the carbon cycle, in which carbon is exchanged among the biosphere, atmosphere, oceans, and geosphere through chemical, physical, geological, and biological processes. (HS-LS2-5)

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. (HS-LS2-2),(HS-LS2-6)
- Moreover, anthropogenic changes (induced by human activity) in the environment—including habitat destruction, pollution, introduction of invasive species, overexploitation, and climate change—can disrupt an ecosystem and threaten the survival of some species. (HS-LS2-7)

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. (HS-LS2-8)

LS4.D: Biodiversity and Humans

- Biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction). (*secondary to HS-LS2-7*)
- 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. (*secondary to HS-LS2-7*) (*Note: This Disciplinary Core Idea is also addressed by HS-LS4-6.*)

PS3.D: Energy in Chemical Processes

	<ul style="list-style-type: none"> The main way that solar energy is captured and stored on Earth is through the complex chemical process known as photosynthesis. <i>(secondary to HS-LS2-5)</i> <p>ETS1.B: Developing Possible Solutions</p> <ul style="list-style-type: none"> When evaluating solutions it is important to take into account a range of constraints including cost, safety, reliability and aesthetics and to consider social, cultural and environmental impacts. <i>(secondary to HS-LS2-7)</i> 	
<p><i>Connections to other DCIs in this grade-band:</i> HS.PS1.B (HS-LS2-3),(HS-LS2-5); HS.PS3.B (HS-LS2-3),(HS-LS2-4); HS.PS3.D (HS-LS2-3),(HS-LS2-4); HS.ESS2.A (HS-LS2-3); HS.ESS2.D (HS-LS2-5),(HS-LS2-7); HS.ESS2.E (HS-LS2-2),(HS-LS2-6),(HS-LS2-7); HS.ESS3.A (HS-LS2-2),(HS-LS2-7); HS.ESS3.C (HS-LS2-2),(HS-LS2-7); HS.ESS3.D (HS-LS2-2)</p>		
<p><i>Articulation of DCIs across grade-bands:</i> MS.PS1.B (HS-LS2-3); MS.PS3.D (HS-LS2-3),(HS-LS2-4),(HS-LS2-5); MS.LS1.B (MS-LS2-8); MS.LS1.C (HS-LS2-3),(HS-LS2-4),(HS-LS2-5); MS.LS2.A (HS-LS2-1),(HS-LS2-2),(HS-LS2-6); MS.LS2.B (HS-LS2-3),(HS-LS2-4),(HS-LS2-5); MS.LS2.C(HS-LS2-1),(HS-LS2-2),(HS-LS2-6),(HS-LS2-7); MS.ESS2.A (HS-LS2-5); MS.ESS3.A (HS-LS2-1); MS.ESS3.C (HS-LS2-1),(HS-LS2-2),(HS-LS2-6),(HS-LS2-7); MS.ESS3.D (HS-LS2-7)</p>		
<p><i>Common Core State Standards Connections:</i></p> <p><i>ELA/Literacy -</i></p> <p>RST.9-10.8 Assess the extent to which the reasoning and evidence in a text support the author’s claim or a recommendation for solving a scientific or technical problem. (HS-LS2-6),(HS-LS2-7),(HS-LS2-8)</p> <p>RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-LS2-1),(HS-LS2-2),(HS-LS2-3),(HS-LS2-6),(HS-LS2-8)</p> <p>RST.11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. (HS-LS2-6),(HS-LS2-7),(HS-LS2-8)</p> <p>RST.11-12.8 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-LS2-6),(HS-LS2-7),(HS-LS2-8)</p> <p>WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-LS2-1),(HS-LS2-2),(HS-LS2-3)</p> <p>WHST.9-12.5 Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. (HS-LS2-3)</p> <p>WHST.9-12.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-LS2-7)</p> <p><i>Mathematics -</i></p> <p>MP.2 Reason abstractly and quantitatively. (HS-LS2-1),(HS-LS2-2),(HS-LS2-4),(HS-LS2-6),(HS-LS2-7)</p> <p>MP.4 Model with mathematics. (HS-LS2-1),(HS-LS2-2),(HS-LS2-4)</p> <p>HSN.Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-LS2-1),(HS-LS2-2),(HS-LS2-4),(HS-LS2-7)</p> <p>HSN.Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. (HS-LS2-1),(HS-LS2-2),(HS-LS2-4),(HS-LS2-7)</p> <p>HSN.Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-LS2-1),(HS-LS2-2),(HS-LS2-4),(HS-LS2-7)</p> <p>HSS-ID.A.1 Represent data with plots on the real number line. (HS-LS2-6)</p> <p>HSS-IC.A.1 Understand statistics as a process for making inferences about population parameters based on a random sample from that population. (HS-LS2-6)</p> <p>HSS-IC.B.6 Evaluate reports based on data. (HS-LS2-6)</p>		