STRATFORD PUBLIC SCHOOLS
Stratford, Connecticut

"Tantum eruditi sunt liberi"
Only The Educated Are Free

Environmental Biology

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DISTRICT MISSION STATEMENT

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The mission of the Stratford school community is to ensure that all students acquire the knowledge, character, and 21st century skills to succeed through high quality learning experiences and community partnerships within a culture of diversity and respect.

Portrait of a Stratford Graduate

- Responsible and Involved Citizen
  - Participate in and contribute with empathy and respect to the community.
  - Demonstrate knowledge of and respect for diverse cultures, identities, and perspectives.
  - Practice responsible digital and in person citizenship as a member of a community.

- Creative and Practical Problem-Solver
  - Define and analyze a problem/problems.
  - Select, evaluate, and apply appropriate resources/strategies necessary to find/generate a solution(s) for problems.
  - Generate and critically evaluate the effectiveness of a solution.

- Informed and Integrative Thinker
  - Apply knowledge from various disciplines and contexts to real life situations.
  - Analyze, evaluate, and synthesize information from multiple and diverse sources to build on and utilize knowledge.
  - Use evidence and reasoning to justify claims/solutions.

- Clear and Effective Communicator
  - Select and use communication strategies (questioning, clarifying, verifying, and challenging ideas) and interpersonal skills to collaborate with others (peers, teachers, community members, families) within a diverse community.
  - Demonstrate, adapt, and articulate thoughts and ideas effectively using/including oral, written, multimedia, non-verbal, and/or a performance appropriate for a particular audience.
  - Receive, understand and process information effectively and with consideration for others through active speaking and listening.

- Self-Directed and Lifelong Learner
  - Apply knowledge to set goals, make decisions, and assess new opportunities.
  - Demonstrates initiative, reliability and concern for quality results/solutions/resources/information within time constraints as applicable.
  - Demonstrate flexibility in thinking/problem-solving/etc. including the ability to incorporate new ideas and revise.

ENVIRONMENTAL BIOLOGY

Course Overview

UNIT #1 : Matter and Energy in Organisms and Ecosystems

Unit Overview
In this unit students will create an answer to the questions: “ How do organisms obtain and use the energy they need to live and grow?, How do matter and energy move through ecosystems?” Students can construct explanations for the role of energy in the cycling of matter in organisms and ecosystems. Students will be able to apply mathematical concepts to develop evidence to support explanations of the interactions of photosynthesis and cellular respiration and develop models to communicate these explanations. Students will understand organisms interactions with each other and their physical environment, how organisms obtain resources, how they change the environment, and how these changes affect both organisms and ecosystems.

UNIT #2 : Interdependent Relationships in Ecosystems

Unit Overview
In this unit students will create an answer to the questions: “ How do organisms interact with the living and non-living environment to obtain matter and energy?” Students will demonstrate the ability to investigate the role of biodiversity in ecosystems and the role of animal behavior in the survival of individuals and species. Students will have an increased understanding of interactions among organisms and how these interactions influence the dynamics of ecosystems. Students will generate mathematical comparisons, conduct investigations, use models, and apply scientific reasoning to link evidence to explanations about interactions and changes within ecosystems.

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Course Overview

UNIT #3 : Human Impact on Ecosystems

Unit Overview
In this unit, students will find answers to the questions, “What impacts do human activities have on the environment and biodiversity?” and “What are some solutions to mitigate the impact of human activities?” Additionally, students will have an understanding of how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity. Emphasis of the unit will be on designing a potential solution to resolve or improve the impact of human activities on the environment and biodiversity.

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Unit Overview of Big Ideas/Performance Expectations/Disciplinary Core Ideas

Units At-a-Glance		
Unit Big Ideas	**Performance Expectations**	**Disciplinary Core Ideas**
Unit 1: Flow of energy in ecosystems	HS-LS2-4 HS-LS2-3 HS-LS2-5 HS-LS1-7 HS-LS1-5 HS-LS2-1	HS.LS2.B HS.PS3.D HS.LS1.C HS.LS2.B HS.LS1.C HS.LS2.A
Unit 2: Biodiversity and dynamics of the environment	HS-LS2-6 HS-LS2-2 HS-LS2-8	HS.LS4.D HS.LS4.C HS.LS2.C **LS2.D**
Unit 3: Human impact on ecosystems	HS-LS2-7 HS-LS4-6 HS-ESS2-7 HS-ESS3-1 HS-ESS3-2 HS-ESS3-3 HS-ESS3-4	HS.ESS2.E HS.ESS3.C HS.ESS3.B HS.ESS3.A HS.ETS1.B

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UNIT #1 : Matter and Energy in Organisms and Ecosystems

Big Idea - Flow of energy in ecosystems		
PE #	Performance Expectation	Disciplinary Core Ideas
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.]	**LS2.B: Cycles of Matter and Energy Transfer in Ecosystems** ● Plants or algae form the lowest level of the food web. At each link upward in a food web, only a small fraction of the matter consumed at the lower level is transferred upward, to produce growth and release energy in cellular respiration at the higher level. Given this inefficiency, there are generally fewer organisms at higher levels of a food web. Some matter reacts to release energy for life functions, some matter is stored in newly made structures, and much is discarded. The chemical elements that make up the molecules of organisms pass through food webs and into and out of the atmosphere and soil, and they are combined and recombined in different ways. At each link in an ecosystem, matter and energy are conserved.

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HS-LS2-3	**Construct and revise an explanation based on evidence for 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]	**LS2.B: Cycles of Matter and Energy Transfer in Ecosystems** ● Photosynthesis and cellular respiration (including anaerobic processes) provide most of the energy for life processes.
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]	**LS2.B: Cycles of Matter and Energy Transfer in Ecosystems** ● 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. **PS3.D: Energy in Chemical Processes** ● The main way that solar energy is captured and stored on Earth is through the complex chemical process known as photosynthesis. *(secondary)*

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HS-LS1-7	**Use a model to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed, resulting in a net transfer of energy.** [Clarification Statement: Emphasis is on the conceptual understanding of the inputs and outputs of the process of cellular respiration.] [Assessment boundary: Assessment should not include identification of the steps or specific processes involved in cellular respiration.]	**LS1.C: Organization for Matter and Energy Flow in Organisms** ● As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products. ● As a result of these chemical reactions, energy is transferred from one system of interacting molecules to another. Cellular respiration is a chemical process in which the bonds of food molecules and oxygen molecules are broken and new compounds are formed that can transport energy to muscles. Cellular respiration also releases the energy needed to maintain body temperature despite ongoing energy transfer to the surrounding environment.
HS-LS1-5	**Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy.** [Clarification statement: Emphasis is on illustrating inputs and outputs of matter and the transfer and transformation of energy in photosynthesis by plants and other photosynthesizing organisms. Examples of models could include diagrams, chemical equations, and	**<u>LS1.C: Organization for Matter and Energy Flow in Organisms</u>** ● The process of photosynthesis converts light energy to stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen.

	conceptual models.] [Assessment boundaries: Does not include specific biochemical steps.]	
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]	**LS2.A: Interdependent Relationships in Ecosystems** ● Ecosystems have carrying capacities, which are limits to the numbers of organisms and populations they can support. These limits result from such factors as the availability of living and nonliving resources and from such challenges such as predation, competition, and disease. Organisms would have the capacity to produce populations of great size were it not for the fact that environments and resources are finite. This fundamental tension affects the abundance (number of individuals) of species in any given ecosystem.
Observable Outcomes:		

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1. Students can calculate changes or differences in matter and energy between trophic levels of an ecosystem, and either illustrate, graph, or identify a mathematical model describing the changes in stored energy throughout the trophic levels of an ecosystem.
2. Students should be able to interpret data from provided information to determine the relationship between organisms at different trophic levels.
3. Students can make a claim using quantitative or abstract reasoning to explain the cycling of matter and flow of energy.
4. Students should be able to use evidence to defend a claim about the role of photosynthesis and aerobic and anaerobic respiration in the cycling of matter and energy in an ecosystem.
5. Students should be able to assemble or complete an illustration or flow chart that is capable of representing how the processes of photosynthesis and cellular respiration cycle carbon by various chemical, physical, geological, and biological processes through two or more spheres (biosphere, atmosphere, hydrosphere, geosphere). This does not include labeling an existing diagram.
    a. Using the developed model, identify and describe the relationships between the processes of photosynthesis and cellular respiration, and the coordinated functions of transferring carbon among two or more spheres (biosphere, atmosphere, hydrosphere, geosphere).
    b. Using the developed model, show that photosynthesis and cellular respiration are important parts of the overall carbon cycle that transfers carbon through two or more spheres (biosphere, atmosphere, hydrosphere, geosphere).
    c. Show that matter and energy are only rearranged during cellular respiration, but never created or destroyed.
6. Students should be able to use a model to identify and describe the relationships in terms of matter and/or energy between the reactants and the products of photosynthesis, and show how sugar and oxygen are produced by carbon dioxide and water through the process of photosynthesis.
7. Students should be able to use a model to show the transfer of matter and flow of energy between an organism and its environment during photosynthesis.

8. Students should be able to make calculations using given data to calculate or estimate factors affecting the carrying capacity of an ecosystem, and should be able to make a claim about different factors that affect the carrying capacity of an ecosystem.

Key Terms:

HS-LS2-4:
Atoms, molecules, chemical equation/process/reaction, interdependent, nutrient, food web, transfer system, equilibrium of ecosystems, decomposer, producer, predator-prey relationship, trophic level.

HS-LS2-3:
Energy flow, organic compound synthesis, chemical processes/reaction, flow of matter, net transfer, biomass, carbon cycle, solar energy, derive, transform matter/energy

HS-LS2-5:
Environment, recycle, ecosystem, biosphere, atmosphere, hydrosphere, geosphere, consumer, microbes

HS-LS1-7:
Molecules, ATP, glycolysis, enzymes, phosphate

HS-LS1-5:
Chemical equation, chemical bond, organic, hydrocarbon, net transfer, chloroplast, chlorophyll, cytoplasm, mitochondria, vacuole, nucleus, protein, ATP, amino acid, photosynthesis, cellular respiration, energy flow, autotroph, heterotrophs, algae, carbon dioxide, glucose, energy

HS-LS2-1:
Predation, resilient, abundance, carrying capacity, interdependent, disturbance, equilibrium of ecosystems, finite, fluctuation,

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stable, biotic, abiotic, climate change, invasive species, sustain, anthropogenic, overexploitation, urbanization, population, emigrants, immigrants, birth/death,

Suggested Phenomena

HS-LS2-4:

In the 6,000-hectare rainforest of San Lorenzo, Panama, there are 312 arthropods for every mammal, including humans.
https://phys.org/news/2012-12-species-mammal-arthropod-lurk-rainforest.html

HS-LS2-3:

After running for a long period of time, human muscles develop soreness and a burning sensation, and breathing rate increases.
https://www.scientificamerican.com/article/why-does-lactic-acid-buil/

HS-LS2-5:

Several acres of trees are cut down and burned, generating clouds of smoke.
https://www.nytimes.com/2019/09/17/world/asia/indonesia-fires-photos.html

HS-LS1-7:

A person feels tired and weak before eating lunch. After eating some fruit, the person feels more energetic and awake.
An athlete completing difficult training feels that her muscles recover and repair faster when she eats more food in a day, compared to when she ate less food in a day.

HS-LS1-5:

The waters of the Laguna Grande lagoon in Puerto Rico give off a bluish-green glow at night when disturbed.
https://www.youtube.com/watch?v=VwfG9s1A8pI
The discovery of hydrothermal vents in 1977 and how the presence of life in the deep ocean in the toxic extreme conditions, in the absence of light, changed what scientists had believed about photosynthesis being the source of energy for life.
https://www.youtube.com/watch?v=D69hGvCsWgA

Suggested Activities

-Flow of Energy in Ecosystem: Flow of Energy in Ecosystems
-Trophic Level Lab: https://betterlesson.com/lesson/632267/trophic-level-lab

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- Food Chain Checkers: https://www.windows2universe.org/teacher_resources/checkers_20march.pdf
-Cycling of Carbon in Ecosystems: https://thewonderofscience.com/hsls25
-Burn Baby Burn: https://www.lifescitrc.org/resource.cfm?submissionID=3717
-Photosynthesis & Respiration Game:
https://biomanbio.com/HTML5GamesandLabs/PhotoRespgames/photoresphtml5page.html
-Exploring Photosynthesis Measuring Dissolved Oxygen from Aquatic Plants:
http://www.stemliteracyproject.org/uploads/3/7/0/6/37068337/exploring_photosynthesis_-_d__lankford_2016__003_.pdf
-Candy Chemosynthesis: Candy Chemosynthesis
-Chemosynthetic Food Web Activity: Chemosynthetic Food Web

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UNIT #2 : Interdependent Relationships in Ecosystems

Big Idea: Biodiversity and dynamics of the environment		
PE #	Performance Expectation	Disciplinary Core Ideas
HS-LS2-6	**Evaluate claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.** [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.]	**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	**Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of**	**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

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

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Observable Outcomes

1. Students should be able to explain how different conditions can impact the interactions and therefore an ecosystem., and explain the complex interactions in ecosystems, factors that affect biodiversity, relationships between species and the environment, and changes in numbers of species and organisms in a stable or changing ecosystem.
2. Students should be able to explain that an ecosystem remains relatively consistent when faced with modest disturbances, but it may experience extreme changes or fluctuations in biodiversity when faced with extreme disturbances.
3. Students should be able to make simple calculations using given data to calculate or estimate factors affecting biodiversity and populations in ecosystems.
4. Students should be able to identify, describe, or construct a claim regarding how specific group behaviors can increase an individual's or species' chances of surviving and reproducing, and use data to support the claim.

Key Terms:

HS-LS2-6:
ecosystem, environment, biosphere, biodiversity, photosynthesis, carbon cycle, carbon dioxide, water cycle, nitrogen cycle, organism, producer, consumer, decomposer, disturbance, fluctuation, stable, equilibrium, force, species, conditions, emergence, extinction, resilience, resources, habitat, niche, native, non-native, invasive, overgrazing, human impact, succession, primary succession, secondary succession.

HS-LS2-2:
carrying capacity, anthropogenic changes, trends, abundance, resilient, invasive species, overexploitation, climate change,biodiversity, extinction, pollution, demographic, population pyramid, deforestation, habitat fragmentation,sustainable, invasive species, abiotic factor, biotic factor,species richness, symbiosis, niche, fragile ecosystem, biodiversity index, zero population growth, density, dispersion, immigration, emigration, limiting factor, birth, death, disease.

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HS-LS2-8: Behavior, behavioral ecology, pheromones, innate behavior, imprinting, spatial learning, social learning, associate learning, problem solving, cognition,game theory, agonistic behavior, mating behavior, mating systems, parental care, mate choice, male competition, reciprocal altruism, shoaling.
Suggested Phenomena **HS-LS2-6** After a fire, the biodiversity of a forest immediately decreases but eventually increases. http://www.fao.org/3/y3582e/y3582e08.htm https://www.youtube.com/watch?v=9kkWxUgMHfA Change in rivers in Yellowstone national park pre and post wolf introduction, which occurred in 1995. https://www.yellowstonepark.com/park/yellowstone-wolves-reintroduction https://cptv.pbslearningmedia.org/resource/a58e3ca2-52ab-45f5-87ac-26ee0d681146/wolves-of-yellowstone-earth-a-new-wild/ **HS-LS2-2** Mount St. Helens 1980 eruption. A look at the landscape ecosystem that exist(s) (ed). Mt. St. Helens: Back from the Dead: https://www.youtube.com/watch?v=clCxpKuglho Worksheet: https://www.cusd80.com/cms/lib/AZ01001175/Centricity/Domain/7190/Mt%20St%20Helens%20Back%20From%20the%20Dead%20Video%20Worksheet.pdf **HS-LS2-8** Ants show one of the highest forms of social (or group) interactions. In the following two videos ants work together to carry a large food item and create a bridge made of ants. The individual goals of ants are less important than the overall goals of the colony. Bees, wasps, termites and even some mammals (like the naked mole-rat) show a similar behavior. https://www.youtube.com/watch?v=hrGoTHj33bY&feature=emb_title https://www.youtube.com/watch?time_continue=42&v=A4uv27nSaH4&feature=emb_title

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Suggested Activities

-Wolves of Yellowstone: WOLVES OF YELLOWSTONE
-Exploring Biomes in Gorongosa National Park: Exploring Biomes in Gorongosa National Park
-Biome Travel Agency: Ninth grade Lesson Biome Travel Agency
-Succession Interactive Game: Succession Interactive
-**Creating Chains and Webs to Model Ecological Relationships:** Creating Chains and Webs to Model Ecological Relationships
-Cool Projects Food Web Game: Food Web Game
-What Happened to the Bald Eagle: Lesson in Env Bio Unit 2 folder
-Food Web: https://www.biologycorner.com/worksheets/food_web_label.html
-Extreme Environments Great Salt Lake: https://learn.genetics.utah.edu/content/gsl/
-Ecodetectives Peril River Game: https://biomanbio.com/HTML5GamesandLabs/EcoGames/ecodetectiveshtml5page.html
-Populations and Ecosystems Activities: https://www.learningscience.org/lsc2dpopulationsecosystems.htm
Yellowstone on Fire Assessment: A Rigorous NGSS Assessment for HS-LS2-6
-Group behavior on individual and species' chances to survive and reproduce

- Social Behavior
- Communication
- Cyclic Behavior

-Butterfly Migration: Part 1: https://betterlesson.com/lesson/634677/butterfly-migration-part-1-2?from=search
Part 2: https://betterlesson.com/lesson/634678/butterfly-migration-part-2-2?from=breadcrumb_lesson

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Unit 3: Human Impact on Ecosystems

<table>
<tr><td colspan="3">Big Idea: Human Impact on Ecosystems</td></tr>
<tr><td>PE #</td><td>Performance Expectation</td><td>Disciplinary Core Ideas</td></tr>
<tr><td>HS-LS2-7</td><td>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]</td><td>LS2.C: Ecosystem Dynamics, Functioning, and Resilience
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.
LS4.D: Biodiversity and Humans
Biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction). (secondary)
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) (Note: This Disciplinary Core Idea is also addressed by HS-LS4-6.)
ETS1.B: Developing Possible Solutions</td></tr>
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		• *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. (secondary)*.
HS-LS4-6	**Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.** [Clarification statement: Emphasis is on testing solutions for a proposed problem related to threatened or endangered species, or to genetic variation of organisms for multiple species.]	**LS4.C: Adaptation** • Changes in the physical environment, whether naturally occurring or human induced, have thus contributed to the expansion of some species, the emergence of new distinct species as populations diverge under different conditions, and the decline–and sometimes the extinction–of some species. **LS4.D: Biodiversity and Humans** • Humans depend on the living world for the resources and other benefits provided by biodiversity. But human activity is also having adverse impacts on biodiversity through overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change. Thus sustaining biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth. Sustaining biodiversity also aids humanity by preserving landscapes of recreational or inspirational value. *(Note: This Disciplinary Core Idea is also addressed by HS-LS2-7.)* **ETS1.B: Developing Possible Solutions** • When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. *(secondary)* • Both physical models and computers can be used in various

		ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs. *(secondary)*
HS-ESS2-7	**Construct an argument based on evidence about the simultaneous coevolution of Earth's systems and life on Earth.** [Clarification Statement: Emphasis is on the dynamic causes, effects, and feedbacks between the biosphere and Earth's other systems, whereby geoscience factors control the evolution of life, which in turn continuously alters Earth's surface. Examples include how photosynthetic life altered the atmosphere through the production of oxygen, which in turn increased weathering rates and allowed for the evolution of animal life; how microbial life on land increased the formation of soil, which in turn allowed for the evolution of land	**ESS2.D: Weather and Climate** ● Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen. **ESS2.E Biogeology** ● The many dynamic and delicate feedbacks between the biosphere and other Earth systems cause a continual co-evolution of Earth's surface and the life that exists on it.

	plants; or how the evolution of corals created reefs that altered patterns of erosion and deposition along coastlines and provided habitats for the evolution of new life forms.] [Assessment Boundary: Assessment does not include a comprehensive understanding of the mechanisms of how the biosphere interacts with all of Earth's other systems.]	
HS-ESS3-1	**Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.** [Clarification Statement: Examples of key natural resources include access to fresh water (such as rivers, lakes, and groundwater), regions of fertile soils such as river deltas, and high concentrations of minerals and fossil fuels. Examples of natural hazards can be from interior processes (such as volcanic eruptions and earthquakes), surface processes (such as tsunamis, mass wasting and	**ESS3.A: Natural Resources** ● Resource availability has guided the development of human society. **ESS3.B: Natural Hazards** ● Natural hazards and other geologic events have shaped the course of human history; [they] have significantly altered the sizes of human populations and have driven human migrations.

	soil erosion), and severe weather (such as hurricanes, floods, and droughts). Examples of the results of changes in climate that can affect populations or drive mass migrations include changes to sea level, regional patterns of temperature and precipitation, and the types of crops and livestock that can be raised.]	
HS-ESS3-2	**Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.** [Clarification statement: Emphasis is on the conservation, recycling and reuse of resources (such as minerals and metals) where possible, and on minimizing impacts where it is not. Examples include developing best practices for agricultural soil use, mining (for coal, tar sands, and oil shales), and pumping (for petroleum and natural gas). Science knowledge indicates what can happen in natural systems—not what should happen.]	**ESS3.A: Natural Resources** ● All forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors. **ETS1.B: Developing Possible Solutions** ● When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. *(secondary)*

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HS-ESS3-3	**Create a computational simulation to illustrate the relationships among the management of natural resources, the sustainability of human populations, and biodiversity.** [Clarification Statement: Examples of factors that affect the management of natural resources include costs of resource extraction and waste management, per-capita consumption, and the development of new technologies. Examples of factors that affect human sustainability include agricultural efficiency , levels of conservation, and urban planning.] [Assessment Boundary : Assessment for computational simulations is limited to using provided multi-parameter programs or constructing simplified spreadsheet calculations.]	**ESS3.C: Human Impacts on Earth Systems** ● The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources.
HS-ESS3-4	**Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.**	**ESS3.C: Human Impacts on Earth Systems** ● Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude ecosystem degradation.

	[Clarification Statement: Examples of data on the impacts of human activities could include the quantities and types of pollutants released, changes to biomass and species diversity , or areal changes in land surface use (such as for urban development, agriculture and livestock, or surface mining). Examples for limiting future impacts could range from local efforts (such as reducing, reusing, and recycling resources) to large-scale geoengineering design solutions (such as altering global temperatures by making large changes to the atmosphere or ocean).]	**ETS1.B: Developing Possible Solutions** • When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. *(secondary)*

Observable Outcomes

1. Students should be able to express or complete a causal chain explaining how human activity impacts the environment. This may include indicating directions of causality in an incomplete model such as a flow chart or diagram, or completing cause-and-effect chains, and identify evidence supporting the inference of causation that is expressed in a causal chain.
2. Students should be able to use an explanation to predict the environmental outcome of a given change in the design of human technology, and Identify or describe relevant aspects of the problem that given design solutions for reducing the impacts of human activities on the environment and biodiversity, if implemented, will resolve or improve.
3. Students should be able to propose/design a potential solution to resolve or improve the impact of human activities on the environment and biodiversity.

4. Students should be able to complete a causal chain explaining how resource availability/natural hazards/climate change drive changes in human society/population/migration. This may include indicating directions of causality in an incomplete model such as a flow chart or diagram, or completing cause and effect chains.
5. Students should be able to evaluate and/or revise a solution to resolve or improve the impact of human activities on the environment and biodiversity.

Key Terms

HS-LS2-7:

Speciation, invasive species, extinction, carrying capacity, competition, urbanization, conservation, overexploitation, overpopulated, endangered species, threatened species, introduced species, overharvesting, greenhouse effect, carbon footprint

HS-LS4-6:

Climate change, genetic variation, invasive species, adverse, anthropogenic, efficient, overexploitation, urbanization, acidification, deforestation, carbon dioxide, concentration, radiation, greenhouse gas, surface runoff, civilization, consumption, mass wasting, urban development, per- capita, degradation, pollutant, best practice, cost-benefit, extract, harvesting of resources, regulation.

HS-ESS2-7:

Plate tectonics, rock formation, fossil record, geologic evidence, meteorite, ocean basin, radioactive, rock strata, time scale, continental boundary, ocean trench, plate tectonics, pressure, topographical map, sedimentation, continental shelf, crustal deformation, crustal plate movement, fracture zone, tectonic process, convection, atmospheric composition, biosphere, geosphere, groundwater, hydrosphere, igneous rock, metamorphic rock, sedimentary rock, water cycle, Earth's climate, Earth system, landslide, deposition, greenhouse gas, mass wasting, molten rock, surface runoff, evolution, photosynthesis

HS-ESS3-1:

Biosphere, geosphere, hydrosphere, atmosphere, renewable, non-renewable, mitigation, economic cost.

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HS-ESS3-3: Biosphere, geosphere, hydrosphere, atmosphere, renewable, non-renewable, mitigation, economic cost, irreversible, reversible, exponential, logarithmic, basin, sustainability, ecological, biome, recycle, reuse, ecosystem, pollution, species, fresh water, mineral, vegetation, societal, wetland, groundwater, human activity, human impact, metal, consumption, per-capita, biodiversity, stabilize, resource availability, fossil fuel, mining, conservation, extract, agriculture, timber, fertile land, solar radiation, biotic, abiotic, depletion, extinction, economics, manufacturing, technology.

Suggested Phenomena

HS-LS2-7:

- A CNN news document that allows the students to understand the last standing of the Northern White Rhino. Showing the students how global interactions can affect population sizes in the environment. Only four northern white rhinos are left
- This video can be used as a hook and have students list invasive species worldwide and see how many they actually know: 25 Most Invasive Creatures On Earth

HS-LS4-6: The videos below are on Biodiversity and Humans. Biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction). Humans depend on the living world for the resources and other benefits provided by diversity. 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.

- Human activities that threaten biodiversity
- Overexploitation
- Habitat destruction
- Pollution
- Introduction of Invasive Species
- Climate change
- Sustaining biodiversity

HS-ESS2-7: The appearance of cyanobacteria is recorded in fossils that formed roughly 3.5 billion years ago. Superior Type banded iron formed roughly 1.8 to 2.7 billion years ago. It is characterized by alternating red and gray layers of iron rich minerals and silica rich minerals.

- Earth - The event that transformed Earth
- Is there a relationship between fossilized cyanobacteria bubbles and simple seaweeds and the composition of Earth's Atmosphere Phenomenon (and Assessment, which can be used later in the unit).
  HS-ESS2-7 Assessment - Is there a relationship between fossilized cyanobacteria bubbles and simple seaweeds and the composition of Earth's Atmosphere? (NY)

HS-ESS3-1:

- Mythbusters: Vegetable Oil as Fuel**:** Vegetable Oil as Fuel — The Wonder of Science
- Straight Vegetable Oil as a Diesel Fuel? Straight Vegetable Oil as a Vehicle Fuel? (Fact Sheet), Energy Efficiency & Renewable Energy (EERE), Vehicle Technologies Of

HS-ESS3-3:

- The Mystery of the MIssing Bees: The specific cause (or causes) of colony collapse disorder has not been found but the fact that a number of bees are dying is clear. This will have massive economic impacts since many of the foods we eat are pollinated by bees. Since humans are both impacting and being impacted by this problem it can be used as an engineering problem in need of a solution.
  The Mystery Of The Missing Bees
  Bumblebees are going extinct in a time of 'climate chaos'
- Transforming Mars: Aside from ethical concerns, turning the planet Mars into a habitable planet would be a scientific challenge. The planet is too cold, lacks a usable atmosphere, and the lack of a magnetic field leaves it susceptible to space weather. Increasing the amount of $CO2$ in the atmosphere could solve two of these problems through the greenhouse effect. This thought-experiment could provide students an opportunity to better understand interactions between Earth systems. Terraforming Mars

HS-ESS3-4:

- Earth is constantly changing. Some changes are a natural part of the climate system, such as the seasonal expansion and contraction of the Arctic sea ice pack. The responsibility for other changes, such as the Antarctic ozone hole, falls squarely on humanity's shoulders. NASA's World of Change series documents how our planet's land, oceans, atmosphere, and Sun are changing over time. Earth: Planet of Altered States

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● The Google Maps Timelapse engine allows you to see the impacts of humans on local environments over the last three decades. Use the search box to find local human impacts. Local phenomenon (e.g. housing developments, logging, shrinking water reservoirs, etc.) can lead to local solutions to human impacts on the land and water. Here is a Google Maps Timelapse ● A Sacred River: Students can evaluate the continued impact of pulse flows in the Colorado River on the health of the estuary. A possible resource could be this June 2018 article: https://www.nrdc.org/onearth/colorado-river-delta-proof-natures-resiliency Another option could have students develop water usage plans for people dependent on water in reservoirs along the Colorado River (mentioned in the article is the Glen Canyon Dam which resulted in the formation of Lake Powell) to ensure that the pulse flow program continues. A Sacred Reunion: The Colorado River Returns to the Sea
Suggested Activities **Bees: The Invaluable Master Pollinators - Activity - TeachEngineering** **Invasive Species of CT Facts Resource:** https://portal.ct.gov/DEEP/Invasive-Species/Invasive-Species **The American Chestnut:** The American Chestnut: From Dominance to Destruction | Maryland Sea Grant Invasive Investigation **HS-LS2-7, CK-12**: Ecosystems: Interactions, Energy, and Dynamics | High School Life Sciences | Next Generation Science Standards **Dynamics, Biodiversity & Developing Possible Solutions:** Grade 9-12 - HS-LS2 Ecosystems: Interactions, Energy, and Dynamics **Unexpected Consequences of Human Daily Life On Habitat and Populations:** Ecology Disrupted: Bighorn Sheep Lesson Plan **Native Species Restoration and its Impact on Local Populations** **Activity**

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Angry Aliens Ecology Game

HS-LS4-6, CK-12: Biological Evolution: Unity and Diversity | High School Life Sciences | Next Generation Science Standards

Ocean Floor: Change Over Time

My NASA Data: Students select satellite datasets to answer questions related to system interactions and feedback.

Climate and Earth Systems: Students model the carbon cycle and it's connection with Earth's climate. Earth Systems Activity

The Greenhouse Effect: Students explore the atmosphere during the ice age and today.
https://phet.colorado.edu/en/simulation/greenhouse

Cyanobacteria and Life on Earth: The Cells That Changed the World

HS-ESS2-7, CK-12: Earth's Systems | High School Earth and Space Sciences | Next Generation Science Standards

Earth and Human Activity: https://cptv.pbslearningmedia.org/collection/earth-human-activity/

NSA Challenge: Recycling for a Cleaner World: Students will develop a strategy to increase recycling and waste diversion.
HS-ESS3-1, CK-12: Earth and Human Activity | High School Earth and Space Sciences | Next Generation Science Standards

Reefs At Risk: Students access and explore a series of interactive maps displaying coral reef data from around the globe.
ReefGIS - Location of Coral Reefs - Reef Basemap

HS-ESS3-3, CK-12: Earth and Human Activity | High School Earth and Space Sciences | Next Generation Science Standards

Natural Resources,Hazards and Climate Change Influence on Human Impact Activities:
https://www.earthsciweek.org/ngss-performance-expectations/hs-ess3-1

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Teaching with Google Earth: Energy Consumption Rates across the USA and the World

A Smog Vacuum Assessment: A Rigorous NGSS Assessment for HS-ESS3-4

HS-ESS3-4, CK-12: Earth and Human Activity | High School Earth and Space Sciences | Next Generation Science Standards