1. Ecological Systems

Content Area: **Science**
Course(s):
Time Period: **Full Year**
Length: **4 weeks**
Status: **Published**

General Overview, Course Description or Course Philosophy

OBJECTIVES, ESSENTIAL QUESTIONS, ENDURING UNDERSTANDINGS

- Photosynthesis and cellular respiration (including anaerobic processes) provide most of the energy for life processes.
- 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.
- 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.
- 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.
- The main way that solar energy is captured and stored on Earth is through the complex chemical process known as photosynthesis.
- Energy cannot be created or destroyed— it only moves between one place and another place, between objects and/or fields, or between systems.
- Energy drives the cycling of matter within and between systems.
- Population dynamics
- Ecological communities and dynamics
- Changes in ecological communities
- Much of science deals with constructing explanations of how things change and how they remain stable.

CONTENT AREA STANDARDS

SCI.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.
SCI.HS-LS2-4	Use a mathematical representation to support claims for the cycling of matter and flow of energy among organisms in an ecosystem.
SCI.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.
SCI.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.
SCI.HS-LS3	Heredity: Inheritance and Variation of Traits
SCI.HS-LS3-3	Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.

RELATED STANDARDS (Technology, 21st Century Life & Careers, ELA Companion Standards are Required)

MA.S-ID.A.1	Represent data with plots on the real number line (dot plots, histograms, and box plots).
MA.K-12.2	Reason abstractly and quantitatively.
MA.K-12.4	Model with mathematics.
MA.N-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.
MA.N-Q.A.2	Define appropriate quantities for the purpose of descriptive modeling.
MA.N-Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.
LA.RL.9-10.8	(Not applicable to literature)
LA.RI.9-10.1	Accurately cite strong and thorough textual evidence, (e.g., via discussion, written response, etc.) and make relevant connections, to support analysis of what the text says explicitly as well as inferentially, including determining where the text leaves matters uncertain.
MA.S-IC.A.1	Understand statistics as a process for making inferences about population parameters based on a random sample from that population.
MA.S-IC.B.6	Evaluate reports based on data.
LA.RI.9-10.7	Analyze various perspectives as presented in different mediums (e.g., a person's life story in both print and multimedia), determining which details are emphasized in each account.
LA.RI.9-10.8	Describe and evaluate the argument and specific claims in a text, assessing whether the reasoning is valid and the evidence is relevant and sufficient; identify false statements and reasoning.
LA.W.9-10.2	Write informative/explanatory texts to examine and convey complex ideas, concepts, and information clearly and accurately through the effective selection, organization, and analysis of content.
LA.W.9-10.5	Develop and strengthen writing as needed by planning, revising, editing, rewriting, trying a new approach, or consulting a style manual (such as MLA or APA Style), focusing on addressing what is most significant for a specific purpose and audience.
LA.W.9-10.7	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.
SCI.HS-ESS2-6	Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.
SCI.HS-ESS3-4	Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.
SCI.HS-LS4-6	Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.
SCI.HS-LS4-5	Evaluate the evidence supporting claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.
TECH.9.4.12.CI.1	Demonstrate the ability to reflect, analyze, and use creative skills and ideas (e.g., 1.1.12prof.CR3a).
TECH.9.4.12.IML.3	Analyze data using tools and models to make valid and reliable claims, or to determine optimal design solutions (e.g., S-ID.B.6a., 8.1.12.DA.5, 7.1.IH.IPRET.8).

STUDENT LEARNING TARGETS

Declarative Knowledge

Students will understand that:

- Energy from photosynthesis and respiration drives the cycling of matter and flow of energy under aerobic or anaerobic conditions within an ecosystem.
- Anaerobic respiration occurs primarily in conditions where oxygen is not available.
- Matter flows between organisms and their environment.
- Energy flows from one trophic level to another as well as through the environment.
- Energy not transferred to higher trophic levels but which is instead used for growth, maintenance, or repair, and/or transferred to the environment, and the inefficiencies in transfer of matter and energy.
- The inputs and outputs of photosynthesis; the inputs and outputs of cellular respiration; and the biosphere, atmosphere, hydrosphere, and geosphere.
- 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.
- The resiliency of an ecosystem is subject to the degree of change in the biological and physical environment of an ecosystem.

Procedural Knowledge

Students will be able to:

- Students identify and describe the evidence to construct the explanation, including:
    - All organisms take in matter and rearrange the atoms in chemical reactions.
    - Photosynthesis captures energy in sunlight to create chemical products that can be used as food

in cellular respiration.
    - Cellular respiration is the process by which the matter in food (sugars, fats) reacts chemically with other compounds, rearranging the matter to release energy that is used by the cell for essential life processes.
- Students use a variety of valid and reliable sources for the evidence, which may include theories, simulations, peer review, and students' own investigations.
- Students use reasoning to connect evidence, along with 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, to construct their explanation. Students describe the following chain of reasoning used to construct their explanation:
    - Energy inputs to cells occur either by photosynthesis or by taking in food.
    - Since all cells engage in cellular respiration, they must all produce products of respiration.
    - The flow of matter into and out of cells must therefore be driven by the energy captured by photosynthesis or obtained by taking in food and released by respiration.
    - The flow of matter and energy must occur whether respiration is aerobic or anaerobic.
- Given new data or information, students revise their explanation and justify the revision (e.g., recent discoveries of life surrounding deep sea ocean vents have shown that photosynthesis is not the only driver for cycling matter and energy in ecosystems).
- Students identify and describe the components in the mathematical representations that are relevant to supporting the claims. The components could include relative quantities related to organisms, matter, energy, and the food web in an ecosystem.
- Students identify the claims about the cycling of matter and energy flow among organisms in an ecosystem.
- Students describe how the claims can be expressed as a mathematical relationship in the mathematical representations of the components of an ecosystem.
- Students use the mathematical representation(s) of the food web to:
    - Describe the transfer of matter (as atoms and molecules) and flow of energy upward between organisms and their environment.
    - Identify the transfer of energy and matter between tropic levels.
    - Identify the relative proportion of organisms at each trophic level by correctly identifying producers as the lowest trophic level having the greatest biomass and energy and consumers decreasing in numbers at higher trophic levels.
- Students describe relationships between components of their model, including:
    - The exchange of carbon (through carbon-containing compounds) between organisms and the environment.
    - The role of storing carbon in organisms (in the form of carbon-containing compounds) as part of the carbon cycle.
- Students describe the contribution of photosynthesis and cellular respiration to the exchange of carbon within and among the biosphere, atmosphere, hydrosphere, and geosphere in their model.
- Students make a distinction between the model's simulation and the actual cycling of carbon via photosynthesis and cellular respiration.
- Students assess the logic of the reasoning, including the relationship between degree of change and stability in ecosystems, and the utility of the reasoning in supporting the explanation of how:
    - Modest biological or physical disturbances in an ecosystem result in maintenance of relatively consistent numbers and types of organisms.
    - Extreme fluctuations in conditions or the size of any population can challenge the functioning of ecosystems in terms of resources and habitat availability, and can even result in a new ecosystem.

EVIDENCE OF LEARNING

Formative Assessments

- Checks for understanding during lesson.
- Use of student-friendly proficiency scales to track progress.
- Do Now activities.
- Student-centered questioning and discussion that is facilitated by instructor.
- Exit Tickets.

Summative Assessments

- Benchmarks – departmental benchmark given at the end of MP1, MP2, and MP3 based on lab practices
- Alternative Assessments
    - Lab inquiries and investigations
    - Lab Practicals
    - Exploratory activities based on phenomenon
    - Gallery walks of student work
    - Creative Extension Projects
    - Build a model of a proposed solution
    - Let students design their own flashcards to test each other
    - Keynote presentations made by students on a topic
    - Portfolio

RESOURCES (Instructional, Supplemental, Intervention Materials)

- Ecology
    - Ecosystems
        - Video: *Flow of Energy Through Producers and Consumers*

        - Analyzing Data: *Ocean Water and Oxygen Concentration*
        - Interactivity: *Food Web*
        - Animation: *The Water Cycle*
        - Case Study: *The Nitrogen Cycle*
        - Exploration Lab: *The Effect of Fertilizer on Algae*
    - Populations
        - Analyzing Data: Populations changes
    - Communities and Ecosystem Dynamics
        - Quick Lab: *How does succession occur?*
    - Humans and Global Change
        - Case Study: *How Does Acid Affect Shells?*
        - Case Study: *Toxic Algal Bloom*

POGIL Biology

- Energy Transfer in Living Organisms
- Ecological Pyramids
- Nutrient Cycles

Gizmos

- Cell Respiration (STEM Case)
- Photosynthesis (STEM Case)
- Carbon Cycle
- Cell Energy Cycle

Textbook:

Biology: The Unity and Diversity of Life 14th Ed.
Cengage

NSTA

Data Nuggets

Online Resources

https://flexbooks.ck12.org/cbook/ck-12-biology-flexbook-2.0/?_gl=1*1iym1h9*_ga*MTg0MjM4NDA3Ny4xNjc3NzY0NDU2*_ga_7PBE4L0PZZ*MTY3Nzc2NDQ1Ni4xLjEuMTY3Nzc2NDg0MS4wLjAuMA..

INTERDISCIPLINARY CONNECTIONS

ELA/Literacy

Mathematics

Technology

Earth Science

ACCOMMODATIONS & MODIFICATIONS FOR SUBGROUPS

See link to Accommodations & Modifications document in course folder.