Biology - Unit 1 - Energy and Matter in Ecosystems

Unit Focus

This unit introduces students to the broad fundamental principles governing living things. Students will explore the integral parts of an ecosystem, specifically the linear flow of energy as it moves within and between organisms, and discover the natural, cyclical flow of matter as it moves within components of the biosphere. Throughout the unit, students will also explore how physiological changes in organisms can influence energy flow in an ecosystem. Students will be required to work collaboratively developing and revising a model that can be used to explain the Feeding Frenzy anchoring phenomenon, and also predict seemingly unknown but related phenomena.

Stage 1: Desired Results - Key Understandings

Standard(s)

Next Generation Science

High School Earth and Space Sciences: 9 - 12

- Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere. *HS-ESS2-6*
- Construct an argument based on evidence about the simultaneous coevolution of Earth's systems and life on Earth. *HS-ESS2-7*

High School Life Sciences: 9 - 12

- Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy. *HS-LS1-5*
- Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules. *HS-LS1-6*
- Use a model to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed resulting in a net transfer of energy. *HS-LS1-7*
- Construct and revise an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions. *HS-LS2-3*
- Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem. *HS-LS2-4*
- Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere. *HS-LS2-5*

Transfer

T1 Create models to explore complex systems, show mastery of key science concepts, and/or develop solutions through creation of a product open to testing and redesign.
T2 Analyze qualitative and quantitative data to interpret patterns, draw conclusions, and/or make predictions.

Meaning

Understanding(s)	Essential Question(s)
U1 The biosphere is the global, ecological system integrating all living things (biotic) and their relationships with the nonliving (abiotic) components of the environment. **U2** The flow of energy into and throughout the Earth system is non cyclical **U3** Plants convert light energy from the sun to stored chemical energy in the form of carbohydrates **U4** All living things have basic needs in order to survive and grow. **U5** Feeding relationships within an ecosystem are adaptations that transfer energy from one organism to another **U6** The second law of thermodynamics states that whenever energy is transformed, there is a loss energy through the release of heat	**Q1** How are the living and nonliving components of the Earth system connected? **Q2** How does energy flow into and within components of the Earth system? **Q3** How have plants and animals evolved to become interdependent? **Q4** How is matter cycled within the Earth system?

Stage 1: Desired Results - Key Understandings

- 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. *HS-LS2-6*
- Evaluate the evidence for the role of group behavior on individual and species' chances to survive and reproduce. *HS-LS2-8*

Next Generation Science Standards (DCI)

Science: 9

- Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen. *ESS2.9.D3*
- 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. *ESS2.9.E1*

Science: 10

- The process of photosynthesis converts light energy to stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen. *LS1.9.C1*
- The sugar molecules thus formed contain carbon, hydrogen, and oxygen: their hydrocarbon backbones are used to make amino acids and other carbon-based molecules that can be assembled into larger molecules (such as proteins or DNA), used for example to form new cells. *LS1.9.C2*
- As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products. *LS1.9.C3*
- Photosynthesis and cellular respiration (including anaerobic processes) provide most of the energy for life processes. *LS2.9.B1*
- 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. *LS2.9.B2*

U7 The coevolution of plants and animals has led to the development of complex plant-animal interactions
U8 The flow of matter is cyclical, and therefore recycled throughout the Earth system.

Acquisition of Knowledge and Skill

Knowledge	Skill(s)
K1 Within the biosphere organisms function and interact among other living organisms at the species, population, and community level, as well as interact with the non living to form ecosystems. **K2** The nonliving abiotic components of the biosphere include the lithosphere, geosphere, hydrosphere, and atmosphere. **K3** Biotic components are the living things that shape an ecosystem, and include producers, such as autotrophs, and consumers called heterotrophs. **K4** Plants convert light energy from the sun to stored chemical energy through the process of photosynthesis, where carbon dioxide and water, along with energy from sunlight is used to manufacture carbohydrates and release oxygen as a byproduct **K5** Matter and energy are transferred within the biosphere through complex feeding relationships called food chains **K6** A hierarchy within a food chain consists of trophic feeding levels that begins with primary producers and ends with tertiary consumers. **K7** Animals that eat plants liberate the chemical energy stored by plants through the process of cellular respiration, where oxygen is used to help break down carbohydrate	**S1** Construct a model that illustrates and explains that natural complexity of an organism's function and interaction with the biotic and abiotic components of the biosphere **S2** Construct a model that compares the interdependent inputs and outputs of matter and the transfer and transformation of energy by photosynthetic organisms with cellular respiration **S3** Analyze and interpret a mathematical model or representation of stored energy in biomass to describe and explain the transfer of energy from one trophic level to another.

Stage 1: Desired Results - Key Understandings

• 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. *LS2.9.B3* • 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. *LS2.9.C1* • Adaptation also means that the distribution of traits in a population can change when conditions change. *LS4.9.C3* **Madison Public Schools Profile of a Graduate** *Critical Thinking* • Analyzing: Examining information/data/evidence from multiple sources to identify possible underlying assumptions, patterns, and relationships in order to make inferences. (POG.1.2) *Collaboration/Communication* • Product Creation: Effectively use a medium to communicate important information. (POG.3.2)	molecules and release carbon dioxide as a byproduct **K8** Due to heat loss and metabolic processes, only a fraction of the energy consumed at the lower trophic levels of a food web is transferred up, resulting in fewer organisms at higher levels. **K9** The various amount of matter on the Earth system is fixed, and is recycled throughout the biosphere in various cyclical process such as the oxygen cycle, carbon cycle, water cycle, and nitrogen cycle. **K10** Vocabulary: Ecology, biosphere, species, population, community, ecosystem, biome, autotroph, producer, photosynthesis, chlorophyll, chemosynthesis, heterotroph, consumer, competitive exclusion principle, herbivore, carnivore, omnivore, detrivore, decomposer, food chain, food web, trophic level, ecological pyramid, biomass, biogeochemical cycle, evaporation, transpiration, nutrient, nitrogen fixation, denitrification, primary productivity, limiting nutrient, adenosine triphosphate (ATP), 2nd Law of Thermodynamics	