Honors Biology - Unit 2 - Energy and Matter in Ecosystems

Unit Focus

Students will explore ecosystems from the molecular level when they examine the processes that sustain life on Earth and through the macroscopic lens of ecosystem dynamics. Students will investigate what factors lead to a balanced, healthy ecosystem and, through a case study, learn about how ecosystems become unbalanced and the factors that cause this disruption. In doing so, students will need to apply their understanding of the cellular processes and chemical reactions that are required in an ecosystem to analyze graphical data and consider the viability of solutions capable of restoring balance. Students will apply the Laws of Thermodynamics and Conservation of Matter to the processes and ecosystems studied.

Stage 1: Desired Results - Key Understandings

Standard(s)

Next Generation Science
High School Life Sciences: 9 - 12

- Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy. *HS-LS1-5*
- 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*
- Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales. *HS-LS2-1*
- 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*
- 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*

Next Generation Science Standards (DCI)
Science: 9

Transfer

T1 Analyze qualitative and quantitative data to interpret patterns, draw conclusions, and/or make predictions.
T2 Communicate effectively based on purpose, task, and audience to promote collective understanding and/or recommend actions.

Meaning

Understanding(s)	Essential Question(s)
U1 Matter and energy move through ecosystems through process that transfer energy and recycle matter. **U2** The processes of photosynthesis and cellular respiration are key drivers of the sustainability of ecosystems. **U3** The rearrangement of atoms in photosynthesis and cellular respiration allow for the transfer of energy and cycling of matter within a system. **U4** Models are often used to demonstrate a variety of factors regarding ecosystem dynamics. **U5** Changes to an ecosystem can cause cascading disruptions to the system. **U6** Carrying capacity is determined by the availability of energy and resources in a system. **U7** Ecosystem dynamics and natural selection are intrinsically linked. **U8** Sometimes people intervene to restore the health and balance of ecosystems.	**Q1** How do natural processes sustain life on Earth? **Q2** What factors are necessary for ecosystems to be self-sustaining? **Q3** How can I use a model to demonstrate ecosystem dynamics? **Q4** How do ecological disruptions impact populations? **Q5** How can factors in an ecosystem drive natural selection?

Stage 1: Desired Results - Key Understandings

- 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*
- 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. *LS1.9.C4*
- 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. *LS2.9.A1*
- 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*

Acquisition of Knowledge and Skill

Knowledge	Skill(s)
K1 Energy cannot be created or destroyed. Energy is stored in bonds. When bonds are broken, energy is released. When bonds are created, energy is stored. **K2** The 10% rule states that about 10% of the energy available at each trophic level is incorporated into the organisms at the next level of an ecosystem. **K3** Ecosystems are dynamic in nature and vulnerable to disruptions. **K4** Vocabulary: trophic, glucose, fixation, limiting factors, biomass, entropy, photosynthesis, cellular respiration, biogeochemical cycles, ecological pyramid, carrying capacity, exponential growth, logistic growth, S-curve, potential energy, kinetic energy, chemical energy, ATP, ADP, law of thermodynamics, law of conservation of matter,	**S1** Demonstrate the Laws of Conservation of Matter and Thermodynamics through chemical equations. **S2** Creation of models to demonstrate understanding of ecosystem dynamics. **S3** Citing evidence for claims regarding an ecological disruption. **S4** Analyzing graphical data to form evidence-based conclusions.

Stage 1: Desired Results - Key Understandings

- 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*
- Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. *PS3.9.B2*
- The availability of energy limits what can occur in any system. *PS3.9.B4*

NGSS/NSTA Science & Engineering Practices
NGSS Science & Engineering Practices: 9-12

- 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. *SE.9-12.6.2*
- Apply scientific reasoning, theory, and/or models to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion. *SE.9-12.6.4*

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)