Biology, Quarter 2, Unit 2.1

Matter and Energy in Ecosystems

Overview

Number of instructional days: 10 (1 day = 53 minutes)

Content to be learned

- Explain how chemical elements and compounds that make up living things are combined and recombined in different ways through the cycling of matter.
- Describe the role of food webs in the cycling of matter.
- Diagram the energy flow in an ecosystem comparing the energy at different trophic levels.

Processes to be used

- Make and use models.
- Interpret diagrams and illustrations that model relationships within a system.
- Use calculations to model changes within a system.
- Trace cycles.
- Use tools and technology.
- Examine patterns of change.
- Evaluate systems.

Essential questions

- How do matter and energy behave differently as they move through living systems?
- Why haven't living systems run out of raw materials since the origin of life?
- What is the source and fate of energy used by living systems?
- Why is the energy available at the lowest trophic level different from the energy available at the higher trophic levels?

Written Curriculum

Grade Span Expectations

LS2 - Matter cycles and energy flows through an ecosystem.

LS2 (9-11) POC+ SAE –4

Trace the cycling of matter (e.g., carbon cycle) and the flow of energy in a living system from its source through its transformation in cellular, biochemical processes (e.g., photosynthesis, cellular respiration, fermentation).

LS2 (9-11)–4 Students demonstrate an understanding of matter and energy flow in an ecosystem by …

4b explaining how the chemical elements and compounds that make up living things pass through food webs and are combined and recombined in different ways (e.g. nitrogen, carbon cycles, O2, & H2O cycles**).**

4a diagramming the energy flow in an ecosystem that compares the energy at different trophic levels. (e.g. What inferences can you make about energy "loss"& use?).

Clarifying the Standards

Prior Learning

In grades K–4, students were introduced to the concept of energy flow, starting with the sun. They developed the knowledge that plants and animals depend on each other.

In grades 5–8, students learned the relationship between photosynthesis and respiration and the cycling of CO_2, H_2O, and O_2. They also developed an understanding of food webs and energy flow. In grades 9–10, students learned the Laws of Thermodynamics, including Conservation of Energy (energy transfers) and the trend towards entropy (loss of heat). They learned the law of conservation of matter and to analyze and balance simple chemical equations to illustrate Conservation of Matter. They learned the differences between exothermic and endothermic reactions.

Current Learning

By the end of this unit, students describe chemical changes that occur as matter. They are able to explain ecosystem processes and models (food chains, food webs, and biomass pyramids) in relation to conservation of matter and the first two laws of thermodynamics. Students learn that living systems are open systems in relation to energy flow (i.e., energy enters living systems as solar radiation, is converted to chemical energy, and is eventually lost as heat to the universe).

Future Learning

Students will learn the specific details of photosynthesis and respiration processes. They will also learn about non-feeding interactions that occur in ecosystems and the relationship of these interactions to energy conservation (i.e., commensalism, mutualism, competition, and cooperation).

Additional Research Findings

See the National Science Digital Library's science literary map (Strand map: The Living Environment / Flow of Matter in Ecosystems 9-12; <http://strandmaps.nsdl.org/?id=SMS-MAP-9001>) for the following research:

- Some middle-school students do not realize that the matter from dead organisms is converted into other materials in the environment. Some middle-school students see decay as a gradual, inevitable consequence of time without need of decomposing agents. Some high-school students believe that matter is conserved during decay, but do not know where it goes.
- Middle-school students seem to know that some kind of cyclical process takes place in ecosystems. Some students see only chains of events and pay little attention to the matter involved in processes such as plant growth or animals eating plants. Other students recognize one form of recycling through soil minerals but fail to incorporate water, oxygen, and carbon dioxide into matter cycles. Even after specially designed instruction, students cling to their misinterpretations. Instruction that traces matter through the ecosystem as a basic pattern of thinking may help correct these difficulties.

See the National Science Digital Library's science literary map (Strand map: The Living Environment / Flow of Matter in Ecosystems 9-12; <http://strandmaps.nsdl.org/?id=SMS-MAP-1422>) for the following research:

- Students' meanings for "energy" both before and after traditional instruction are considerably different from its scientific meaning. In particular, students believe energy is associated only with humans or movement, is a fuel-like quantity that is used up, or is something that makes things happen and is expended in the process. Students rarely think energy is measurable and quantifiable. Although students typically hold these meanings for energy at all ages, upper elementary school students tend to associate energy only with living things, in particular with growing, fitness, exercise, and food.
- Some students of all ages have difficulty identifying the sources of energy for plants and animals. Students tend to confuse energy and other concepts such as food, force, and temperature. As a result, students may not appreciate the uniqueness and importance of energy conversion processes like respiration and photosynthesis. Although specially designed instruction does help students correct their understanding about energy exchanges, some difficulties remain. Careful coordination between The Physical Setting and The Living Environment benchmarks about conservation of matter and energy and the nature of energy may help alleviate these difficulties.
- Middle school and high school students tend to think that energy transformations involve only one form of energy at a time. Although they develop some skill in identifying different forms of energy, in most cases, their descriptions of energy change focus only on forms that have perceivable effects. The transformation of motion to heat seems to be difficult for students to accept, especially in cases with no obvious temperature increase. Finally, it may not be clear to students that some forms of energy, such as light, sound, and chemical energy, can be used to make things happen.

Notes About Resources and Materials

Biology, Quarter 2, Unit 2.2

Matter and Energy Flow: Coupled Reactions

Overview

Number of instructional days: 10 (1 day = 53 minutes)

Content to be learned

- Explain energy transfer with cells in photosynthesis and cellular respiration.
- Track specific processes involving ATP production and consumption in photosynthesis and cellular respiration.
- Relate photosynthesis and respiration to the cycling of matter.
- Identify energy molecules, such as ATP, and their role in energy conversions.

Processes to be used

- Make, use, and analyze models.
- Interpret diagrams and illustrations.
- Demonstrate understanding through comparing and contrasting.
- Use tools and technology.
- Examine patterns of change.
- Evaluate systems and energy.

Essential questions

- How do plants convert solar radiation into usable chemical energy as organic matter?
- What role does cellular respiration play in the cycling of matter from organic molecules into inorganic reservoirs?
- What role does photosynthesis play in the cycling of matter from inorganic reservoirs into organic molecules?
- What role does ATP play in the conversion of energy from food into energy that is available to perform cellular processes?

Written Curriculum

Grade Span Expectations

LS2 - Matter cycles and energy flows through an ecosystem.

LS2 (9-11) POC+ SAE –4

Trace the cycling of matter (e.g., carbon cycle) and the flow of energy in a living system from its source through its transformation in cellular, biochemical processes (e.g., photosynthesis, cellular respiration, fermentation).

LS2 (9-11)–4 Students demonstrate an understanding of matter and energy flow in an ecosystem by …

4b explaining how the chemical elements and compounds that make up living things pass through food webs and are combined and recombined in different ways (e.g. nitrogen, carbon cycles, O2, & H2O cycles**).**

4aa explaining the energy transfer with cells in photosynthesis and cellular respiration, tracking ATP production and consumption.

Clarifying the Standards

Prior Learning

In grades K–4, students learned how to identify sources of energy for survival (i.e., light or food). Students identified and explained how the physical structure/characteristics of an organism allows it to survive (i.e., roots for water). They also learned that the visible spectrum is part of the electromagnetic spectrum and they explained the way that plants and animals in a habitat depend on each other.

In grades 5–8, students learned how each type of cell, tissue, and organ has a distinct structure and set of functions that serve the organism as a whole. Students at this level learned how to identify the sun as the major source of energy for life on earth and to sequence the energy flow in an ecosystem. They described the basic processes and recognized the substances involved in photosynthesis, including the chemical formulas of the substances. Students learned how to explain the relationship between respiration and photosynthesis, and interpreted a model that traced the flow of energy in a food web. In grades 5–8, students also described the basic process of respiration and recognized the names of chemical formulas for the substances involved in respiration. In grades 9–10, students learned the difference between exothermic and endothermic reactions. They also learned about waves and the electromagnetic spectrum.

Current Learning

Students describe the biochemical pathways of photosynthesis, citing inputs, outputs, energy conversions, and the role of ATP in this process. Students' understanding of the role of specific plant structures (roots and leaves, xylem and phloem, chloroplasts) and their functions in the process of photosynthesis is reinforced. Students describe the importance of photosynthesis by plants in providing food for human consumption, either directly or indirectly. Students must have an understanding of the role of chloroplast in the process of photosynthesis.

They describe the catabolic and anabolic biochemical pathways (glycolysis, transition reaction, Krebs cycle, electron transport) of cellular respiration, citing inputs, outputs, energy conversions, and the role of

ATP in this process. It is important to reinforce student understanding of the role of mitochondria in the process of aerobic respiration and to explain the process of fermentation, including its use in the production of food and beverages.

Future Learning

Students will learn the role of mitochondria in the release of energy from food through the process of cellular respiration. They will also learn about the balance between photosynthesis and respiration as an example of equilibrium in an ecosystem. Students will learn the relationship between agriculture and habitat destruction. While it is not mandated by the standards, teachers *could* use mitochondrial DNA analysis as an example of molecular evidence of evolution. Students will learn that ecological interactions have evolved based on the need to acquire or conserve energy.

Additional Research Findings

**For general misconceptions about energy, see quarter 2, Unit 2.1, Matter and Energy in Ecosystems.*

See the National Science Digital Library's science literary map (Strand map: The Living Environment/Flow of Matter in Ecosystems 9–12; <http://strandmaps.nsdl.org/?id=SMS-MAP-1422>) for the following research:

- Students' meanings for "energy" both before and after traditional instruction are considerably different from its scientific meaning. In particular, students believe energy is associated only with humans or movement, that it is a fuel-like quantity that is used up, or that it is something that makes things happen and is expended in the process. Students rarely think energy is measurable and quantifiable. Although students typically hold these meanings for energy at all ages, upper-elementary school students tend to associate energy only with living things, in particular with growing, fitness, exercise, and food.
- Some students of all ages have difficulty identifying the sources of energy for plants and animals. They tend to confuse energy and other concepts such as food, force, and temperature. As a result, students may not appreciate the uniqueness and importance of energy conversion processes like respiration and photosynthesis. Although specially designed instruction does help students correct their understanding about energy exchanges, some difficulties remain. Careful coordination between The Physical Setting and The Living Environment benchmarks about conservation of matter and energy and the nature of energy may help alleviate these difficulties.
- Middle school and high school students tend to think that energy transformations involve only one form of energy at a time. Although they develop some skill in identifying different forms of energy, in most cases, their descriptions of energy change focus only on forms that have perceivable effects. The transformation of motion to heat seems to be difficult for students to accept, especially in cases with no obvious temperature increase. Finally, it may not be clear to students that some forms of energy, such as light, sound, and chemical energy, can be used to make things happen.

See the National Science Digital Library's science literary map (Strand map: The Living Environment/Flow of Matter in Ecosystems 9–12; <http://strandmaps.nsdl.org/?id=SMS-MAP-9001>) for the following research:

- Students of all ages see food as substances (water, air, minerals, etc.) that organisms take directly in from their environment. In addition, some students of all ages think food is a requirement for growth, rather than a source of matter for growth. They have little knowledge about food being transformed and made part of a growing organism's body.

- Middle school and high school students have difficulty thinking of the human body as a chemical system and have little knowledge of the elements composing the living body. In particular, middle-school students think organisms and materials in the environment are very different types of matter. Students see these substances as fundamentally different and not transformable into each other.
- Some students of all ages hold misconceptions about plant nutrition. They think plants get their food from the environment rather than manufacturing it internally, and that food for plants is taken in from the outside. These misconceptions are particularly resistant to change. Even after traditional instruction, students have difficulty accepting that plants make food from water and air, and that this is their only source of food. Understanding that the food made by plants is very different from other nutrients, such as water or minerals, is a prerequisite for understanding the distinction between plants as producers and animals as consumers.
- Some middle school students do not realize that the matter from dead organisms is converted into other materials in the environment. Some middle school students see decay as a gradual, inevitable consequence of time without need of decomposing agents. Some high school students believe that matter is conserved during decay, but do not know where it goes.
- Middle school students seem to know that some kind of cyclical process takes place in ecosystems. Some students see only chains of events and pay little attention to the matter involved in processes such as plant growth or animals eating plants. Other students recognize one form of recycling through soil minerals, but fail to incorporate water, oxygen, and carbon dioxide into matter cycles. Even after specially designed instruction, students cling to their misinterpretations. Instruction that traces matter through the ecosystem as a basic pattern of thinking may help correct these difficulties.

Notes About Resources and Materials

Biology, Quarter 2, Unit 2.3

Ecosystem Balance and Change

Overview

Number of instructional days: 16 (1 day = 53 minutes)

Content to be learned

- Define and give examples of equilibrium in an ecosystem.
- Describe ways in which humans can modify ecosystems.
- Predict and explain the potential impact of human modification of ecosystems.
- Describe ways in which natural events can modify ecosystems.
- Predict potential effects of ecosystem modifications due to natural events.

Processes to be used

- Use tools and technology.
- Evaluate a variety of published sources.
- Interpret diagrams and illustrations.
- Analyze natural systems and predict change.
- Make predictions based on evidence.
- Conduct laboratory or field investigations.

Essential questions

- How do various factors contribute to ecosystem stability?
- How do various factors contribute to ecosystem change?
- How have human use and misuse of the environment impacted the equilibrium of ecosystems?
- How can natural events alter ecosystems over time?
- What evidence supports conclusions about how the human species and other organisms are affected by environmental factors?

Written Curriculum

Grade Span Expectations

LS2 - Matter cycles and energy flows through an ecosystem.

LS2 (9-11) INQ+SAE -3

Using data from a specific ecosystem, explain relationships or make predictions about how environmental disturbance (human impact or natural events) affects the flow of energy or cycling of matter in an ecosystem.

LS2 (9-11)-3 Students demonstrate an understanding of equilibrium in an ecosystem by …

3a defining and giving an example of equilibrium in an ecosystem.

3b describing ways in which humans can modify ecosystems and describe and predict the potential impact (e.g. human population growth; technology; destruction of habitats; agriculture; pollution; and atmospheric changes).

3c describing ways in which natural events (e.g. floods and fires) can modify ecosystems and describe and predict the potential effects.

LS 4 - Humans are similar to other species in many ways, and yet are unique among Earth's life forms.

LS4 (9-11) NOS+INQ -9

Use evidence to make and support conclusions about the ways that humans or other organisms are affected by environmental factors or heredity (e.g., pathogens, diseases, medical advances, pollution, mutations).

LS4 (9-11) –9 Students demonstrate an understanding of how humans are affected by environmental factors and/or heredity by …

9b providing an explanation of how the human species impacts the environment and other organisms (e.g. reducing the amount of the earth's surface available to those other species, interfering with their food sources, changing the temperature and chemical composition of their habitats, introducing foreign species into their ecosystems, and altering organisms directly through selective breeding and genetic engineering).

Clarifying the Standards

Prior Learning

In grades K–4, students were introduced to the concept that plants and animals have specific environmental needs. Students learned how to make a simple food web. They also learned to identify sources of energy needed for survival. They explored how a habitat provides for the needs of the organisms that live there, and learned that plants and animals in that habitat depend on each other. Students also learned to identify which of the senses are needed to survive a given situation.

In grades 5–8, students defined an ecosystem and identified a variety of relationships within it. Students identified biotic and abiotic factors and analyzed how these factors affect a given ecosystem. They used visual models to track population changes in an ecosystem and learned that the sun is the major source of

energy for life on earth. They sequenced energy flow and described the basic processes and substances in photosynthesis and respiration; they also recognized the names and chemical formulas of the substances involved in photosynthesis and respiration.

In grades 9–10, students learned that energy transformations occur in different systems and reviewed exothermic and endothermic reactions. They also learned that physical and chemical earth processes (including the hydrologic cycle, weathering, and element cycling) alter the earth's crust.

Current Learning

Students expand their understanding of abiotic and biotic factors in ecosystems. For example, in addition to trophic interactions such as parasitism and predation, students learn other types of biotic interactions such as mutualism, competition, and cooperation, as well as the role that these interactions play in ecosystem stability. Students study specific human impacts on ecosystems and examine how human activities lead to changes in distribution and abundance of biotic and abiotic factors (i.e., reducing the amount of the earth's surface available to other species, interfering with food sources, changing the temperature and chemical composition of habitats, introducing foreign species into ecosystems, and altering organisms directly through selective breeding and genetic engineering). The concepts of primary and secondary ecological succession and the role of natural or human disruption of the ecosystem on succession are important to the understanding of ecosystem balance and change. Natural disruptions of ecosystems may include fire, volcanism, and flooding, while human disruptions include agriculture, pollution, logging, diversion or damming of rivers, and climate change.

Future Learning

Students will learn that changes in biotic and abiotic factors in ecosystems can exert natural selection pressures that drive the process of evolution. They will study the role that competition between members of a population and/or between different species in an ecosystem plays in natural selection and speciation. They will learn that changes in the characteristics of organisms occur as a result of changes in allele frequencies within populations and that these changes sometimes happen naturally and sometimes they are induced through selective breeding and/or genetic engineering.

Additional Research Findings

See the National Science Digital Library's science literary map (Strand map: The Living Environment/Interdependence of Life 9–12; <http://strandmaps.nsdl.org/?id=SMS-MAP-2122> for the following research:

- Lower elementary school students can understand simple food links involving two organisms. Yet they often think of organisms as independent of each other, but dependent on people to supply them with food and shelter. Upper elementary students may not believe food is a scarce resource in ecosystems, thinking that organisms can change their food at will according to the availability of particular sources. Students of all ages think that some populations of organisms are numerous in order to fulfill a demand for food by another population.
- Middle school and high school students may believe that organisms are able to effect changes in bodily structure in order to exploit particular habitats or that organisms respond to a changed environment by seeking a more favorable environment. It has been suggested that the language about adaptation used by teachers or textbooks to make biology more accessible to students may cause or reinforce these beliefs.

- Some middle school students think dead organisms simply rot away. They do not realize that the matter from the dead organism is converted into other materials in the environment. Some middle school students see decay as a gradual, inevitable consequence of time without need of decomposing agents. Some high school students believe that matter is conserved during decay, but do not know where it goes.

Notes About Resources and Materials