Unit 3: Energy and Matter in Ecosystems

Instructional Days: 15

Unit Summary
What happens to the matter and energy that are part of each organism? In this unit of study, students develop an understanding of the idea that plants get the materials they need for growth chiefly from air and water. Using models, students can describe the movement of matter among plants, animals, decomposers, and the environment, and they can explain that energy in animals' food was once energy from the sun. The crosscutting concepts of *energy and matter* and *systems and system models* are called out as organizing concepts for these disciplinary core ideas. Students are expected to demonstrate grade-appropriate proficiency in *developing and using models* and *engaging in argument from evidence.* Students are also expected to use these practices to demonstrate understanding of the core ideas. This unit is based on 5-LS1-1, 5-LS2-1, and 5-PS3-1.
Student Learning Objectives
Support an argument that plants get the materials they need for growth chiefly from air and water. *[Clarification Statement: Emphasis is on the idea that plant matter comes mostly from air and water, not from the soil.]* **(5-LS1-1)**
Develop a model to describe the movement of matter among plants, animals, decomposers, and the environment.*[Clarification Statement: Emphasis is on the idea that matter that is not food (air, water, decomposed materials in soil) is changed by plants into matter that is food. Examples of systems could include organisms, ecosystems, and the Earth.] [Assessment Boundary: Assessment does not include molecular explanations.]* **(5-LS2-1)**
Use models to describe that energy in animals' food (used for body repair, growth, motion, and to maintain body warmth) was once energy from the sun. *[Clarification Statement: Examples of models could include diagrams, and flow charts.]* **(5-PS3-1)**

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5-LS1-1	Support an argument that plants get the materials they need for growth chiefly from air and water.
5-LS2-1	Develop a model to describe the movement of matter among plants, animals, decomposers, and the environment
5-PS3-1	Use models to describe that energy in animals' food (used for body repair, growth, motion, and to maintain body warmth) was once energy from the sun
PS3.D	The energy released from food was once energy from the sun that was captured by plants in the chemical process that forms plant matter from air and water
LS1.C	Food provides animals with the materials they need for body repair and growth and the energy they need to maintain body warmth and for motion
LS2.A	The food of almost any kind of animal can be traced back to plants
LS2.B	Matter cycles between the air and soil and among plants, animals, and microbes as these organisms live and die

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Enduring Understandings

- All food chains begin with the sun, and energy moves from one organism to another in a food chain.
- The oxygen content and availability of sunlight help determine the nature of living things on land and in the water.
- Living and nonliving things are different, interact and have specific roles in the environment.
- Ecosystems vary and change over time.

Essential Questions

- How is life dependent on the sun?
- What are the dynamics of life on Earth?
- How do animals and plants get energy?

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Unit Sequence	
Part A: *Where do plants get the materials they need for growth?*	
Concepts	**Formative Assessment**
• Matter is transported into, out of, and within systems. • Plants acquire their material for growth chiefly from air and water.	*Students who understand the concepts are able to:* • Describe how matter is transported into, out of, and within systems. • Support an argument with evidence, data, or a model. • Support an argument that plants get the materials they need for growth chiefly from air and water. *(Emphasis is on the idea that plant matter comes mostly from air and water, not from the soil.)*

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Unit Sequence	
Part B: *How does matter move among plants, animals, decomposers, and the environment?*	
Concepts	**Formative Assessment**
• Science explanations describe the mechanisms for natural events. • A system can be described in terms of its components and their interactions. • The food of almost any kind of animal can be traced back to plants. • Organisms are related in food webs in which some animals eat plants for food and other animals eat the animals that eat plants. • Some organisms, such as fungi and bacteria, break down dead organisms (both plants or plants parts and animals) and therefore operate as *decomposers*. • Decomposition eventually restores (recycles) some materials back to the soil. • Organisms can survive only in environments in which their particular needs are met.	*Students who understand the concepts are able to:* • Describe a system in terms of its components and interactions. • Develop a model to describe phenomena. • Develop a model to describe the movement of matter among plants, animals, decomposers, and the environment. *(Assessment does not include molecular explanations.)* • Emphasis is on the idea that matter that is not food—such as air, water, decomposed materials in soil—is changed into matter that is food. Examples of systems could include: ✓ Organisms ✓ Ecosystems ✓ Earth

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Unit Sequence	
Part C: *How can energy in animals' food be traced to the sun?*	
Concepts	**Formative Assessment**
• Energy can be transferred in various ways and between objects. • The energy released from food was once energy from the sun, which was captured by plants in the chemical process that forms plant matter (from air and water). • Food provides animals with the materials they need for body repair and growth and the energy they need for motion and to maintain body warmth.	*Students who understand the concepts are able to:* • Describe how energy can be transferred in various ways and between objects. • Use models to describe phenomena. • Use models to describe that energy in animals' food (used for body repair, growth, motion, and to maintain body warmth) was once energy from the sun. • Examples of models could include: ✓ Diagrams ✓ Flowcharts

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What It Looks Like in the Classroom
In every habitat and ecosystem on Earth, plants and animals survive, grow, reproduce, die, and decay. What happens to the matter and energy that are part of each organism? Where does it come from and where does it go? In this unit of study, students make observations and use models to understand how energy flows and matter cycles through organisms and ecosystems. Students should first understand that plants acquire their material for growth chiefly from air and water. Students will need opportunities to observe a variety of plants over time. As students document plants' continual need for water and air in order to grow, they recognize that this evidence supports the argument that plants acquire their material for growth chiefly from air and water (not from soil). In addition, as students observe that plants also need sunlight, they begin to recognize that plants use energy from the sun to transform air and water into plant matter. Once students understand that plants acquire material for growth from air and water, they need opportunities to observe animals and plants interacting within an ecosystem. Terrariums, such as those built in 3-liter bottles, are ideal for this because they are large enough for small plants and animals to survive and grow, yet easy to build and maintain. In these terrariums, students should observe plants growing and providing a source of food for small herbivores, carnivores consuming other animals, and decomposers consuming dead plant material. All of these interactions may not be observable within a single terrarium; however, a class could use a number of 3-liter bottles to set up different ecosystems, each with a few carefully chosen plants and animals. This will give students opportunities to observe different types of interactions within a variety of enclosed systems. When students record their observations of these small systems, it is important that students be able to: ✓ Identify the living and nonliving components of a system. ✓ Describe the interactions that occur between the living and nonliving components of each system. ✓ Develop models (such as food chains or food webs) that describe the movement of matter among plants, animals, decomposers, and the environment. As students continue to observe each terrarium, they learn that: ✓ The food of almost any kind of animal can be traced back to plants. ✓ Organisms are related in food webs in which some animals eat plants for food and other animals eat the animals that

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eat plants.

- ✓ Some organisms, such as fungi and bacteria, break down dead organisms (both plants or plant parts and animals) and therefore operate as decomposers.
- ✓ Decomposition eventually restores (recycles) some materials back to the soil.
- ✓ A healthy ecosystem is one in which multiple species of different types are each able to meet their needs in a relatively stable web of life.
- ✓ Organisms can survive only in environments in which their particular needs are met.
- ✓ Matter cycles between the air and soil and among plants and animals as these organisms live and die.
- ✓ Organisms obtain gases and water from the environment and release waste matter (gas, liquid, or solid) back into the environment.

Furthermore, students can conduct research to determine the effects of newly introduced species to an ecosystem.

After investigating the movement of matter in ecosystems, students revisit the concept of energy flow in systems. At the beginning of this unit of study, students learned that energy from the sun is transferred to plants, which then use that energy to change air and water into plant matter. After observing the interactions between the living and nonliving components of small ecosystems, students recognize that energy, like matter, is transferred from plants to animals. When animals consume plants, that food provides animals with the materials they need for body repair and growth and with the energy they need to maintain body warmth and for motion. Students can use diagrams or flowcharts to describe the flow of energy within an ecosystem, tracing the energy in animals' food back to the energy from the sun that was captured by plants.

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Connecting with English Language Arts/Literacy and Mathematics
English Language Arts Students should use information from print and digital sources to build their understanding of energy and matter in ecosystems. As students read, they should use the information to answer questions, participate in discussions, solve problems, and support their thinking about movement of matter and the flow of energy through the organisms in an ecosystem. In this unit of study, students are also required to build models to describe the cycling of matter and the flow of energy in ecosystems. They can enhance their models using multimedia components, such as graphics and sound, and visual displays. *Mathematics* In this unit students should: • Use appropriate tools in strategic ways when making and recording observations of the living and nonliving components of an ecosystem. • Model with mathematics when using tables, charts, or graphs to organize observational data. • Reason abstractly and quantitatively when analyzing data that can be used as evidence for explaining how matter cycles and energy flows in systems. • Convert among different-sized standard measurement units within a given measurement system and use these conversions to help explain what happens to matter and energy in ecosystems.

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Modifications
(Note: Teachers identify the modifications that they will use in the unit. See NGSS Appendix D: All Standards, All Students/Case Studies for vignettes and explanations of the modifications.) • Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community. • Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling). • Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies). • Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences). • Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings. • Use project-based science learning to connect science with observable phenomena. • Structure the learning around explaining or solving a social or community-based issue. • Provide ELL students with multiple literacy strategies. • Collaborate with after-school programs or clubs to extend learning opportunities. • Restructure lesson using UDL principals (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA).

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Research on Student Learning
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-school 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. Some students of all ages have difficulty in identifying the sources of energy for plants and also for animals. [8] 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. 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. 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. [6] 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. Students' meaning for “energy,” both before and after traditional instruction, is considerably different from its scientific meaning. In particular, students believe energy is associated only with humans or movement, is a fuel-like quantity which 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 (NSDL, 2015).

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Prior Learning

Kindergarten Unit 4: Basic Needs of Living Things

- All animals need food in order to live and grow. They obtain their food from plants or from other animals. Plants need water and light to live and grow.

Grade 2: Relationships in Habitats

- Plants depend on water and light to grow.
- Plants depend on animals for pollination or to move their seeds around.

Grade 4: Weathering and Erosion

- Living things affect the physical characteristics of their regions.

Future Learning

Grade 4 Unit 5: Transfer of Energy

- Energy is present whenever there are moving objects, sound, light, or heat. When objects collide, energy can be transferred from one object to another, thereby changing their motion. In such collisions, some energy is typically also transferred to the surrounding air; as a result, the air gets heated and sound is produced.)
- Light also transfers energy from place to place.
- Energy can be moved from place to place by moving objects or through sound, light, or electric currents.

Grade 4 Unit 6: Forces and Motion

- The faster a given object is moving, the more energy it possesses.
- Energy is present whenever there are moving objects, sound, light, or heat. When objects collide, energy can be transferred from one object to another, thereby changing their motion. In such collisions, some energy is typically also transferred to the surrounding air; as a result, the air gets heated and sound is produced.)

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Grade 4 Unit 7: Using Engineering Design with Force and Motion Systems

- The expression “produce energy” typically refers to the conversion of stored energy into a desired form for practical use.

LS1.C: Organization for Matter and Energy Flow in Organisms

- Plants, algae (including phytoplankton), and many microorganisms use the energy from light to make sugars (food) from carbon dioxide from the atmosphere and water through the process of photosynthesis, which also releases oxygen. These sugars can be used immediately or stored for growth or later use.
- Within individual organisms, food moves through a series of chemical reactions in which it is broken down and rearranged to form new molecules, to support growth, or to release energy.

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- Within individual organisms, food moves through a series of chemical reactions in which it is broken down and rearranged to form new molecules, to support growth, or to release energy.

LS2.A: Interdependent Relationships in Ecosystems

- Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors.
- In any ecosystem, organisms and populations with similar requirements for food, water, oxygen, or other resources may compete with each other for limited resources, access to which consequently constrains their growth and reproduction.
- Growth of organisms and population increases are limited by access to resources.
- Similarly, predatory interactions may reduce the number of organisms or eliminate whole populations of organisms. Mutually beneficial interactions, in contrast, may become so interdependent that each organism requires the other for survival. Although the species involved in these competitive, predatory, and mutually beneficial interactions vary across ecosystems, the patterns of interactions of organisms with their environments, both living and nonliving, are shared.

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LS2.B: Cycle of Matter and Energy Transfer in Ecosystems

- Food webs are models that demonstrate how matter and energy is transferred between producers, consumers, and decomposers as the three groups interact within an ecosystem. Transfers of matter into and out of the physical environment occur at every level. Decomposers recycle nutrients from dead plant or animal matter back to the soil in terrestrial environments or to the water in aquatic environments. The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem.

LS4.D: Biodiversity and Humans

- Changes in biodiversity can influence humans' resources, such as food, energy, and medicines, as well as ecosystem services that humans rely on—for example, water purification and recycling. *(secondary)*

Connections to Other Units

This unit applies the ideas learned in **Grade 5 Unit 2: Changes to Matter.** In this unit, students developed an understanding of the idea that regarless of the type of change that matter undergoes, the total weight of matter is conserved.

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Sample of Open Education Resources
Bottle Biology Terrarium: Students will create a terrarium, make observations of the terrarium, then develop a model to explain how matter transfers within the ecosystem. This resource describes the process of creating a terrarium (which will serve as the phenomena that the students observe), but does not include specific lesson details or instructional strategies.
Biodomes Engineering Design Project: This activity is a culmination of a 16 day unit of study where students explore the biosphere's environments and ecosystems. In this final activity, students apply what they learned about plants, animals, and decomposers to design and create a model biodome. Engaging in the engineering design process, students construct a closed (system) environment containing plants and animals existing in equilibrium. Provided with a variety of materials (constraints), teams of students will use their imagination and culminating knowledge to design a biodome structure following the criteria of the activity that models how plants, insects, and decomposers work together in a system. (The activity can be conducted as a structured or open-ended design. It is recommended to allow students the opportunity to be true engineers and follow the opened-ended design.)

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Teacher Professional Learning Resources
Connections Between Practices in *NGSS*, Common Core Math, and Common Core ELA The presenter was Sarah Michaels from Clark University. In this seminar Dr. Michaels talked about connecting the scientific and engineering practices described in A Framework for K–12 Science Education with the Common Core State Standards in Mathematics and English Language Arts. **Engineering Design as a Core Idea** The presenter was Cary Sneider, Associate Research Professor at Portland State University in Portland, Oregon. The seminar focused on the Core Idea of Engineering, led by Cary Sneider, Associate Research Professor at Portland State University. Cary explained the overall *NGSS* engineering components for K-2, MS and HS, and went through a number of practical examples of how teachers could develop modules and investigations for their students to learn them. Cary also spoke about the ways in which teachers could include cross-cutting engineering concepts to a number of classroom subjects. The seminar concluded Q & A session with Cary. Visit the resource collection. Continue discussing this topic in the community forums. ***NGSS* Core Ideas: Energy** The presenter was Jeff Nordine of the San Antonio Children's Museum. Ramon Lopez from the University of Texas at Arlington provided supporting remarks. The program featured strategies for teaching about physical science concepts that answer questions such as "How is energy transferred between objects or systems?" and "What is meant by conservation of energy?" Dr. Nordine began the presentation by talking about the role of disciplinary core ideas within *NGSS* and the importance of energy as a core idea as well as a crosscutting concept. He then shared physicist Richard Feynman's definition of energy and related it to strategies for teaching about energy. Dr. Nordine talked about the elements of the energy core idea and discussed common student preconceptions. Participants had the opportunity to ask questions and discuss ideas for classroom application with other participating teachers. Visit the resource collection. Continue discussing this topic in the community forums.

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NGSS Core Ideas: Ecosystems: Interactions, Energy, and Dynamics

The presenters were Andy Anderson and Jennifer Doherty of Michigan State University. This was the ninth web seminar in a series focused on the disciplinary core ideas that are part of the Next Generation Science Standards (NGSS). The program featured strategies for teaching about life science concepts that answer questions such as "How do organisms interact with the living and nonliving environments to obtain matter and energy?" and "How do matter and energy move through an ecosystem?"

Dr. Anderson and Dr. Doherty began the presentation by discussing the two main strands of the ecosystems disciplinary core idea: community ecology and ecosystem science. They talked about common student preconceptions and strategies for addressing them. Next, Dr. Anderson and Dr. Doherty shared learning progressions for this core idea, showing how student understanding builds from elementary through high school. Last, the presenters described approaches for teaching about ecosystems and shared resources to use with students. Participants had the opportunity to submit their questions and comments in the chat.

Visit the resource collection.

Continue discussing this topic in the community forums.

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Appendix A: NGSS and Foundations for the Unit		
Support an argument that plants get the materials they need for growth chiefly from air and water. *[Clarification Statement: Emphasis is on the idea that plant matter comes mostly from air and water, not from the soil.]* (**5-LS1-1**)		
Develop a model to describe the movement of matter among plants, animals, decomposers, and the environment.*[Clarification Statement: Emphasis is on the idea that matter that is not food (air, water, decomposed materials in soil) is changed by plants into matter that is food. Examples of systems could include organisms, ecosystems, and the Earth.] [Assessment Boundary: Assessment does not include molecular explanations.]* (**5-LS2-1**)		
Use models to describe that energy in animals' food (used for body repair, growth, motion, and to maintain body warmth) was once energy from the sun. *[Clarification Statement: Examples of models could include diagrams, and flow charts.]* (**5-PS3-1**)		
The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Engaging in Argument from Evidence • Support an argument with evidence, data, or a model. (5-LS1-1) **Developing and Using Models** • Develop a model to describe phenomena. (5-S2-1) • Use models to describe phenomena. (5-PS3-1)	**LS1.C: Organization for Matter and Energy Flow in Organisms** • Plants acquire their material for growth chiefly from air and water. (5-LS1-1) **LS2.A: Interdependent Relationships in Ecosystems** • The food of almost any kind of animal can be traced back to plants. Organisms are related in food webs in which some animals eat plants for food and other animals eat the animals that eat plants. Some	**Energy and Matter** • Matter is transported into, out of, and within systems. (5-LS1-1) • Energy can be transferred in various ways and between objects. (5-PS3-1) **Systems and System Models** • A system can be described in terms of its components and their interactions. (5-LS2-1) -

	organisms, such as fungi and bacteria, break down dead organisms (both plants or plants parts and animals) and therefore operate as "decomposers." Decomposition eventually restores (recycles) some materials back to the soil. Organisms can survive only in environments in which their particular needs are met. A healthy ecosystem is one in which multiple species of different types are each able to meet their needs in a relatively stable web of life. Newly introduced species can damage the balance of an ecosystem. (5-LS2-1) **LS2.B: Cycles of Matter and Energy Transfer in Ecosystems** • Matter cycles between the air and soil and among plants, animals, and microbes as these organisms live and die. Organisms obtain gases, and water, from the environment, and release waste matter (gas, liquid, or solid) back into the environment. (5-LS2-1) **PS3.D: Energy in Chemical Processes**	***Connections to the Nature of Science*** **Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena** • Science explanations describe the mechanisms for natural events. (5-LS2-1)

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	and Everyday Life • The energy released [from] food was once energy from the sun that was captured by plants in the chemical process that forms plant matter (from air and water). (5-PS3-1) **LS1.C: Organization for Matter and Energy Flow in Organisms** • Food provides animals with the materials they need for body repair and growth and the energy they need to maintain body warmth and for motion. (secondary to 5-PS3-1)	

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English Language Arts	Mathematics
Quote accurately from a text when explaining what the text says explicitly and when drawing inferences from the text. (5-LS1-1) **RI.5.1** Draw on information from multiple print or digital sources, demonstrating the ability to locate an answer to a question quickly or to solve a problem efficiently. (5-LS2-1), (5-PS3-1) **RI.5.7** Integrate information from several texts on the same topic in order to write or speak about the subject knowledgeably. (5-LS1-1) **RI.5.9** Write opinion pieces on topics or texts, supporting a point of view with reasons and information. (5-LS1-1) **W.5.1** Include multimedia components (e.g., graphics, sound) and visual displays in presentations when appropriate to enhance the development of main ideas or themes. (5-LS2-1), (5-PS3-1) **SL.5.5**	Reason abstractly and quantitatively. (5-LS1-1), (5-LS2-1) **MP.2** Model with mathematics. (5-LS1-1), (5-LS2-1) **MP.4** Use appropriate tools strategically. (5-LS1-1) **MP.5** Convert among different-sized standard measurement units within a given measurement system (e.g., convert 5 cm to 0.05 m), and use these conversions in solving multi-step, real world problems. (5-LS1-1) **5.MD.A.1**

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Common Vocabulary	
Ecosystem	Product
Algae	Transform
Atmosphere	Transformation
Body repair	Independent
Consumer	Organism
Cycle	Role
Food web	Chemical
Matter	Convert
Organization	Store
Photosynthetic plants	Decomposer
Plant matter	Energy flow