Grade 7 Science, Unit 7

Organization for Matter and Energy Flow in Organisms

Overview

Unit abstract

Upon completion of this unit of study, students will have a basic understanding that cells provide a context for the plant process of photosynthesis in the movement of matter and energy needed for the cell. Students can use conceptual and physical models to explain the transfer of energy and cycling of matter as they construct explanations for the role of photosynthesis in cycling matter in ecosystems. They can construct scientific explanations for the cycling of matter in organisms and the interactions of organisms to obtain matter and energy from an ecosystem to survive and grow. They understand that sustaining life requires substantial energy and matter inputs, and that the structure and functions of organisms contribute to the capture, transformation, transport, release, and elimination of matter and energy. The crosscutting concept of energy and matter supports an understanding of the cycling of matter and energy flow into and out of organisms.

Essential questions

- How do organisms obtain and use matter and energy?
- How do matter and energy move through an ecosystem?

Bristol–Warren, Central Falls, Cranston, Segue Institute for Learning, Tiverton, and Woonsocket, with process support from The Charles A. Dana Center at the University of Texas at Austin

Written Curriculum

Next Generation Science Standards

MS. Matter and Energy in Organisms and Ecosystems

Students who demonstrate understanding can:

MS-LS1-6. **Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms.** [Clarification Statement: Emphasis is on tracing movement of matter and flow of energy.] [Assessment Boundary: Assessment does not include the biochemical mechanisms of photosynthesis.]

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
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific knowledge, principles, and theories. ▪ Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) 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. (MS-LS1-6) --- ***Connections to Nature of Science*** **Scientific Knowledge is Based on Empirical Evidence** ▪ Science knowledge is based upon logical connections between evidence and explanations. (MS-LS1-6)	**PS3.D: Energy in Chemical Processes and Everyday Life** ▪ The chemical reaction by which plants produce complex food molecules (sugars) requires an energy input (i.e., from sunlight) to occur. In this reaction, carbon dioxide and water combine to form carbon-based organic molecules and release oxygen. *(secondary to MS-LS1-6)* **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. (MS-LS1-6)	**Energy and Matter** ▪ Within a natural system, the transfer of energy drives the motion and/or cycling of matter. (MS-LS1-6)

Connections to other DCIs in this grade-band: **MS.PS1.B** (MS-LS1-6); **MS.ESS2.A** (MS-LS1-6)

Articulation across grade-bands: **5.PS3.D** (MS-LS1-6); **5.LS1.C** (MS-LS1-6); **5.LS2.A** (MS-LS1-6); **5.LS2.B** (MS-LS1-6); **HS.PS1.B** (MS-LS1-6); **HS.LS1.C** (MS-LS1-6); **HS.LS2.B** (MS-LS1-6) **HS.ESS2.D** (MS-LS1-6)

Common Core State Standards Connections:

ELA/Literacy –

RST.6-8.1	Cite specific textual evidence to support analysis of science and technical texts. (MS-LS1-6)
RST.6-8.2	Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions. *(MS-LS1-6)*
WHST.6-8.2	Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content. (MS-LS1-6)

WHST.6-8.9 Draw evidence from informational texts to support analysis, reflection, and research. (MS-LS1-6)

Mathematics –

6.EE.C.9 Use variables to represent two quantities in a real-world problem that change in relationship to one another; write an equation to express one quantity, thought of as the dependent variable, in terms of the other quantity, thought of as the independent variable. Analyze the relationship between the dependent and independent variables using graphs and tables, and relate these to the equation. *(MS-LS1-6)*

MS. Matter and Energy in Organisms and Ecosystems

Students who demonstrate understanding can:

MS-LS1-7. Develop a model to describe how food is rearranged through chemical reactions forming new molecules that support growth and/or release energy as this matter moves through an organism. [Clarification Statement: Emphasis is on describing that molecules are broken apart and put back together and that in this process, energy is released.] [Assessment Boundary: Assessment does not include details of the chemical reactions for photosynthesis or respiration.]

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

Developing and Using Models

Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems.

- Develop a model to describe unobservable mechanisms. (MS-LS1-7)

Disciplinary Core Ideas

PS3.D: Energy in Chemical Processes and Everyday Life

- Cellular respiration in plants and animals involve chemical reactions with oxygen that release stored energy. In these processes, complex molecules containing carbon react with oxygen to produce carbon dioxide and other materials. *(secondary to MS-LS1-7)*

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

- 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. (MS-LS1-7)

Crosscutting Concepts

Energy and Matter

- Matter is conserved because atoms are conserved in physical and chemical processes. (MS-LS1-7)

Connections to other DCIs in this grade-band: **MS.PS1.B** (MS-LS1-7)

Articulation across grade-bands: **5.PS3.D** (MS-LS1-7); **5.LS1.C** (MS-LS1-7); **5.LS2.B** (MS-LS1-7); **HS.PS1.B** (MS-LS1-7); **HS.LS1.C** (MS-LS1-7); **HS.LS2.B** (MS-LS1-7)

Common Core State Standards Connections:

ELA/Literacy –

SL.8.5 Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest. *(MS-LS1-7)*

Clarifying the standards

Prior learning

The following disciplinary core ideas are prior learning for the concepts in this unit of study.

By the end of Grade 5, students know that:

- 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).
- 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.
- 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.
- 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.
- 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.

Progression of current learning

Driving question 1
What is the role of photosynthesis in the cycling of matter and flow of energy into and out of an organism?

Concepts	Practices
• Photosynthesis has a role in the cycling of matter and flow of energy into and out of organisms. • The flow of energy and cycling of matter can be traced. • The chemical reaction by which plants produce complex food molecules (sugars) requires an energy input (i.e., from sunlight) to occur. In this reaction, carbon dioxide and water combine to form carbon-based organic molecules and release oxygen.	• Construct a scientific explanation for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms based on valid and reliable evidence obtained from sources (including the students' own experiments). • Construct a scientific explanation for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms based on 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.

- 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.
- Sugars produced by plants can be used immediately or stored for growth or later use.
- Within a natural system, the transfer of energy drives the motion and/or cycling of matter.

Driving question 2

How is food rearranged through chemical reactions to form new molecules that support growth and/or release energy as this matter moves through an organism?

Concepts

- Food is rearranged through chemical reactions, forming new molecules that support growth.
- Food is rearranged through chemical reactions, forming new molecules that release energy as this matter moves through an organism.
- Molecules are broken apart and put back together to form new substances, and in this process, energy is released.
- Cellular respiration in plants and animals involves chemical reactions with oxygen that release stored energy.
- In cellular respiration, complex molecules containing carbon react with oxygen to produce carbon dioxide and other materials.
- 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.
- Matter is conserved during cellular respiration because atoms are conserved in physical and chemical processes.

Practices

- Develop and use a model to describe how food is rearranged through chemical reactions.

Integration of content, practices, and crosscutting concepts

Students will construct explanations about the role of photosynthesis using evidence obtained from sources, including the students' own experiments or outside sources. Student-constructed informative/explanatory responses will cite specific textual evidence, determine the central ideas to support their analysis, and provide an accurate summary distinct from their own prior knowledge or opinions. Some experiments could include observing elodea releasing oxygen, depriving a plant of sunlight or water, or using glucose test strips.

In this unit of study, emphasis is on the transfer of energy that drives the motion and/or cycling of matter. Students can represent the matter and energy involved in the process of photosynthesis using the equation for this reaction. Using this equation, students can build ball-and-stick models to show how carbon dioxide and water are rearranged to form glucose. Students can also draw conclusions about the cycling of matter and the flow of energy by observing plants such as elodea. By contrasting elodea plants in a variety of controlled environments, students can draw conclusions about how carbon dioxide and oxygen enter and leave organisms.

Students could also perform investigations where the input of light energy is manipulated. In these investigations, students can observe that even if the matter required for photosynthesis is present, the process will not proceed if light energy is not available. If light is available, students will be able to test the leaves of certain plants for the presence of stored sugar in the form of starch. If light is not available, students will observe that the sugars are not stored as starch in the leaves. This will emphasize that the transfer of light energy drives the cycling of matter into chemical energy. Students can also trace the flow of energy using models such as energy pyramids.

Using the data collected during their investigations and observations of simulations, students construct an explanation for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms. They could participate in s short research project in which they will use textual evidence to support their analysis. As part of their research, students will provide an accurate summary of the text they use and determine the central ideas or conclusions of the text. They can they write informative or explanatory texts to explain the process. As a result of their research, students should be able to observe that the information they gather through research supports their scientific observations. They could then make predictions about the impact of different environmental changes on the cycling of matter and flow of energy. For example, students could make predictions about the impact that volcanic eruptions that produce massive clouds of sunlight-blocking ash that linger long periods of time could have on life in the affected area.

Student learning will progress to developing and using models to describe how food is rearranged through chemical reactions. These reactions form new molecules that support growth and/or release energy as the matter moves through an organism. Students can integrate multimedia and visual displays into models to clarify information, strengthen claims and evidence, and add interest. Emphasis is on describing that molecules are broken apart and reassembled and that in this process, energy is released. Student models will demonstrate that matter is conserved in cell respiration. Models can be created using materials similar to those used in students' photosynthesis models, thereby emphasizing the complementary nature of photosynthesis and cellular respiration. Students can also act out the roles of variables within the chemical-reaction rearrangement to deepen their understanding.

Integration of DCI from prior units within this grade level

Content learned in Unit 1, Structure and Properties of Matter; Unit 2, Interactions of Matter; and Unit 3, Chemical Reactions, provides a basis for student understanding of the cycling of matter and flow of energy into and out of organisms emphasized in this unit.

Integration of mathematics and English language arts/literacy

Mathematics

- Use variables to represent two quantities involved in the process whereby photosynthesis plays a part in the cycling of matter and energy into and out of organisms. Write an equation to express one quantity, thought of as the dependent variable, in terms of the other quantity, thought of as the independent variable. Analyze the relationship between the dependent and independent variables using graphs and tables, and relate these to the equation.

English language arts/literacy

- Cite specific textual evidence to support analysis of science and technical texts about the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms.
- Determine the central ideas about the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinion.
- Write informative/explanatory texts to examine the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms, and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content.
- Draw evidence from informational texts to support analysis, reflection, and research about the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms.
- Integrate multimedia and visual displays into presentations about how food is rearranged through chemical reactions to form new molecules that support growth and/or release energy as the matter moves through an organism to clarify information, strengthen claims and evidence, and add interest.

Future learning

Physical science

- Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy.
- In many situations, a dynamic and condition-dependent balance between a reaction and the reverse reaction determines the numbers of all types of molecules present.
- The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions.

Life science

- The process of photosynthesis converts light energy into stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen.
- 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.
- As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products.

- 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 that can transport energy to muscles are formed.
- Cellular respiration releases the energy needed to maintain body temperature despite ongoing energy transfer to the surrounding environment.
- 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.

Earth and space science

- The foundation for Earth's global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's re-radiation into space.
- Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen.
- Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate.

Number of Instructional Days

Recommended number of instructional days: 15 (1 day = approximately 50 minutes)

Note—The recommended number of days is an estimate based on the information available at this time. Teachers are strongly encouraged to review the entire unit of study carefully and collaboratively to determine whether adjustments to this estimate need to be made.