HIGH SCHOOL LIFE SCIENCE: PHOTOSYNTHESIS AND RESPIRATION

Standards Bundle

Standards are listed within the bundle. Bundles are created with potential instructional use in mind, based upon the potential for related phenomena that can be used throughout a unit.

HS-LS1-5 Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy. (SEP: 2; DCI: LS1.C; CCC: Systems, Energy/Matter) [Clarification Statement: Emphasis is on illustrating inputs and outputs of matter and the transfer and transformation of energy in photosynthesis by plants and other photosynthesizing organisms. Examples of models could include diagrams, chemical equations, and conceptual models.] *[Assessment Boundary: Assessment does not include specific biochemical steps.]*

HS-LS1-7 Use a model of the major inputs and outputs of cellular respiration (aerobic and anaerobic) to exemplify the chemical process in which the bonds of food molecules are broken, the bonds of new compounds are formed, and a net transfer of energy results. (SEP: 2; DCI: LS1.C; CCC: Energy/Matter) [Clarification Statement: Emphasis is on the conceptual understanding of the inputs and outputs of the process of cellular respiration.] *[Assessment Boundary: Assessment should not include identification of the steps or specific processes involved in cellular respiration.]*

HS-LS2-5 Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere. (SEP: 2; DCI: LS2.B, PS3.D; CCC: Systems) [Clarification Statement: Examples of models could include simulations and mathematical models.] *[Assessment Boundary: Assessment does not include the specific chemical steps of photosynthesis and respiration.]*

Content Overview

This section provides a generic overview of the content or disciplinary core ideas as an entry point to the standards.

Life requires the inputs of matter and energy. Light energy is captured by chlorophyll during photosynthesis by the forming of chemical bonds in sugar. The sugar can be used as a building block for other molecules such as proteins, DNA, or lipids. It can also be consumed by other organisms to provide energy and building blocks for their unique molecules. The energy can be used to perform daily functions such as movement, stored for later use, or passed onto other organisms and the environment. Carbon serves as the backbone for many life-giving molecules for organisms and can come from living and non-living sources. In living organisms, carbon is an integral component of both photosynthesis and respiration. This energy and matter is cycled between the air, water, land, and as well as within organisms as they eat, expel wastes, and go about their daily activities.

Phenomena

Phenomena can be used at varying levels of instruction. One could be used to anchor an entire unit, while another might be more supplemental for anchoring just a unit. Please remember that phenomena should allow students to engage in the SEP and use the CCC/DCI to understand and explain the phenomenon.

- A bromothymol blue solution with elodea plant turns yellow in the dark but stays blue in the light.
- Plants grow well in light but not in the dark.

- People need to eat plants and/or animals to survive.
- If a person blows air through a straw into a bromothymol blue solution, it turns yellow.
- Ocean carbon dioxide levels are rising.
- Photosynthesis produces sugar yet soybeans contain protein.
- The proteins/lipids in a cow are not all identical to humans' proteins.
- Time-lapse photos of an organism decaying
- Atmospheric carbon dioxide levels change with the seasons.
- A plant grows in plain water.
- Distiller's grain is fed to cows and pigs because of its high protein content.
- Soil analysis data showing inorganic and organic composition.
- A balloon attached to a flask with yeast and sugar expands.

Storyline

This section aims to decode not only the DCI connections but also the SEP and CCC in a detailed account of how they possibly fit together in a progression for student learning, including both rationale and context for the bundle.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models ● Develop a model based on evidence to illustrate the relationships between systems or components of a system. ● Use a model based on evidence to illustrate the relationships between systems or between components of a system.	**LS1.C: Organization for Matter and Energy Flow in Organisms** ● The process of photosynthesis converts light energy to stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen. ● As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products.	**Energy and Matter** ● Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. ● Energy cannot be created or destroyed; it only moves between one place and another place, between objects and/or fields, or between systems.

	• 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. **LS2.B: Cycles of Matter and Energy Transfer in Ecosystems** • 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. **PS3.D: Energy in Chemical Processes** • The main way that solar energy is captured and stored on Earth is through the complex chemical process known as photosynthesis. (Secondary)	**Systems and System Models** • Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions — including energy, matter and information flows — within and between systems at different scales.

In this standard bundle, students will create and use models that will illustrate how plants use light energy, carbon dioxide, and water to create glucose and oxygen. They will cite reliable evidence to support their models which can include both textual as well as laboratory experiences. Glucose, in turn, can be used for energy, assembled into more complex carbohydrates, or the carbon used as the backbone of other biological molecules such as proteins, lipids, and nucleic acids. Students' models will define systems on a variety of scales (e.g., cellular, field, pond) and include the sources and movement of both energy and matter between organisms and their environment as well as between organisms. Students will utilize previous knowledge about chloroplasts and mitochondria and their relationship within a plant cell.

Special attention is paid to the cycling of carbon. Students will create and use models that will illustrate the relationship between carbon as it cycles between the biosphere, atmosphere, geosphere, and hydrosphere. The atmosphere provides a source of carbon dioxide for photosynthesis as well as a sink for the carbon dioxide produced from the respiration and combustion of once-living organisms (e.g., coal, oil, trees). Good quality soil depends on partially decayed organic matter. Models may also include sources of and concerns for the rising carbon dioxide levels dissolved in our ocean waters and atmosphere.

Formative Assessment

Formative assessment is crucial because all learners benefit from timely and focused feedback from others. It promotes self-reflection, self-explanation, and social learning. It can also make learning more relevant. Each of the questions below might be used throughout the formative assessment process. Specific *prompts may focus on individual practices, core ideas, or crosscutting concepts, but, together, the components need to support inferences about students' three-dimensional science learning as described in a given bundle, standard or lesson-level performance expectation.*

SEP Developing and Using Models

- Show the flow of carbon among the components in a prairie ecosystem including plants, animals, air, and water).
- construct a model to explain why a tube of bromothymol blue solution and elodea will either remain blue or turn yellow depending on its exposure to light.
- Manipulate, collect data, and form evidence-based conclusions from a simulation to investigate factors affecting photosynthesis rates.

CCC Energy and Matter

- Explain how a soybean creates glucose from photosynthesis yet also has protein in it.
- Give evidence for the conservation of energy when sunlight is used to create sugar molecules.
- Explain where the oxygen produced from photosynthesis comes from.
- When presented with data on the efficiency of energy conversion from plant to animal, account for losses of energy to the environment in their explanations.

CCC Systems and Systems Models

- What would happen in an ecosystem if plant numbers were decreased?
- Explain, using evidence, how a human consumes a variety of plant and animal lipids but doesn't contain many of those lipids in their body.
- Identify places within the biosphere, atmosphere, geosphere, and hydrosphere where carbon would be present.

Performance Outcomes

These are statements of how students use knowledge and are similar to the standards in how they blend DCI, SEP, and CCC, but at a smaller grain size. These are potential outcomes for instruction as it plays out in lessons and activities in the classroom. It is important to also think of these as smaller outcomes that build toward the larger goal of mastering the standards.

- **Create a model** depicting the *flow* of carbon between the biosphere, geosphere, atmosphere, and hydrosphere by citing specific examples within each.
- **Use a simulation** on the effects of carbon dioxide levels on temperature to explain how *energy flows* within the *system*.
- Given a **diagram** of a prairie *ecosystem*, indicate the flow of carbon between the components of the system.
- Given a **photo** of a pond ecosystem, indicate the flow of energy between organisms and the environment.
- Given a **graphic model** of global carbon dioxide levels by season, explain using evidence reasons for the fluctuations in matter and since *matter cannot be created or destroyed*, where is it primarily located (CO_2) during each season.
- **Create a model** showing how a human can take in plant and animal matter and have the *energy* needed for growth, movement, and repair.