

Life Science Standard **LS1A****Content Standard:**

Students know that carbon-containing compounds are the building blocks of life. Photosynthesis is the process that plant cells use to combine the energy of sunlight with molecules of carbon dioxide and water to produce energy-rich compounds that contain carbon (food) and release oxygen.

Performance Indicators:

Explain how plant cells use photosynthesis to produce their own food. Use the following equation to illustrate how plants rearrange atoms during photosynthesis:



Explain the importance of photosynthesis for both plants and animals, including humans.

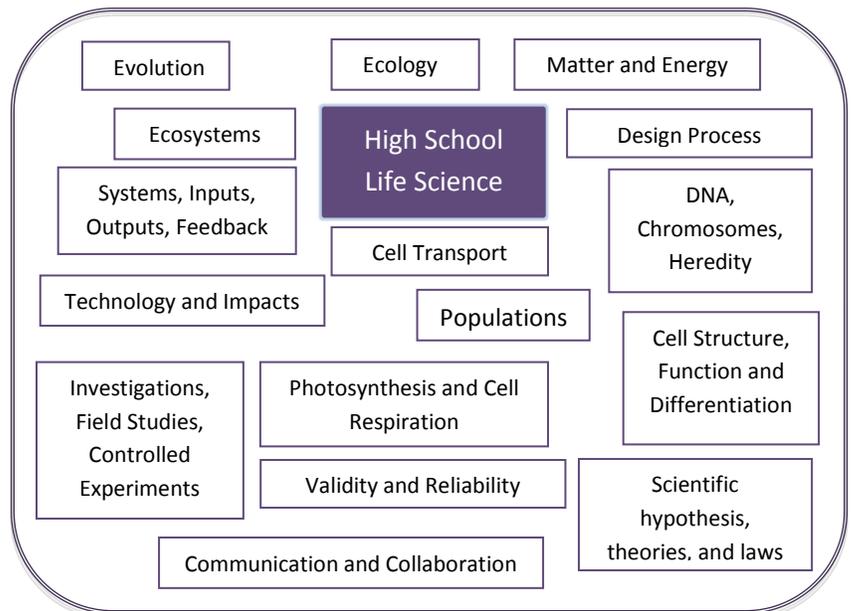
Item Specifications:

Identify inputs and/or outputs of matter and/or energy in photosynthesis using words and/or chemical formulas (i.e., inputs are carbon dioxide/ CO_2 , water/ H_2O , light energy; outputs include glucose/ $\text{C}_6\text{H}_{12}\text{O}_6$, oxygen/ O_2).

Describe the rearrangement of atoms during photosynthesis using the chemical equation for photosynthesis.

Explain the role of photosynthesis in the life of plants (e.g., photosynthesis is the only source of glucose that provides chemical energy or is incorporated into large molecules).

Explain the role of photosynthesis in the life of animals (e.g., photosynthesis is the source of the chemical energy animals require to live and grow; photosynthesis provides oxygen).

**Reflective Questions for Students:**

How is it that carbon is an atom that allows organisms to both store and release energy?

When you think about the answers to these questions, think about models that you could develop; diagrams that would demonstrate processes; and functions of parts in relationship

Assessment Information

<http://www.k12.wa.us/Science/Assessments.aspx>

Quick Links for Students:

The following links will help you visualize the process of photosynthesis:

- Carbon Cycle: <http://earthobservatory.nasa.gov/Features/CarbonCycle/page1.php>
- Phytoplankton: http://news.nationalgeographic.com/news/2004/06/0607_040607_phytoplankton.html
- Carbon Dioxide Uptake: <http://www.atmosphere.mpg.de/enid/1vd.html>
- Photosynthesis Game: <http://www.atmosphere.mpg.de/enid/1vd.html>

Teacher Center

Elements of Effective Science Instruction

Disciplinary Core Ideas

Photosynthesis & respiration: Students should be able to identify the reactants, products, and basic purposes of photosynthesis and cellular respiration. They should be able to explain the interrelated nature of photosynthesis and cellular respiration in the cells of photosynthetic organisms. Students should be able to identify where cellular respiration and photosynthesis occur at the sub-cellular level.

Essential teaching components leading to the big ideas:

Student acquisition of the content of science involves opportunities to meet state crosscutting and domain standards and recognize how the big ideas fit within a large conceptual framework. Learning is best achieved through sequencing learning targets into learning progressions that inform teacher's instructional decision making.

Photosynthesis – converts water, carbon dioxide and sunlight into glucose and oxygen

- CO₂ comes from the atmosphere, energy comes from the sun
- Formula is: $6 \text{ CO}_2 + 6 \text{ H}_2\text{O} + \text{sunlight} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6 \text{ O}_2$
- Occurs in the chloroplasts
 - uses chlorophyll (green pigment that absorbs all light colors except green which it reflects) to capture sun's energy
- Occurs in 2 stages: light reaction and Calvin cycle
- Occurs in autotrophs (organisms that make their own food)
- Rate of Photosynthesis depends on 2 things: light intensity and temperature

A resource for teaching about photosynthesis:

<http://www.emc.maricopa.edu/faculty/farabee/biobk/biobookps.html>.

Private Universe Project in Science – Focus Photosynthesis.

In this Annenberg series entitled the **Private Universe Project in Science**; teachers should view the segment called *Biology: Why Are Some Ideas So Difficult (Workshop 2)*. In this video, teachers will find an excellent discussion on the difficulties of teaching photosynthesis to students. To view this and any Annenberg video you will first need to register, but it is free! You will find other useful videos at this site too.

Teachers can access this video segment at

<http://www.learner.org/resources/series29.html>

Another helpful resource can be found at Photosynthesis from the Teachers Domain (PBS).

<http://www.teachersdomain.org/resources/tdc02/sci/life/stru/photosynth/index.html>

This website summarizes photosynthesis and provides additional teaching links.

<http://www.stteresa.net/photosynthesis.pdf>

**Cross Cutting Ideas:
Designing for Learning**

Strategies to reveal student understanding include:

- Paige Keeley's Formative assessment probes available through nsta.org
- Teacher's Toolkit: Misconceptions in the science classroom, Science Scope at www.nsta.org
This article in Science Scope offers suggestions for identifying science misconceptions in general.
- Private Universe Project in Science at <http://www.learner.org/resources/series29.html> is a collection of videos probing misconceptions of several important science concepts and offers insight into how these misconceptions interfere with learning.
- <http://www.doe.mass.edu/omste/ste/default.html>: Go to the life science file on this page for extensive descriptions of common student misconceptions about concepts in biology.

Prerequisite knowledge required:

Middle school students recognize that living cells and the subcomponents are comprised of molecules. Students realize proteins are molecules that have specific shapes and identify the importance of proteins in carrying out the work of cells. Students can explain that individual cells carry out all the basic functions of any living thing. Students often confuse the relationship between a cell, a nucleus and biological molecule like proteins and DNA. Students realize that includes only proteins, carbohydrates, and fats and can explain that food is used as both a source of energy and building materials in organisms. They realize that plants produce their own food and animals must take it in by eating other organisms. Students can describe the mitochondrion as a cell structure where energy is released and transformed into chemical energy that the cell can use later. They understand that plants undertake photosynthesis to produce food (glucose), but sometimes confuse the process of photosynthesis and respiration, particularly in plants. Students can explain that all organisms need to reproduce (replicate), including single-celled organisms like bacteria.

(From: <http://www.doe.mass.edu/omste/ste/default.html>)

Learning progressions may include:

High school students can draw sub-cellular organelles found inside a plant and animal cell, and relate those organelles to their functions. Students can predict what would happen if one of these structures was removed or ablated. They can compare and contrast, at the cellular level, the general structures and degrees of complexity of prokaryotes and eukaryotes and predict what structures one would find if looked at under the microscope. Students can compare and contrast a virus and a cell. They can identify the reactants, products, and basic purposes of photosynthesis and cellular respiration and explain the interrelated nature of these in the cells of photosynthetic organisms.

(From: <http://www.doe.mass.edu/omste/ste/default.html>)

Scientifically oriented questions focused on clarifying and extending student understanding include:

What is the big picture of photosynthesis? Can I describe inputs and outputs when thinking about photosynthesis?
What factors might impact photosynthetic processes?
What are the characteristics of photosynthetic organisms?

Activities supporting opportunities for students to make claims, use evidence and communicate reasonings include:

Can photosynthesis be used to generate oxygen for travelers to Mars?

Does photosynthesis play a role in climate change?

<p align="center"><u>Cross Cutting Ideas:</u> <i>Sense Making</i></p>	<p align="center"><u>Cross Cutting Ideas:</u> <i>Classroom Culture and Environment</i></p>
<p>Planning time in the lessons to support time for students to make sense of what they are learning include:</p> <ul style="list-style-type: none"> This website offers a variety of professional development lessons and videos for strategies to teach specific concepts within science. http://www.teachersdomain.org/search/?q=strategies+for+effective+teaching&fq_grade=PK&fq_grade=PS. 	<p>Activities that show how photosynthesis relates to students' everyday lives include:</p> <ul style="list-style-type: none"> This site has a laboratory lesson on photosynthesis. http://www.the-aps.org/education/k12curric/activities/pdfs/carswell.pdf This site has a ten minute lecture on photosynthesis. http://www.neok12.com/php/watch.php?v=zX6d4f790c51017d6404007f&t=Photosynthesis
<p>Strategies to focus on student conversations, interactive notebook prompts, model-building include:</p>	<p>Activities that show how scientists think and do science in relationship to this content standards include:</p> <ul style="list-style-type: none"> This site explains the discovery of photosynthesis and the processes used by scientists. http://www.neok12.com/php/watch.php?v=zX425c515e42660904500606&t=Photosynthesis