Some Background Concerning Life Science Content Standards for Fifth-Grade Teachers:

Extracting Energy from Food

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Introduction

The background information for teachers in this document addresses the following life science content standards[1] for fifth-grade teachers:

2. Plants and animals have structures for respiration, digestion, waste disposal, and transport of materials. As a basis for understanding this concept:

g. *Students know plant and animal cells break down sugar to obtain energy, a process resulting in carbon dioxide (CO_2) and water (respiration).*

For additional information, see pages 70-72 in the *Science Framework for California Public Schools Kindergarten Through Grade Twelve* and visit the websites listed at the end of this document.

Biological Overview: Structure of Organisms

Life science students sometimes have difficulty remembering what level of biological structure is being discussed in each classroom activity. Therefore, Table 1 is an important reference to reduce student confusion in life sciences.

[1] As specified in *Science Framework for California Public Schools Kindergarten Through Grade Twelve.* Sacramento: California Department of Education, 2003, pp 70-72.

Table 1. Internal structure of multicellular creatures. Biologists study the bodies of plants and animals at several levels of biological organization.

Level of Biological Organization	Description	Animal Examples	Plant Examples
ORGANISM	One individual of a species	You!	Sunflower
Body Systems	Organs that work together within an animal	Circulatory system Respiratory system Digestive system Urinary system	[Not Applicable]
Organs	A part of an organism with a special function	Heart Lungs Stomach	Flower Leaf Stem Root
Tissues	Several types of cells that function together	Blood Muscle Nerve	Epidermis Xylem Phloem
Cells	Smallest independent unit of life	Red blood cell White blood cell Brain cell	Guard cell Vessel Root hair
Organelles	Structure within a cell	Mitochondria	Chloroplasts Mitochondria
Molecules	Chemical compound	Water Sugar Carbohydrate Protein Fat	Water Carbon dioxide Chlorophyll Oxygen gas Sugar
Atoms	Chemical element	Carbon atom Hydrogen atom Oxygen atom	Carbon atom Hydrogen atom Oxygen atom
Subatomic	Particles that make an atom	Electron Proton Neutron	Electron Proton Neutron

Life Science Topic: Extracting Energy from Food

How Plant and Animal Cells Release Energy from Food

Science Framework[2] for California Public Schools
Grade 5: Standard Set 2. Life Sciences: 2.g. "*Students know* plant and animal cells break down sugar to obtain energy, a process resulting in carbon dioxide (CO_2) and water (respiration)."

> *"Cellular respiration is a process of producing energy by the chemical break-down of carbohydrate (sugar) molecules—a process that is the reverse of photosynthesis. The chemical process is as follows:*
> *sugar + oxygen react to form carbon dioxide + water*
>
> > *The process is expressed in the following equation:*
> > $C_6H_{12}O_6 + 6\ O_2 \rightarrow 6\ CO_2 + 6\ H_2O$
>
> *Both plants and animals break down sugar to release its energy in a form they can use. This process is called cellular respiration. Carbon dioxide and water are reaction by-products. In animals the carbon dioxide is released into the blood, where it can be transported to the lungs. In the lungs carbon dioxide and oxygen are exchanged (which is the other use of the term respiration) during the act of breathing. It should be noted that cellular respiration is not the same as breathing."*

Background for Teachers
Food can be described as molecules of carbohydrates, fats, and proteins, which are broken down into smaller molecules, such as sugar. Both plants and animals release energy from sugar in special organelles (*mitochondria*) that reside in every cell. Mitochondria are called the "powerhouses" of our cells because they break apart sugar molecules to release "energy packets" (which are used in almost all other chemical reactions to keep the cell alive).

All plant and animal cells have mitochondria.

Plant cells have both mitochondria (which metabolize food) and chloroplasts (which make food) (Figure 1).

[2] As specified in *Science Framework for California Public Schools Kindergarten Through Grade Twelve.* Sacramento: California Department of Education, 2003, pp 70-72.

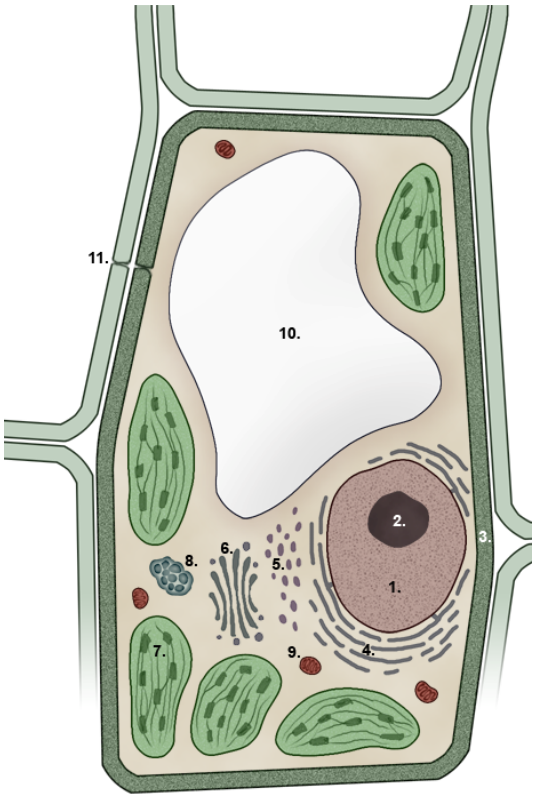

Figure 1. Diagram[3] of plant cell. In this picture, chloroplasts are green (#7) and mitochondria are red (#9).

The chemical reaction that takes place in mitochondria is the opposite of photosynthesis, which is the same chemical reaction as combustion (burning) except that instead of releasing energy from food as light and heat (fire), much of the energy from food is captured into little "energy packets." These "energy packets" are used to drive other chemical reactions in the cell, like the ones you are using to think (each brain cell has mitochondria) and to blink (muscle cells have mitochondria).

The process of releasing sunlight energy
from sugar molecules
and putting the energy into "energy packets"
is called *cellular respiration*.

[3] Drawing from http://upload.wikimedia.org/wikipedia/commons/0/06/Kasvisolu.png

The chemical reaction of cellular respiration[4], which takes place in the mitochondria of plant and animal cells, can be summarized as follows:

1. Mitochondria take in sugar molecules from food.
2. Mitochondria take in oxygen molecules from the air.
3. Energy is released as "energy packets" and heat.
4. Carbon-dioxide molecules are released into the air.
5. Water molecules are released into the air.

During cellular respiration, some of the energy (over 50%) is lost as heat, which helps to keep animal bodies warm (if they have insulation). Some animals do lots of cellular respiration (they have a high metabolism). Most plants have low metabolisms; however, some plant species conduct enough cellular respiration and release enough heat to become warmer than their surroundings. Some plants can even melt snow (Figure 2).

Figure 2. Photograph[5] of skunk cabbage. This plant species is unusual in that it can become warmer than its surroundings, due to heat released during cellular respiration. This early spring plant can melt through snow!

[4] It should be noted that cellular respiration (a chemical reaction) is not the same as body respiration (breathing via the lungs).
[5] Photograph by Zlesack, D (2009) in University of Minnesota website . http://blog.lib.umn.edu/efans/ygnews/2009/04/whats-up-with-that-3.html

Summary of Cell Metabolism[6]

Metabolism can be described as all the chemical reactions in a cell that keep that cell alive. Each one of these chemical reactions requires energy.[7]

The reason we eat and breathe is to provide food molecules and oxygen molecules to our cells for *cellular respiration*, a chemical reaction that provides energy for all other chemical reactions[8]. Cellular respiration takes place in organelles called mitochondria. Mitochondria are in the cells of plants, animals, fungi, algae, and protozoa.

The energy in our food originally came from the sunlight,[9] and was captured by plants in a process called *photosynthesis*, a chemical reaction that makes sugar from air (carbon-dioxide molecules in the air). This sugar is the basic building block for all other food molecules (carbohydrates, fats, and proteins). Photosynthesis takes place in organelles called chloroplasts. Chloroplasts are in the cells of plants and algae.

The oxygen molecules (O_2) in Earth's atmosphere originally came from plants and algae through the process of photosynthesis, where chlorophyll molecules (in a chloroplast) capture sunlight energy (or even energy from a lightbulb) and use that energy to break 2 water molecules (H_2O) and make 1 oxygen molecule (O_2).

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[6] The following peer-reviewed article discusses common misconceptions that many teachers have about photosynthesis and respiration. McNall Krall R, Lott KH, Wymer CL (2009) I**nservice elementary and middle school teachers' conceptions of photosynthesis and respiration.** *Journal of Science Teacher Education* 20:41–55. (www.springerlink.com/content/682p5863278g44mj/fulltext.pdf)

[7] Chemical reactions in living cells also require enzymes (proteins that act as catalysts).

[8] Exception: energy for the light reaction of photosynthesis comes from sunlight, not food.

[9] The following children's book was written by a professor of ecology from MIT, and celebrates how sunlight energy is inside every organism on Earth. Bang M, Chisholm P (2009) *Living Sunlight: How Plants Bring the Earth to Life.* Blue Sky Press, New York, New York.

Websites

Cellular Respiration

Chemistry 4 Kids Educational Site
This website contains simple descriptions of chemical reactions that take place in animal and plant cells.

http://www.chem4kids.com/files/bio_metabolism.html
This page describes metabolism in plant and animal cells.

Biology 4 Kids Educational Site
This website contains simple descriptions and diagrams of respiration.

http://www.biology4kids.com/files/cell_mito.html
This page describes mitochondria and the role in respiration.

Kidipede Educational Site of History and Science
This website contains biology information for middle school students.

www.historyforkids.org/scienceforkids/chemistry/reactions/combustion/digestion
This page describes cellular respiration as combustion.

http://www.historyforkids.org/scienceforkids/biology/cells/mitochondria.htm
This page describes mitochondria in the cells of plants and animals.