Teacher Notes for Food, Energy and Body Weight

This analysis and discussion activity helps students to understand the relationships between food, cellular respiration, energy, physical activity, and changes in body weight. At the end of the activity, each student asks and researches an additional question using recommended reliable internet sources.

Learning Goals

In accord with the Next Generation Science Standards, this activity:

- reinforces student understanding of the Disciplinary Core Idea LS1.C: "… Cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken", carbon dioxide and water are formed, and the energy released is used in the production of ATP from ADP and P. Then, the hydrolysis of ATP provides the energy needed for many biological processes.
- engages students in the recommended Scientific Practices, including constructing explanations, using mathematics, and asking questions.
- can be used to illustrate the Crosscutting Concept, Energy and matter: Flows, cycles and conservation, including that energy can be converted from one form to another, but energy cannot be converted to matter (in biological processes).
- helps students to prepare for Performance Expectation HS-LS1-7, "Use a model to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds and new compounds are formed resulting in a net transfer of energy."

Students learn that food, calories and energy are not equivalent concepts.

- **Food** contains organic molecules which can be used for cellular respiration which produces ATP; hydrolysis of ATP provides the energy for the processes of life. Food also provides atoms and molecules that can be used for growth and repair of body tissues.
- **Energy** is a property of all sorts of biological and non-biological systems (e.g. the chemical energy available from cellular respiration of food molecules or the kinetic energy of moving muscles or cars).
- A **calorie** is a unit of measure of energy.³

Instructional Suggestions and Background Information

Before students begin this activity, they should have a basic understanding of how our bodies use food to provide (1) energy for body processes and (2) atoms and molecules needed for growth and repair of our bodies. One helpful introductory activity is "How do biological organisms use energy?" (http://serendip.brynmawr.edu/exchange/bioactivities/energy).

To maximize student participation and learning, I suggest that you have your students work in pairs or individually to complete groups of related questions and then have a class discussion after each group of related questions. In each discussion, you can probe student thinking and help

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1 by Dr. Ingrid Waldron, Department of Biology, University of Pennsylvania, 2016. These Teacher Notes, the related Student Handout, and other activities for teaching biology are available at http://serendip.brynmawr.edu/exchange/bioactivities.


3 In this activity I use the lower case "calories" because this usage of nutritional calories is more familiar to students, even though technically I am referring to Calories = kilocalories.
them develop a sound understanding of the concepts and information covered before moving on to the next group of related questions.

If you use the Word document to make changes in the Student Handout, please consult the PDF file to see the correct format for the Student Handout.

A key is available upon request to Ingrid Waldron (iwaldron@sas.upenn.edu). Additional background information and instructional suggestions are included in the paragraphs below.

In discussing the introductory chart and question 1, you may want to explain to your students that fatty acids, glycerol and amino acids can also be used as inputs for cellular respiration and these molecules come from the digestion of fats and proteins in foods.

You may want to point out the parallel between the dual uses of food we eat and the dual uses of sugars produced by photosynthesis, as discussed in “Photosynthesis and Cellular Respiration” (http://serendip.brynmawr.edu/exchange/bioactivities/photocellrespir).

Estimated annual per capita food consumption in the US includes 75 pounds of added fats and oils, 152 pounds of caloric sweeteners, 195 pounds of meat and fish, 200 pounds of grains, 593 pounds of dairy, and 708 pounds of fruits and vegetables (http://www.usda.gov/factbook/chapter2.pdf). Notice that the types of foods at the beginning of this list have high calorie density; foods in the last two categories weigh substantially more per calorie consumed, in large part because they contain a lot of water.

In discussing question 4, you will want to emphasize the important points that, although energy can be converted to other forms of energy and the atoms in reactant molecules can be reorganized into atoms in different product molecules, energy can not be converted to matter or vice versa.

If a person eats food with more calories than needed for body activities, some of the organic molecules contained in the food will not be used for cellular respiration, so the atoms in these molecules will not be given off as CO₂ and H₂O. The body uses surplus organic molecules to synthesize:

- triglycerides which are stored in fat cells in our adipose tissue and
- glycogen (a polymer of glucose) which is stored in the liver and muscles.

Less than a day's worth of energy is stored in the form of glycogen (~800 calories). In contrast, a normal weight person has enough stored fat to provide energy for about two months (~140,000 calories). Fat provides more energy per gram than carbohydrates or proteins (9 calories per gram vs. 4) and fat stores also have less associated water. For both reasons, fat requires less weight per calorie stored. This is an advantage for organisms like animals that are mobile, which is a major advantage of fat as the main energy storage molecule in animals.

The section on Eating and Exercising is based on a case study for teaching nutrition, "A Light Lunch? A Case in Calorie Counting". Additional information is available at http://sciencecases.lib.buffalo.edu/cs/collection/detail.asp?case_id=460&id=460. The Student Handout omits many aspects of the complex physiology of weight gain and weight loss. For example, this activity does not discuss the hormonal and metabolic changes which make it difficult to maintain weight loss after obesity (http://arstechnica.com/science/2016/05/big-
Questions 5 and 6 focus on the effects of diet and physical activity on obesity, but question 7 introduces the broader health effects of diet and physical activity. To research their questions, your students can use the sources listed in the Student Handout and also search for summaries of news articles in https://www.sciencedaily.com/news/health_medicine/ (but caution your students to distinguish between the ads and the news articles). If your students want to explore additional resources, you may want to use the resources available at http://www.library.georgetown.edu/tutorials/research-guides/evaluating-internet-content and http://www.virtualsalt.com/evalu8it.htm to help your students learn about how to evaluate the reliability of different sources. This research project can be used to engage your students in the NGSS-recommended science practices of "asking questions" and "obtaining, evaluating, and communicating information".

Related Activities
“How do muscles get the energy they need for athletic activity?”
(http://serendip.brynmawr.edu/exchange/bioactivities/energyathlete)
In this analysis and discussion activity, students learn about aerobic cellular respiration, anaerobic fermentation, and hydrolysis of creatine phosphate (phosphocreatine). Students analyze how these processes contribute to ATP production in muscle cells during different types of athletic activity. In addition, they gain understanding of general principles such as the conservation of energy and the importance of interactions between body systems to accomplish functions such as supplying the energy that muscles need for physical activity. Students apply this knowledge to an analysis of how the training effects of regular aerobic exercise contribute to an increase in muscle cells’ capacity for aerobic respiration.

"Cellular Respiration and Photosynthesis – Important Concepts, Common Misconceptions, and Learning Activities" (http://serendip.brynmawr.edu/exchange/bioactivities/cellrespiration) provides an overview of energy, ATP, cellular respiration, and photosynthesis. This overview summarizes important concepts and common misconceptions and suggests a sequence of learning activities designed to develop student understanding of these concepts and overcome any misconceptions.