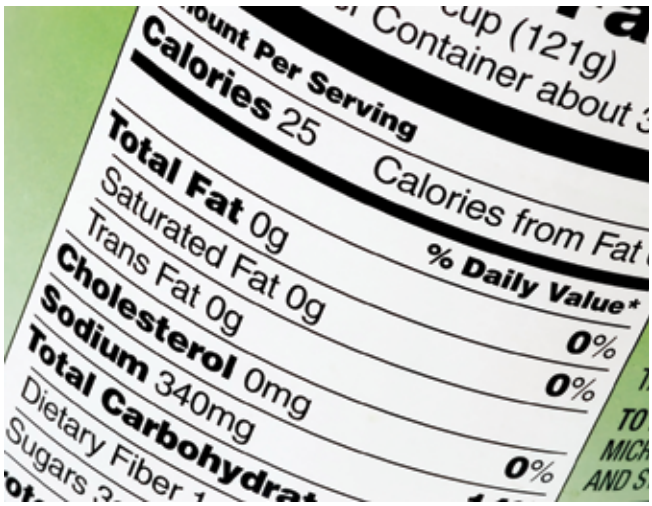
Chapter 10: Energy Balance

Energy Equilibrium

Meal planning is an important part of creating a healthy diet. For good health, people should plan weekly meals to help them make good choices. Each day adolescents should eat 1 ½ cups of fruit, 2 ½ cups of vegetables, 6 ounces of grains (½ of them being whole grains), 5 ounces of protein, and 3 cups of dairy. Eating the recommended amounts of each food group may help to prevent disease and support the body with nutrients. Eating too many calories from unhealthy foods can put individuals at risk for becoming overweight, developing dental cavities, and experiencing heart problems, diabetes, high blood pressure, and other diseases. In this chapter, students will learn about the calorie as the unit of energy we obtain from food, and how to interpret health information from a variety of sources. These topics are important to help students understand nutritional concepts.



FOOD EXPLORATION LAB

Energy Balance

- Teacher Preparation
- Teacher Lab Answer Key
- Student Lab

INVESTIGATING YOUR HEALTH

Managing Your Meals

- Teacher Answer Key

Try This At Home: Magnificent Menu

SUPPLEMENTAL MATERIALS

Energy Balance Equation

- Teacher Preparation Slides
- Student Demonstration Slides & Video

Food Explorations Lab:
Energy Balance

TEACHER LESSON PREPARATION

Lesson Focus

Understand the concept of energy balance and the importance of a healthy diet

Lesson Description

Students will determine the potential energy (kilocalories) of a peanut through measurements obtained during teacher use of a bomb calorimeter. Students will also make comparisons to the actual Nutrition Fact Label and identify possible sources of error.

Academic Content Standards

ELA Common Core Standards for Literacy in Science and Technical Subjects (R-reading, W-writing, SL-speaking and listening, L-language) Grades 6-8

R-1 Cite specific textual evidence to support analysis of what the text says explicitly as well as inferences drawn from the text.

R-3 Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.

R-4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical content relevant to grade (6-8) text and topics.

R-7 Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g. in a flowchart, diagram, model, graph or table).

R-10 Read and comprehend complex literary and informational texts independently and proficiently.

W-2 Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content.

SL-1 Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade (6-8) topics, texts, and issues, building on others' ideas and expressing their own clearly.

L-1 Acquire and use accurately grade-appropriate general academic and domain-specific words and phrases; gather vocabulary knowledge when considering a word or phrase important to comprehension or expression.

Next Generation Science Standards

Performance Expectations

MS-PS1-2 Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.

MS-PS1-6 Undertake a design project to construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes.

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.

Disciplinary Core Ideas

PS1.B Chemical Reactions

- Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants.
- Some chemical reactions release energy; others absorb energy.

ETS1.B Developing Possible Solutions: A solution needs to be tested and then modified on the basis of the test results in order to improve it.

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, support growth, or release energy.

Crosscutting Concepts

- Macroscopic patterns are related to the nature of microscopic and atomic-level structure.
- The transfer of energy can be tracked as energy flows through a designed or natural system.

Background Information

Our bodies need food for energy. Some foods provide more energy than others. More specifically, some foods are better sources of energy because they allow our bodies to store more **potential energy**. Potential energy is stored energy that has not been used. The amount of potential energy varies among foods. Our bodies convert the potential energy, measured in calories, to **chemical energy**. Chemical energy is the energy stored in chemical bonds that is released during a chemical reaction. A **calorie** is the amount of energy needed to raise one milliliter of water one degree Celsius. A **kilocalorie** (kcal) is the amount of energy required to raise the temperature of one liter of water one degree Celsius. Kilocalories are also known as the calories seen on food labels. They are a good method to use when measuring our energy. **Joules** is another unit used to measure energy intake. A joule (J) is equal to the amount of energy expended to force one newton through one meter. Just like ounces and grams are units used to measure weight, calories and joules are units used to measure energy.

It is important to consume the right amount of energy. Everyone burns energy at his or her own rate; however, we can calculate a range of calories we need for daily functions. We can keep track of our energy consumption using the **energy balance equation**. This equation subtracts energy burned from energy consumed to determine if we have consumed too little or too much energy. Consistently consuming too much or too little energy will have lasting effects on our bodies. Consuming too little energy will cause our bodies to breakdown too much stored energy, leading to malnutrition. Consuming too much energy will cause our bodies to store too much energy, leading to obesity. We need to consume a balanced diet to ensure the best health outcomes. Selecting foods from all five food groups, according to the daily recommendations for our age and gender, is essential to our health. The five food groups include Dairy, Grains, Protein, Vegetables, and Fruit. They provide us with a well-rounded diet based on our macronutrient recommendations. Macronutrients are carbohydrates, protein, and fat. We need all three to keep our bodies functioning properly. Selecting too many energy-dense foods and too little nutrient-dense foods will lead to health problems.

Energy dense foods, like doughnuts and French fries, are foods high in calories and low in nutrients. Nutrient dense foods, like broccoli and strawberries, can be high or low in calories, but are always high in nutrients. A **bomb calorimeter** can be used to measure the energy in food. This tool measures the amount of heat generated by a chemical reaction by releasing the energy from food in the form of heat. For example, when determining the amount of energy in a peanut, the peanut is placed in the calorimeter and burned. As the peanut is burning, its energy is being transferred to the water sitting above in the form of heat; therefore the increase in water temperature can be used to determine the peanut's energy.

Materials

Teacher Materials

NOTE: Teacher material list is based on 6 groups of 4-5 students (24-30 students total).

Demonstration *(see Suggested Lesson Plan steps 7-16)*

Safety goggles	Apron
1 empty soda can	1 empty metal coffee can (large enough to fit a soda can inside)
1 cork	1 uncoated paper clip (any size)
1 graduated cylinder	100mL distilled water (room temperature)
1 thermometer (Celsius)	1 lighter
1 forceps	1 peanut for calorimeter
1 glass or metal rod (16cm or longer)	1 can opener with a triangular end (church key)

Student Materials

NOTE: Student material list is based on 1 group of 4-5 students. Refer to the FoodMASTER Middle "Equipment and Material Lists by Chapter" for whole class estimates (24-30 students divided into 6 groups) on perishable and nonperishable materials.

1 small bowl
1 triple beam balance
1 cup of peanuts
1 graduated cylinder or liquid measuring cup
100mL distilled water (room temperature)

Teacher Pre-Lab Preparation

1. Review pertinent background information.

2. Prepare needed materials for each group.

3. If time is a concern, construct the bomb calorimeter before hand and pre-weigh the single peanut.

4. The mathematics within this lesson may be challenging to some students. Consider guiding students through the mathematics portion of the lab, or assigning one student within each group to lead others through the work.

IMPORTANT NOTE: A portion of this lab investigation (burning of food) should occur in an open area outside unless you have access to a fume hood in your classroom.

WARNING: Students with peanut allergies may not be able to participate in this investigation.

Construction of the Bomb Calorimeter:

1. **Option 1:** Use the triangular end of the can opener to put four holes evenly spaced around the bottom edge of the coffee can to make a bomb calorimeter. One hole should be large enough to fit a peanut through. **Option 2:** Remove the bottom of an open coffee can.

2. Drill or poke holes (size of a pencil eraser or smaller) through a small aluminum can (soda) opposite each other about 1 cm below the top. Do not remove the top. The water and thermometer can be placed into the can through the drinking opening.

3. Insert a glass or metal rod, 16cm or longer through the holes you made at the top of the soda can. This rod will support the can when it is placed across the top of the coffee can.

   NOTE: If using Option 1 construction, placing the soda can on the base of the coffee can instead of hanging it should provide a sufficient temperature increase.)

4. See steps 9-15 of the Suggested Instructional Plan.

Suggested Instructional Plan

1. Review scientific vocabulary and knowledge prerequisites:

Bomb Calorimeter	**Calorie**	**Kilocalorie**
Energy Balance	**Joule**	

2. Consider having your students research kilocalories as a unit of measuring energy in food prior to beginning the lab investigation.

3. Distribute Materials:

   It is recommended that materials are organized into stations for easier distribution. Materials are recommended based on the amount needed for 1 class of 30 students. Students should be arranged in small groups of 4-5.

   Each group should receive:

   - Student Lab Investigation Worksheets (1 per student)
   - Student Materials

3. Ask students to read *Energy Equilibrium* and complete the focus questions for this lab investigation.

4. Before beginning the lab investigation:

   a. Require students to wash their hands.

   b. Emphasize the importance of practicing good food safety behaviors by not consuming substances used as part of the lab investigation.

6. Launch the lab by asking students to observe and make a prediction about the kilocalorie content of peanuts.

7. Next, complete the **teacher demonstration** or show the provided video lab demonstration *(Food Explorations Lab: Energy Balance)*. If you use the video, make sure students record the measurement values provided in the appropriate tables.

8. To complete the teacher demonstration, begin by weighing and recording the mass of a single peanut. This same peanut will later be placed into the bomb calorimeter. Students should record the weight in Table C. If you completed this step ahead of time, simply provide students with the weight of the single peanut.

9. Next, place 100mL of room temperature distilled water in the soda can.

10. Place the soda can inside of the coffee can.

11. Unwrap the paper clip and insert it in the cork.

12. Wrap the paper clip attached to the cork around the peanut. If the peanut breaks off while it is burning, you will have to burn a new peanut. Be sure to re-weigh the peanut each time.

13. Light the peanut with a wooden match or lighter. Once it ignites, immediately place the coffee can around the burning peanut or insert it through a hole in the bottom of the calorimeter.

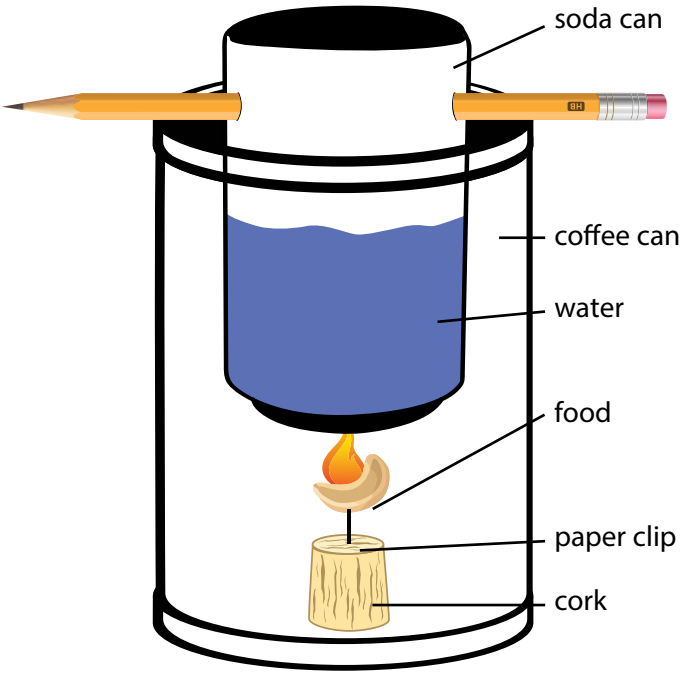
14. Make sure the peanut burns completely. If the fire goes out, re-light the peanut.

WARNING: If you have to relight the peanut, be careful to use caution when touching the heated coffee can.

15. Once the peanut has completely burned, stir the water with the thermometer and measure the temperature. Both cans may be warm. Be careful not to burn yourself.

16. After the burned peanut has cooled, measure and record its weight. Students should record the weight in Table C.

17. Allow students to work in small groups on the Student Lab Investigation worksheet to further explore the topic and respond to lab questions.



18. You should use Celsius thermometers. If your thermometer measures in degrees Fahrenheit, before proceeding with the conclusion questions students must first convert degrees Fahrenheit (°F) to degrees Celsius (°C): °C = 5/9 *(°F -32). You may consider completing this math for students or guiding them through the conversion. An example of the °F to °C conversion, as it relates to conclusion question #1, is provided for you below. The water temperatures provided in the equation below are for example purposes only.

$$5/9\ (70°F\ (\Delta T) - 32) = 21.11°C$$

$$5/9\ (71°F\ (\Delta T) - 32) = 21.67°C$$

(21.67°C after burning peanut) – 21.11°C before burning peanut) = 0.56°C water (ΔT)

100 gram water × 1 cal/g/°C × 0.56°C = 56 cal (Q) or 0.056 kcal

19. Follow-up with a class discussion about the relationship between human health and consuming nutrient dense (foods high in nutrients, low in calories - e.g. vegetables/ fruits) versus calorie dense foods (foods high in calories, low in nutrients - e.g. French fries, soda). See Teacher Bites for ideas on how to further extend this lesson.

Teacher Bites: Lesson Extension

- Explore the energy density of other foods by using the bomb calorimeter or reviewing Nutrition Facts labels.

Investigating Your Health:
Magnificent Menu

STUDENT HEALTH INVESTIGATION

Lesson Focus

Determine how to meet current Dietary Guidelines, and make suggestions for improvement based on their 24-hour recall. Students will also identify the importance of a healthy diet.

Lesson Description

Students will perform a 24-hour recall, compare their results to the current Dietary Guidelines, and make suggestions for improvement.

Academic Content Standards

ELA Common Core Standards for Literacy in Science and Technical Subjects (R-reading, W-writing, SL-speaking and listening, L-language) Grades 6-8

R-1 Cite specific textual evidence to support analysis of what the text says explicitly as well as inferences drawn from the text.

R-4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical content relevant to grade (6-8) text and topics.

R-10 Read and comprehend science/technical texts in the grades 6-8 text.

W-2 Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content.

W-7 Conduct short research projects to answer a question (including a self-generated question) drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.

W-9 Draw evidence from informational texts to support analysis, reflection, and research.

Next Generation Science Standards

Performance Expectations

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.

Disciplinary Core Idea

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, support growth, or release energy.

Science and Engineering Practices

Analyzing and Interpreting Data: Analyze and interpret data to determine similarities and differences in the findings.

Suggested Instructional Plan

1. Review Scientific Vocabulary and Knowledge Prerequisites:

   Meal Management **Empty Calories** **24-hour Recall**

2. Instruct students to research the health benefits of consuming a balanced diet prior to beginning the investigation. Students should seek to identify specific food groups, their health benefits, and common food sources of each.

3. Student responses for this investigation will vary.

4. If completed in-class, allow students to work in small groups on Investigation worksheet to further explore the topic and respond to questions.

5. Follow-up with a class discussion about student findings related to the health benefits of consuming a balanced diet and student generated ideas for making their own diet "balanced."