

# Roasted Vittles

Students investigate how much energy is stored in foods by burning a food sample and calculating how many calories of heat are released.

**Grade Level:** 9-12

**Subject Areas:** English Language Arts, Health, Mathematics, Science

**Setting:** Classroom

**Time:**

**Preparation:** 50 minutes

**Activity:** Two 50-minute periods

**Vocabulary:** Adenosine triphosphate (ATP), calorie, Calorimeter, Carbohydrate, Chemical bond, Food Calorie, Glucose, Kinetic energy, Molecule, Potential energy, Protein, Respiration, Solar energy, Stored energy

**Major Concept Areas:**

- Definition of energy
- Energy flow in living systems

**Getting Ready:**

Consider having student helpers construct the Roasting Apparatus before class. **CAUTION: This activity involves the use of an open flame.**

**Objectives**

Students will be able to:

- explain that food contains energy;
- describe how energy in food can be measured; and
- relate good eating habits to consumption of food energy.

**Rationale**

Understanding that foods contain energy helps students appreciate their dependence on energy. Calculating the amount of energy in foods promotes students' understanding that energy can be measured and supports the knowledge that energy is converted from one form to another.

**Materials**

- Nutrition labels found on packaged foods (optional)
- Copies of the following pages:
  - [Building and Using a Simple Calorimeter](#)
  - [Data and Results Table](#)
  - [Calories Used During Physical Activities](#) (optional)
- All materials listed on [Building and Using a Simple Calorimeter](#)
- Find additional resources related to this activity on [keepprogram.org](http://keepprogram.org) > Curriculum & Resources

**Background**

Did you know that a jelly doughnut contains enough chemical energy—or stored potential energy—to accelerate a large car from zero to 70 miles per hour? (See [The Energy-Packed Jelly Doughnut](#).) It is amazing that an item so small can hold so much energy. Where did this energy come from and where is it stored in the doughnut?

The energy in the food we eat, including jelly doughnuts, initially came from the sun. Through photosynthesis, plants use the sun's energy to recombine atoms from carbon dioxide and water to make sugars such as glucose. The energy used during photosynthesis is stored in the chemical bonds of glucose. For organisms to retrieve the energy that is stored in food, the chemical bonds must be broken. The cells in our bodies break the bonds in food molecules in a process similar to burning. When wood is burned, however, a lot of energy is released at once. This type of burning would be deadly if it took place in our cells.

Even releasing all the energy from a single glucose molecule at once would be like trying to light a candle with a welding torch (remember that the energy stored in a jelly doughnut is equal to that of a speeding car).

Consequently, the burning that occurs in the cells of living organisms, called respiration, is a more controlled process. In respiration, energy from the chemical bonds of several molecules are transferred to more manageable molecules called adenosine triphosphate (ATP). However, since no energy conversion is 100 percent efficient, not all of the energy from the food molecules is transferred to ATP. Some of the energy is lost as heat. Feel your skin; the warmth you feel is heat generated by cellular respiration, energy that originally came from the sun.

Knowing that energy in food can be released by burning provides us with a way to measure the amount of energy stored in foods. Burning food converts stored chemical energy to heat energy. Heat is measured in units called calories. A calorie is the amount of heat used to raise the temperature of one gram of water one degree Celsius. Scientists and nutritionists can measure the amount of heat energy in foods using a calorimeter.

The amount of heat energy in packaged foods is found on the nutrition label. However, the energy unit listed there is actually Food Calorie or Calorie (capital C), which is equal to 1,000 Calories or one kilocalorie (kcal).

- 1 Calorie (with a capital C) = 1,000 calories (small case c)
- = 1 kilocalorie

Because of their chemical makeup, different foods have different amounts of stored energy. Carbohydrates, such as sugars and starches, are good sources of energy. Other types of food, such

Nutrition Facts		
Serving Size 10 Pretzels (30g)		
Servings Per Container About 8		
Amount Per Serving		
Calories 110		Calories from Fat 10
% Daily Value*		
Total Fat	1g	2%
Saturated Fat	0g	0%
Cholesterol	0mg	0%
Sodium	105mg	4%
Total Carbohydrate	24g	8%
Dietary Fiber	less than 1g	3%
Sugars	1g	
Protein	2g	
Not a significant source of Vitamin A, Vitamin C, Calcium and Iron.		
* Percent Daily Values are based on a 2000 calorie diet. Your daily values may be higher or lower depending on your calorie needs:		
	Calories:	2,000    2,500
Total Fat	Less than	65g    80g
Sat Fat	Less than	20g    25g
Cholesterol	Less than	300mg    300mg
Sodium	Less than	2400mg    2400mg
Total Carbohydrate		300g    375g
Dietary Fiber		25g    30g
Calories per gram:		
Fat 9 • Carbohydrate 4 • Protein 4		

as proteins and fats, are also high in energy because they are large molecules with many chemical bonds. Proteins are used by the body for building muscles and bones. Fats are needed for healthy hair and skin, and to help insulate the body. In general, fats have nine calories per gram, while proteins and carbohydrates have four calories per gram.

A key to good nutrition is to consume only as much food energy as you need, because the excess energy may be stored as fat. While some fat is necessary for insulation and general body maintenance, too much stored fat is unhealthy. Generally, adolescent females need 1,200 to 3,000 Calories per day and adolescent males need 2,100 to 3,900 Calories per day. However, more active youth—such as those participating in sports—require more energy.

A jelly doughnut contains carbohydrates and fats. It is a good energy source, containing around 240 Calories. However, for an individual who needs only 2,000 Calories per day, two doughnuts could supply over ten percent of the recommended daily Caloric intake. Therefore, unless you plan to have an active morning, you might consider eating whole wheat toast and fruit instead (a slice of bread and an orange provide 125 Calories).

## Procedure

There are two types of calorimeter apparatus that can be used for this experiment, found on [Building and Using a Simple Calorimeter](#). The Open Beaker Calorimeter is quite simple and makes use of items commonly found in most science classrooms. It will generate meaningful data, however much of the energy released by the food sample is lost to the surroundings, so results will differ considerably from energy content values found on the food packaging labels. The Metal Can Calorimeter greatly reduces the heat loss to the surroundings, and thus yields results that will be closer to values published on the package labels. However, fabrication of the calorimeter cans is a time consuming process, and does present some risk to students, who might cut themselves on sharp metal edges. To save time and reduce risk, teachers might opt to have one or two mechanically inclined students fabricate a class set of Metal Can Calorimeters several days beforehand that can then be used on the day of instruction.

## Orientation

Ask students why they want and need to eat food (have them categorize their answers under “wants”

and “needs”). Focus on the needs. See if students can categorize the needs into two groups: (1) need for energy, and (2) need for materials (such as protein) to build cells and tissues. The body needs food energy to move, build and repair cells, breathe, think, and so on. Ask students about the foods they eat. How do they decide what and what not to eat? Why might they choose not to eat cake or candy? Ask students if they consider how many Calories are in the food they eat. Determine what students know about Calories. How do they define a Calorie?

Provide students with the correct definition of calories and Food Calories (or kilocalories).

### Steps

1. Emphasize that food is an energy source for humans (similar to gasoline being a fuel source for automobiles). Explain that energy is stored in the chemical bonds of the food molecules.
2. Ask students how they think our bodies get energy from food. Students may mention that food is digested, but that does not release energy. Digestion in the stomach just breaks the food down into smaller molecules of proteins, lipids (fats and oils) and carbohydrates (sugars and starches) that can be absorbed into the bloodstream. The chemical bonds between the atoms that make lipids and carbohydrates serve as a source of energy for all of the cells in our body. To use this energy, cells must release the energy from these chemical bonds, much like when energy is released by burning a piece of wood in a fireplace. The process of combustion (burning) breaks chemical bonds and changes chemical energy into heat.
3. Inform students that our bodies release stored energy in food through a process called respiration. Point out that respiration is similar to releasing energy by burning a piece of wood, but that the burning process in respiration occurs more gradually and is more controlled. Advanced students may know that through respiration, energy is transferred from the glucose molecule to the ATP molecules.
4. Show students nutrition facts labels from several packages of food, or read information from the **Table of Calorie Contents of Selected Foods**. What information from the label helps them determine how much energy is in the food? Refer students to the

Calories listed. Remind them of the definitions of calorie and Food Calorie.

5. Help students understand that heat energy is measured in units called calories. If students do not understand what is meant by a unit of measure, go over examples familiar to them (e.g., height is measured in units called feet or meters, weight is measured in units called pounds or kilograms).
6. Ask students if they think measuring the heat energy released by burning food would be an accurate way to measure the energy contained in food. Remind students of the first law of thermodynamics (energy is neither created nor destroyed, but is converted from one form to another). Therefore, determining how much heat is released by burning food is one way of determining the energy in food. However,

### Table of Calorie Contents of Selected Foods\*

1 medium apple .....	80
1 medium potato .....	145
1 medium tomato .....	25
1 medium orange .....	60
1 large carrot .....	30
1 large egg, fried .....	95
1 slice cheese pizza .....	290
1 large meat taco .....	570
1 hamburger .....	300–500
1 roasted chicken breast.....	140
1 fried chicken breast .....	215–365
1 slice cheddar cheese .....	115
1 cup corn flakes .....	110
1 cup whole milk.....	150
1 cup 2 percent milk .....	120
1 cup skim milk.....	85
1 cup ice cream.....	270
1 milkshake .....	360
1 slice white bread .....	65
1 slice wheat bread .....	60
1 jelly doughnut.....	140

\*From United States Department of Agriculture, Human Nutrition, and Information Service. Calories and weight: The USDA pocket guide. Washington, D.C.: United States Department of Agriculture, Human Nutrition, and Information Service, 1991.

since no conversion is 100 percent efficient, this measurement is not completely accurate.

7. Give students copies of *Building and Using a Simple Calorimeter* and *Data and Results Table*, and then review the objectives and instructions. Divide the class into cooperative working groups. Responsibilities of group members could include Direction Reader/Leader, Materials Gatherer/Calorimeter Assembler, Experimenter/Roasting Device, and Recorder/Reporter.
8. Have the groups construct the calorimeter apparatus and follow directions to determine the caloric content of the food sample, carefully recording all findings and answering all questions on the *Data and Results Table*. See **Calculations** for a description of the formulas needed to answer Questions 10, 11, and 12.
9. The procedure found on *Building and Using a Simple Calorimeter* asks students to repeat the calorimetry process with a second food sample of the same type, and then average the results. This is a good strategy to keep faster paced students engaged, while others that require more time or individualized instruction can catch up by performing the experiment only a single time.

### Additional Optional Steps

10. Instructors may wish to have students compare their results with other groups measuring the same food type. Clearly food items like walnuts or pecans will vary in the number of calories released depending on the size of the piece that is burned, but the results for the energy content per unit mass of food burned should be somewhat similar when expressed in calories/gram. Students can discuss variations in their experimental procedure and sources of error that might have contributed to any differences in their results.
11. Instructors may wish to have students first conduct the experiment using the Open Beaker Calorimeter, and then repeat the experiment with the same food item using the Metal Can Calorimeter. Students can then compare the results of the two experiments to see which apparatus provided a more accurate measure of the heat content of the food item. The Metal Can Calorimeter limits the heat loss to the surroundings due to convection and radiation through the air. Thus, more of the heat released from the food is actually absorbed by the water. This tends to give results that are much closer to the accepted calorie content of the food item

being measured. If this procedure is followed, then instructors will want to provide students with two data sheets, copied back to back.

12. Instructors may wish to have students first perform the experiment using a food that is primarily made of lipids (e.g. walnut, pecan, peanut), and then repeat the experiment using a food that is primarily made of carbohydrates (marshmallow, pretzel, salad crouton, etc.). For example, for walnuts, about 83 percent of the calories are from lipids (fat/oil), 9 percent from carbohydrates, and 8 percent from protein. By comparison, for a marshmallow roughly 97 percent are from carbohydrates (primarily sugar), 2 percent from protein, and 1 percent from lipids (fat/oil).

Students may then compare the energy content per unit mass for different food groups. The results should show that the energy content (in Calories per gram) for lipids is larger than the energy content for carbohydrates. Lipids have an energy content of about 9 kilocalories per gram, whereas carbohydrates generally are closer to 4 kilocalories per gram. This demonstrates the impressive energy density of lipids, and explains why many living organisms store energy in the form of fats or oils. If this procedure is followed, then instructors will want to provide students with two data sheets, copied back to back.

### Closure

Discuss the results of the students' findings. Possible responses to the questions include the following:

- Evidence of energy is that the food sample burns.
- Most of the heat from the burning food sample escapes into the surrounding air. The water also loses heat energy to the air. The food sample did not burn completely.
- See **Background** for information about comparing burning to respiration.

Discuss reasons why it is important to know how much energy is available in foods. Have students discuss the importance of food energy in relation to healthy eating habits (see **Assessment**).

### Assessment

#### Formative

- Can students explain why we need food to survive?
- Did the group accurately set up the calorimeter

apparatus and measure volume and temperature of the water?

- Are the calculations on *Building and Using a Simple Calorimeter* correct?
- How thorough were students' responses to questions?

### Summative

Have students read food labels to estimate how many Calories they consume in a day (or a week). Then use the *Calories Used During Physical Activities* chart to figure out how many Calories they expend. How do the amounts compare? What conclusions can they draw about their diet and exercise? **Caution: Emphasize that other conditions, such as the type of food students eat and when they eat, should be considered prior to making any changes. It is also a good idea to discuss their findings with a nutritionist.**

- Following are several approaches students can use to present the importance of food energy in relation to healthy eating habits:
  - Write a persuasive paper about good eating habits, highlighting problems associated with eating too many or too few Calories.
  - Produce a play or write a song for students in younger grades that illustrates the importance of getting the proper amount of Calories.
- Another way students can demonstrate their understanding of concepts in this activity is to redesign the calorimeter apparatus to reduce heat loss. This would yield results that are closer to the energy values on food package labels. Students may be asked to list/write design ideas, or to conceptualize them in a sketch or a scale drawing. More advanced students may even wish to fabricate a prototype calorimeter based on their designs

### Related KEEP Activities

Students may want to further explore energy-related food issues. Some ideas are found in 6–12 Energy Sparks for Theme II: “Energy Costs of Food.” Extend concepts from this activity by having students consider projects described in Action Ideas in the Energy Sparks section.

### Additional Note

This activity was formerly called Roasted Peanuts. Some teachers may recognize this classical experiment using peanuts as a food sample. Due to food allergies, many schools now discourage the use of peanuts for this experiment. Furthermore, other food types that have a higher surface area to volume ratio and lower moisture content tend to burn more completely and give better results. For example, walnuts and pecans tend to be better performing foods with high lipid content. Marshmallows, pretzels, and salad croutons tend to be better performing foods with high carbohydrate content.

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# The Energy-Packed Jelly Doughnut

Suppose all the chemical energy in a jelly doughnut could be used to accelerate a large car. How fast would the car be going in miles per hour after it had accelerated from a standstill? A jelly doughnut has about 240 Calories of chemical energy stored in it. One Calorie or kilocalorie, the unit used to measure the energy contained in food, equals 1,000 calories. Converting the 239 Calories to calories, we get:

$$239 \text{ Calories} \times \frac{1,000 \text{ calories}}{1 \text{ Calorie}} = 239,000 \text{ calories}$$

The 239,000 calories need to be converted into another unit of energy called joules. This is done because joules are defined in terms of units of mass (kilograms) and speed (meters per second).

$$1 \text{ joule} = \frac{1 \text{ kilogram} \times (1 \text{ meter})^2}{(1 \text{ second})^2}$$

These units help us get the answer we want. Since one calorie is equal to 4.18 joules:

$$239,000 \text{ calories} \times \frac{4.18 \text{ joules}}{1 \text{ calorie}} = 1 \text{ million joules}$$

The energy needed to accelerate the car from a standstill to its final speed is equal to the change in the car's kinetic energy. The formula is: Change in kinetic energy of car =  $\frac{1}{2} \times (\text{mass of car}) \times (\text{final speed})^2 - \frac{1}{2} \times (\text{mass of car}) \times (\text{starting speed})^2$

Assume the car weighs 4,500 pounds, the approximate weight of a 1995 Cadillac Fleetwood. This weight is equal to a mass of 2,045 kilograms. Since the car is at a standstill before being accelerated, its starting speed equals zero.

Because the source of the car's energy is the jelly doughnut, we set this energy equal to the change in kinetic energy of the car.

$$\begin{aligned} 1,000,000 \text{ joules} &= \frac{1}{2} (2,045 \text{ kg}) (\text{final speed})^2 - \frac{1}{2} (2,045 \text{ kg}) (0)^2 \\ 1,000,000 \text{ joules} &= \frac{1}{2} (2,045 \text{ kg}) (\text{final speed})^2 - 0 \\ 2,000,000 &= (2,045 \text{ kg}) (\text{final speed})^2 \\ \frac{2,000,000 \text{ joules}}{2,045} &= (\text{final speed})^2 \end{aligned}$$

$$\begin{aligned} \text{Solving for the final speed, we get: } \text{final speed} &= \frac{\sqrt{2,000,000 \text{ joules}}}{2,045 \text{ kg}} \\ &= \frac{\sqrt{2,000,000 \text{ kg meter}^2 / \text{kg meter}^2 / \text{second}^2}}{2,045 \text{ kg}} \\ &= \sqrt{978 \text{ meter}^2 / \text{second}^2} \\ &= 31.3 \text{ meters/second} \end{aligned}$$

Converting 31.3 meters per second into miles per hour, we get:

$$\frac{31.3 \text{ meters}}{\text{seconds}} \times \frac{3,600 \text{ seconds}}{1 \text{ hour}} \times \frac{3.28 \text{ feet}}{1 \text{ meter}} \times \frac{1 \text{ mile}}{5,280 \text{ feet}} = 70 \text{ miles per hour}$$

This result may lead us to wonder why we don't just stuff jelly doughnuts into the gas tanks of our cars. There are two reasons. First, a car engine is not designed to convert the energy in a jelly doughnut into motion, nor can an engine be designed to do this effectively. Second, a typical car engine converts about 15 to 25 percent of the energy in gasoline into motion. Even if an engine could be built to use the energy of jelly doughnuts, most of this energy would be lost as heat.

Human "engines" don't fare any better—only about 15 to 20 percent of the food energy we eat is used to move our muscles. However, our bodies are designed to convert the energy in jelly doughnuts and other foods into motion. Given our inclination toward sweets, this may be a good thing. We probably wouldn't want to sacrifice jelly doughnuts just to drive to the grocery store.

# Calculations...

## For Step 10 on Student Activity Sheet (calculating the number of calories gained by the water)

Formula: **Mass of water (g) x 1 c/g °C x Change in Temperature (°C) = calories (c)**

- Mass of the water is 100 grams if you measure 100 ml of water (remember that one milliliter of water = one gram of water).
- One c/g °C (or one calorie/gram °C) is the heat capacity of water. In other words, it takes one calorie of heat energy to raise the temperature of one gram of water one degree Celsius.
- The change in temperature in the water is the figure from Column 6 (Row 1 if the exercise is completed once, Row 3 if two runs are averaged).

$$(100 \text{ g}) \times (1 \text{ c/g } ^\circ\text{C}) \times (\text{column 4}) ^\circ\text{C} = \text{___ c}$$

The grams and c/g °C will cancel out, leaving the calories unit remaining. Example, if the temperature change is 15 °C:

$$100 \text{ g} \times 1 \text{ c/g } ^\circ\text{C} \times 15 ^\circ\text{C} = 1,500 \text{ c}$$

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## For Step 11 on Student Activity Sheet (converting calories to Calories)

Formula: **Heat gained by water (calories or c) x 1 Calorie/1,000 calories = Food Calories**  
(answer from #10) calories x 1 Calorie/1,000 calories = \_\_\_ Calories

Example, if the water gained 1,500 calories of heat:

$$1,500 \text{ calories} \times 1 \text{ Calorie}/1,000 \text{ calories} = 1.5 \text{ Calories}$$

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## For Step 12 on Student Activity Sheet (calculating Calories per gram)

If students weighed the mass of the food sample (Column 3), they can figure out how many Calories there are for each gram of food. To do so, divide the Calories found in Question 11 by the mass.

Formula: **Food Calories gained by water/mass of food sample = Calories/gram**  
(answer from Question 11) Calories / \_\_\_ grams = Calories/g

Example, if the weight of the food sample was 0.2 grams:

$$0.15 \text{ Calories}/0.2 \text{ g} = 0.75 \text{ Calories/g}$$

# Typical Experimental Data and Results

The following data and discussion is illustrative of what might be expected if conducting this procedure using a walnut as the food sample. Results will differ if other food types are used, but the analysis will follow the same process.

1. According to the USDA, a typical walnut half has a mass of about 2 grams, and contains about 14 Food Calories (i.e. kilocalories).
2. When burning a walnut half using the Open Beaker Calorimeter method, students typically observe a change in temperature of around 50 oC. Performing the heat calculations:

$$\text{heat} = (\text{mass of water})(\text{specific heat capacity of water})(\text{change in Temp of water})$$

$$q = m C \Delta T$$

$$q = (100 \text{ g of water})(1 \text{ cal/ gram/ } ^\circ\text{C})(50 \text{ } ^\circ\text{C})$$

$$q = 5000 \text{ calories} = 5 \text{ kilocalories} = 5 \text{ Food Calories}$$

3. The combustion of the walnut is usually not complete, and some residual mass remains in the ash. Students typically find that about 90-95 percent of the original mass of the walnut is consumed in the combustion process (depending on how patient/thorough they are). When calculating the energy content per unit mass using this typical student data for the Open Beaker Calorimeter we see that:

$$\text{heat gained by water/ mass of walnut burned}$$

$$= 5 \text{ Calories} / 1.9 \text{ grams}$$

$$= 2.63 \text{ Calories per gram of walnut}$$

4. Note that the accepted value for walnuts from the USDA is about 7 Calories per gram. So we see that the water in the calorimeter only absorbed about 1/3 of the energy that was released from the food. The rest of the energy released would have been transferred to portions of the surroundings other than the water. This energy would have been absorbed by the glass beaker, the metal support for the walnut, and the air in the classroom, all of which also would have experienced an increase in temperature.
5. If using the Metal Can Calorimeter, students should find that the heat absorbed by the water is somewhat greater, assuming that all other variables are controlled for. This is because less heat is lost to the surroundings using this apparatus. Thus, the experimental results for the Metal Can Calorimeter are usually closer to the accepted values published by the USDA and found on food package labels.
6. The results above would be similar for other food types that are high in oil content. Other examples that can be used for this experiment besides walnuts would include pecans, peanuts, cashews, and macadamias. Walnuts and pecans generally tend to give somewhat better results because they have a textured surface, and thus have more exposure to oxygen from the atmosphere, which encourages combustion.
7. If carbohydrate (sugar or starch) based food samples, such as marshmallows, pretzels, or salad croutons are burned, the energy content per unit mass (in Calories per gram) is typically about HALF the value of lipid (fat or oil) based food samples.

# Building and Using a Simple Calorimeter

## Purpose

To investigate how much energy is stored in foods by burning a food sample (such as a walnut or marshmallow) and calculating how many calories of heat are released.

## Materials

For **Open Beaker Calorimeter** apparatus, you'll need:

- Ring stand or heating stand with ring and wire gauze
- Glass beaker (200-400 mL)

For **Metal Can Calorimeter** apparatus, you'll need:

- Clean empty can (ex: soup can or 12 oz soda can)
- Metal punch or lever style juice can opener
- Metal cutters/shears
- Test tube (25 mm diameter x 200 mm tall)
- Test tube holder

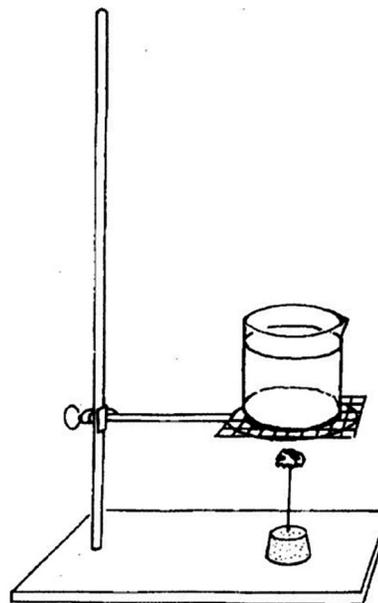
NOTE: The Metal Can Calorimeter is a more complex apparatus, but it produces more accurate results. Depending on the amount of time available, your instructor may arrange to have this apparatus fabricated ahead of time.

For both types of calorimeter apparatus, you'll need:

- Goggles
- Tongs or hot pads
- Celsius thermometer
- Water
- Graduated cylinder (100 mL)
- A piece of clay or cork wrapped in aluminum foil
- A straight pin
- Balance (optional)
- Hand-held butane kitchen/fireplace lighter
- Food sample to burn (foods that work well include walnut, pecan, cashew, peanut, macadamia nut, marshmallow, pretzel, breakfast cereal, salad crouton)

## Procedure

1. Gather the materials listed. Your teacher will tell you which calorimeter apparatus and what food type you are using and if there are any variations in the materials listed.



**Open Beaker Calorimeter**



**Metal Can Calorimeter**

# Building and Using a Simple Calorimeter

2. If a balance is available, determine the initial mass of your food sample. Record your answer in grams in Column 1, Row 1 of the **Data and Results Table**.
3. Carefully place the food sample on the end of the straight pin. Make sure that the cork or clay stand is protected by a layer of aluminum foil to prevent it from catching fire and also to discourage it from absorbing heat that is released.
4. Set up the calorimeter apparatus as pictured in the diagram. Position the height of the beaker or test tube so that when the food sample is placed underneath, there is about a one-inch space between the glass and the top of the food sample.

## 5A. Instructions for Open Beaker Calorimeter

Use a graduated cylinder to measure 100 mL of water from the tap. Pour the water in the glass beaker, and place it on the ring stand as shown. Put the thermometer in the water. Do not allow the thermometer to touch the bottom or the sides of the glass. Measure the initial temperature of the water (in Celsius) and record it in the data table Column 4, Row 1 of the **Data and Results Table**.

## 5B. Instructions for Metal Can Calorimeter

Use a graduated cylinder to measure 60 mL of water from the tap. Pour the water into the glass test tube, that is held in place by the test tube holder in the metal can calorimeter as shown. Put the thermometer in the water. Do not allow the thermometer to touch the bottom or the sides of the glass. Measure the initial temperature of the water (in Celsius) and record it in the data table Column 4, Row 1 of the **Data and Results Table**.

6. Slide the food sample out from beneath the calorimeter, then use the butane lighter to light it on fire. Once the food sample is burning, gently slide it back beneath the calorimeter. If the flame goes out, remove the food sample, re-ignite it with the lighter, and then slide it back into place (this avoids heating the water with the fuel from the butane lighter). Continue this process until the food sample is completely burned leaving only black or gray colored char/ash. This should take about 1-2 minutes. **Caution: Every group**

**member must wear goggles when the food sample is burning. Use tongs or heat pads to handle any part of the calorimeter apparatus. In case of burns, place the affected skin under cold running water. Quickly throw water on flames or smother with a head pad or blanket. Notify your teacher immediately.**

7. Observe the temperature rise during heating and after the food sample has burned completely. Record the highest temperature in Column 5, Row 1 of the **Data and Results Table**. It may help to measure the temperature every 30 seconds until the highest temperature is reached.
8. Calculate the change in temperature of the water by subtracting the initial temperature (Column 4) from the final temperature (Column 5). Note this change in temperature in Column 6, Row 1. Determine the final mass of the food sample (if anything), and record in Column 2. Calculate the mass of the food that was burned by subtracting the initial mass minus the final mass, and write this answer in Column 3 of the **Data and Results Table**.
9. If time allows, repeat the procedure using another food sample of the same type with roughly the same mass and size. Record this data in Row 2. After completing the procedure a second time, average the measurements in each column together (add them together and divide by two). Write the average values in Row 3 of the **Data and Results Table**.
10. Calculate the number of calories of heat gained by the water; this is the heat transferred from the food sample to the water. Your teacher will help you with these calculations. Write your answer in Row 4 of the **Data and Results Table**.
11. Remember that the calories used to measure heat are not exactly the same as the Calories listed on food labels. Food Calories are equal to 1,000 calories (or 1 kilocalorie); (1 calorie = 1/1,000 Calorie). Therefore, you need to divide the calories you found in Step 10 by 1,000. Write your answer in Row 5 of the **Data and Results Table**.

# Building and Using a Simple Calorimeter

**12.** If directed by your teacher, divide the number of Food Calories by the mass of your food sample to determine the energy content per unit mass (in Calories per gram). Write your answer in Row 6 of the **Data and Results Table**.

**13.** If time allows, repeat the procedure for another food item, such as a different type of nut or dried food. While the Calorimeter cools, answer the questions below. Make sure the Calorimeter has cooled before taking it apart.

## Questions

**1.** What evidence is there that food contains energy? Where is the energy contained in the food?

**2.** If you calculated the energy content per unit mass of your food in Calories per gram (Procedure Step #12) then answer question 2a below. If you did not perform this calculate, then skip below to answer question 2b.

**2a.** The table below lists the accepted values for the energy content of some common foods in Calories per gram. Most likely, your experimental results do not agree with the accepted value found in the table for your food sample. What are the reasons for this difference? (Hint: Was all the energy stored in the food sample transferred to the water?)

*Approximate energy content per unit mass for some common food items (source: USDA)*

Food Sample	Energy Content (Calories/gram)
Breakfast Cereal	4
Pecan	7
Peanut	6
Pretzel	4
Marshmallow	3
Salad Crouton	4
Walnut	7

**2b.** Do you think the Calories gained by the water are the same as the Calories that were contained in the food sample? Explain. (Hint: Was all the energy stored in the food sample transferred to the water?)

**3.** How does burning a food sample in the calorimeter compare to how our bodies get energy from food that we eat?

What are the similarities?

What are the differences?

# Data and Results Table

**Date** \_\_\_\_\_

Names	Responsibilities

Type of Calorimeter Used and Volume and Mass of Water: (Circle One)	Open Beaker	Metal Can
	100 ML = 100 grams	60 mL = 60 grams

**Type of Food Burned:** \_\_\_\_\_

	Mass of Food Sample (grams)			Temperature of Water (°C)		
	Column 1	Column 2	Column 3	Column 4	Column 5	Column 6
Row	Before Burning	After Burning	Change in Mass (Col. 1 - Col. 2)	Initial Temperature	Highest Temperature	Change in Temperature (Col. 5 - Col. 4)
<b>1. Trial #1</b>						
<b>2. Trial #2</b>						
<b>3. Average</b>						

Calculations	Answer	
<b>4.</b> Calculate the heat gained by the water in calories (See Step #10 of Procedure) <b>Formula:</b> Mass of water in grams × 1 calorie/gram °C × Change in temp in °C =		calories
<b>5.</b> Food Calories (kilocalories) gained by water (See Step #11 of Procedure) <b>Formula:</b> _____calories × 1 Food Calorie/1,000 calories =		Food Calories
<b>6.</b> Energy content per unit Mass of the food sample (See Step # 12 of Procedure) <b>Formula:</b> _____Food Calories gained by water/Mass of Food Burned in grams =		Food Calories/ gram
<b>7.</b> Calories/gram listed on the nutrition label (optional)		

# Calories Used During Physical Activities

	Female (110 lb)	Male (130 lb)
	Kilocalories used in one hour	
<b>LOW ENERGY ACTIVITIES</b>		
Sleeping	54	60
Resting in bed	58	70
Watching television	66	78
Sitting at a desk	74	90
Eating	78	84
Sitting and talking	78	90
Standing quietly	78	96
Talking on the telephone (sitting)	84	90
Sitting and reading	90	100
Dressing	97	118
Walking slowly	99	120
Cooking	102	120
<b>MODERATE ENERGY ACTIVITIES</b>		
Shopping	135	165
Showering and dressing	156	180
Cleaning	180	204
Bicycling (5.5 miles per hour)	192	216
Golf (9 holes in 2 hours, pulling clubs)	198	228
Walking (2.5 miles per hour)	198	228
Housework (mopping, scrubbing floors, cleaning windows)	220	245
Doing calisthenics	234	270
Weight training	234	270
Tennis (singles, recreational)	234	312
Walking (3.5 miles per hour)	246	282
Volleyball (recreational)	276	312
Power walking (4 miles per hour)	298	360
<b>HIGH ENERGY ACTIVITIES</b>		
Swimming (crawl)	330	378
Lawn mowing (power mower)	336	396
Basketball (half court)	438	498
Soccer	468	534
Roller skating (leisure)	486	558
Bicycling (13 miles per hour)	516	588
Jogging (10 minutes per 1 mile)	528	594
Jogging (8 minutes per 1 mile)	588	672
Basketball (full court)	588	672
Cross country skiing (quickly)	596	720
Snow shoveling (heavy)	955	1,005
Sprinting	1,920	2,178

Data derived from tables in Edwards, Sally. The Equilibrium Plan. Arbor House, New York, 1987.