Chapter 10: Energy Balance

Energy Equilibrium

Did you know that the food we eat provides us with energy?

We use energy 24 hours a day, seven days a week. Each person needs a different amount of energy, and that amount changes throughout our lives. The idea is to consume just enough energy for our bodies to function; not too much or too little. We need to find a balance between energy burned and energy consumed because excess energy is stored in our bodies as fat.

The energy we consume is measured in ***kilocalories*** (kcal). A kilocalorie is defined as the amount of energy required to raise the temperature of a liter of water one degree Celsius. You may have heard of calories instead of kilocalories. The term ***calorie*** refers to a unit of food energy. This energy is expressed in 1000-calorie metric units, known as a kilocalorie; one kilocalorie equals 1000 calories. On food labels, kilocalories (kcal) are called calories, but in actuality the number reported represents kilocalories. For example, a food label may state one serving contains 110 calories, which means the food really contains 110,000 calories. However, food labels in the United States use Calories (capitalized), which is the same as kilocalories. Internationally, the energy measurement of ***kilojoules*** is used. It is another way to measure the same item. One kilojoule is approximately equal to 0.25 kilocalories.

To find out exactly how many calories are in food, scientists can use a ***bomb calorimeter***. A bomb calorimeter measures the heat released when food is burned, which provides an estimate of potential energy in the food. The amount of energy an object possibly has is known as **potential energy**. The bomb calorimeter is used because it mimics the method our body uses to break down food. When the food is heated in the calorimeter, the carbon and hydrogen bonds break, releasing energy in the form of heat. These reactions result in the formation of carbon dioxide and water. The calorimeter measures the rise in temperature with a thermometer. A

calorie is equal to each degree the temperature rises for 1 gram of water. For example, if the temperature of 100g of water changes from 17 degrees Celsius and to 44 degrees Celsius while the food is being burned, the food is around 2700 calories or 2.7 kcalories. You will learn more about these units of energy in the *Food Explorations Lab* of this chapter.

Another method used to determine the calorie content of a food is to calculate kilocalories based on ***macronutrient*** content. There are three macronutrients; carbohydrates, protein, and fat. Carbohydrates and proteins contain 4 kcal per gram, while fat contains 9 kcal per gram. For example if a food contains 15 grams of carbohydrates, 2 grams of protein, and 11 grams of fat it will have (4x15)+ (4x2) + (9x11) = 167 kcal. To find the kcal in food you need multiply the gram weight (number of gram) by the kcal per gram. For example, the kcal from carbohydrate in the food above can be found by multiplying 15 grams by 4 kcal per gram (15 x 4 = 60).

Understanding the nutrient content of foods is very important for our health. While a food may be low in calories, those calories may be loaded with fat or sugar. These foods have very few nutrients in the form of protein, vitamins, and minerals. We need these nutrients for a healthy body. There are many different sources in which we can find information about what we should be eating, but choosing the right one may be tricky. Try looking for sources from the United States Department of Agriculture (USDA). Practicing healthy eating habits is very important for our health. Let's find out how different foods may affect our bodies based on their composition!

Think About It

1. The energy needed to raise 1 liter of water 1 degree Celsius is a kilocalorie.

2. How many kilocalories would it take to raise 10 liters of water 1 degree Celsius? 10

3. How many kilocalories would it take to raise 5 liters of water 2 degrees Celsius? 10

4. What is the difference between a kilocalorie and a calorie?

A calorie is a smaller unit of a kilocalorie (1 kilocalorie = 1,000 calories)

Food Explorations Lab:
Energy Balance

STUDENT LAB INVESTIGATIONS

Name: _____

Lab Overview

In this investigation, you will work in groups and with your teacher to determine the potential energy of a peanut through the use of a bomb calorimeter.

Lab Objectives:

In this lab, you will learn how to…

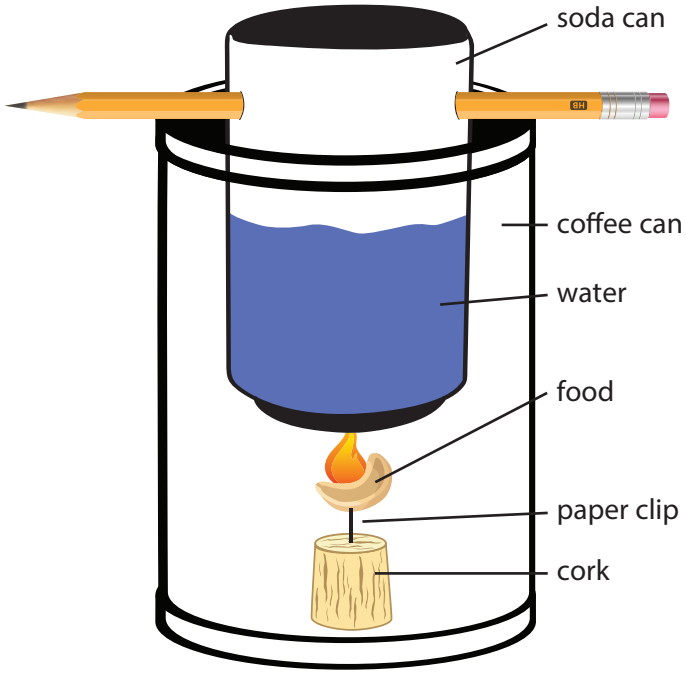
1. Calculate the energy content in peanuts using measurements involving the bomb calorimeter.
2. Compare experimental results to accepted values (Nutrition Fact Label) and identify possible sources of error.
3. Suggest possible design improvements to the bomb calorimeter to reduce error.
4. Explain the importance of maintaining a diet that provides proper calorie content.

Lab Safety: Before beginning ANY investigation you should put on your safety goggles and apron. It is important to avoid getting chemicals on your hands. Always wash your hands following completion of an investigation. When handling food, you should also wash your hands prior to beginning an investigation.

Observations of Burning Energy

MATERIALS

small bowl to weigh peanuts
graduated cylinder or liquid measuring cup (any size)
triple beam balance
distilled water (room temperature)
peanuts



PROCEDURE

In this investigation, you will work in groups and with your teacher to determine the energy density of a peanut through the use of a bomb calorimeter.

1. Within your group, measure 100mL of distilled water.
2. Place your thermometer in the water, wait 30 seconds and record its temperature. Record your findings in Table A.
3. Predict how many peanuts consist of approximately 200 kilocalories. Obtain the amount that represents your prediction, weigh the peanuts, and record the amount of grams in Table B.
4. Your teacher will demonstrate or show a video of the remaining procedural steps within this investigation. Your teacher will weigh and record the weight of a single peanut prior to placing it in the bomb calorimeter. You should also record the weight of the single peanut in Table C.

A bomb calorimeter can be made using everyday items such as a coffee can, soda can, pencil, paperclip and cork.

5. Your teacher will place 100mL of room temperature distilled water in a soda can and then measure the temperature of the water.

6. Your teacher will place the soda can inside of the coffee can.

7. Your teaching will uncoil the paper clip and insert it in the cork.

8. Your teacher will wrap the paper clip attached to the cork around the peanut.

9. Your teacher will ignite the peanut. Once on fire, he or she will immediately place the coffee can around the burning food or insert the burning food into the coffee can through a hole near the bottom.

10. Your teacher will make sure the food burns completely. If the fire goes out, he or she will re-light the food.

11. Once the food has completely burned, your teacher will stir the water with the thermometer and re-measure the temperature. Record the temperature in Table A.

12. After the burned food has cooled, your teacher will measure and record its mass. You should also record the mass in Table C.

Table A: Bomb Calorimeter Water Temperature

	Water Temperature BEFORE Burning (°C)	Water Temperature AFTER Burning (°C)
Peanut	21°C	23°C

Table B: Bomb Calorimeter Mass Prediction

	Mass - PREDICTION (Grams)
Peanut	50g

TABLE C: Bomb Calorimeter Mass Measurements

	Mass BEFORE Burning (Grams)	Mass AFTER Burning (Grams)
Peanut	1g	0g

Conclusion:

1. Calculate the calories released by the peanut in the bomb calorimeter using the following equation:

$$mc\Delta T = Q$$

Q = Amount of Heat Transferred (calories)

m = Mass of Water

C = Specific Heat of Water – 1 cal/g/°C

ΔT = Change in Temperature (°C)

(23 °C after burning) – (21 °C before burning) = 2 °C (ΔT)

100 gram(s) water (**m**) × 1 calorie/g/°C (**c**) × 2 °C (ΔT) = 200 calories(**Q**)

2. Calculate the kilocalories released by the peanut. 1000 calories = 1 kilocalorie

$$\frac{200 \text{ calories}}{1 \text{ gram peanut}} \times \frac{1 \text{ kilocalorie}}{1000 \text{ calories}} = 0.2 \text{ kcal/gram of peanut}$$

3. Using the Nutrition Facts label on the peanut container, find the potential energy (calories per gram – before burning) of the peanut.

160 kilocalories ÷ 28 grams = 5.71 kilocalorie/gram

4. How does the value obtained in question 3 compare to the value in question 2? Describe possible sources of error that would explain any differences.

   The value in question 2 is much smaller. The bomb calorimeter was not closed, so some of the heat could have escaped, decreasing the rise in water temperature.

5. How would you improve the design of the coffee can bomb calorimeter to produce more accurate measurements of caloric energy?

   Because heat loss is a problem, you could heat or cool the water to keep the temperature constant. Then, measure the energy that is required to keep the temperature constant.

6. Using the mass obtained from your prediction (Table B) and your results from question 3, determine how many *actual* total calories (potential energy) are in the peanuts you measured out? By what percentage did you over or underestimate the portion? What surprised you about your estimate of the kilocalorie content of 200 grams peanuts?

   50 grams (predicted peanuts) × 5.71 kcal (kcal/gram peanuts) = 286 kcal predicted peanuts

   286 kcal predicted peanuts ÷ 200 kilocalories = 1.43 x 100 =

   143 % accurate

7. Which method do you think is more accurate when estimating the potential energy (kilocalorie content) of food: (1) looking at the amount of the food and estimating based on your own knowledge or (2) multiplying the amount of food to be eaten by the kilocalories listed on the Nutrition Facts label? Why?

   The most accurate measure of potential energy would be to multiply the amount of food to be eaten by the kilocalories listed on the Nutrition Facts. It would be more appropriate to multiply those numbers by the amount eaten than to determine on my own.

8. Based on the reading, why do we need to eat food?

   We need to eat food because it supplies our bodies with the energy needed to function. We need to balance our energy burned with energy consumed.

9. Based on the reading, what will happen if you take in too much potential energy from food? Too little? Describe the negative implications for humans in both situations.

   Too much potential energy from food will lead to body fat storage (overweight and obesity). There are many health problems related to excess fat including heart disease, stroke, and diabetes. Too little potential energy from food will lead to excess burning of stored energy. This can lead to malnourishment and weakness.

Investigating Your Health:

Managing Your Meals

Name: _____

Objective: Investigate meal management by completing a 24-hour recall, comparing your results to the guidelines, and by making suggestions for improvement. Identify the benefits of eating healthy and the consequences of an unhealthy diet.

Meal management means planning what you eat ahead of time. You should do this so that you are able to eat a well-balanced diet. The food groups include fruits, vegetables, grains, protein, and dairy. Each day you should eat 1 ½ cups of fruit, 2 ½ cups of vegetables, 6 ounces of grains (make ½ 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 your body with the nutrients it needs. By overeating or eating too many empty calorie foods, you are putting yourself at risk for becoming overweight, developing dental cavities, and experiencing heart problems, diabetes, high blood pressure, and other diseases.

Empty calories are foods that provide calories, but have little to no other nutritional value. Candy and soda are examples of empty calorie foods. Although meal management is important, you should allow for some flexibility in your planning. A certain food you had planned on eating may not be available, or your friends and family might influence you to eat something else.

A ***24-hour recall*** is when a person is asked to recall all of the food and drinks he/she had within the past 24 hours. This is only one of the many ways you can evaluate your diet.

1. The first step is recording a quick list of everything you had to eat or drink in the past 24 hours.

2. Next, add more detail onto your quick list. This step includes recording times you ate or drank something, brand names, foods eaten in combination, and the quantity. Some examples of foods eaten in combination include milk in cereal and ingredients in a sandwich or salad.

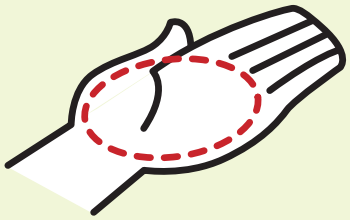
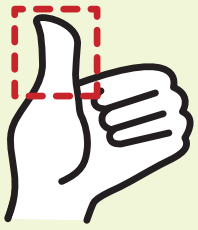
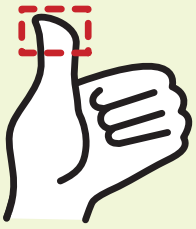
3. The third and final step is to review your list and add anything you may have missed, or any more details you remember.

Evaluating your diet will help you identify if you are following the recommendations for each food group and if you have any improvements to make. Use the *Try This at Home* recipe to help you plan a day's worth of balanced meals!

Food Group	Amount	Examples
Protein Foods	5 ounces daily	1 oz = 1 egg, 1 tbsp peanut butter, ¼ cup cooked beans, 1 oz meat or 1 slice lunchmeat
Grains	6 ounces daily	1 oz = 1 slice bread, ½ cup pasta or oatmeal, or 1 cup dry cereal
Vegetables	2 ½ cups daily	½ cup = ½ cup raw or cooked vegetables or 1 cup leafy green vegetables
Fruits	1 ½ cups daily	½ cup = ½ cup canned fruit or 1 small orange or peach
Dairy	3 cups daily (2 cups under age 8)	1 cup = 1 cup of milk or yogurt, 2 slices cheddar cheese or 3 slices American cheese

Recalling Nutrition

1. Using the table below as a guide, complete a 24-hour recall for yourself. Choose a day that best represents your normal eating habits.

Hand Symbol	Equivalent	Foods	Calories
	**Fist** 1 cup	Rice, pasta Fruit Veggies	200 75 40
	**Palm** 3 ounces	Meat Fish Poultry	160 160 160
	**Handful** 1 ounce	Nuts Raisins	170 85
	**2 Handfuls** 1 ounce	Chips Popcorn Pretzels	150 120 100
	**Thumb** 1 ounce	Peanut butter Hard cheese	170 100
	**Thumb tip** 1 teaspoon	Cooking oil Mayonnaise, butter Sugar	40 35 15

My 24-Hour Recall

Date: _____ Day of the Week: _____

Time	Quantity	Food or Drink	Who you ate with
7:15 AM	1 cup	Honey Nut Cheerios	No one else
	1 cup	2% Milk	No one else
10:00 AM	1 small	Apple	Friends
11:30 AM	2 slices	Whole wheat bread	Friends
	2 ounces	Deli Ham	Friends
	1 Tbsp.	Mayonnaise	Friends
	$\frac{1}{8}$	Tomato	Friends
	1 small bag	Lays Classic Potato Chips	Friends
	1 cup	Peach Yogurt	Friends
	1 cup	Water	Friends
1:00 PM	1 cup	Gatorade	No one else
3:00 PM	1 large	Banana	No one else
5:30 PM	1 cup	Spaghetti	Family
	$\frac{1}{2}$ cup	Pasta sauce	Family
	3 ounces	Skinless chicken breast	Family
	2 cups	Cooked broccoli	Family
	1 slice	Garlic bread w/ butter	Family
6:30 PM	1 $\frac{1}{2}$ cups	Mint chocolate chip ice cream	Family

2. Record how much you ate from each food group.

Fruits	Vegetables	Grains	Protein	Dairy
2 cups	2 ½ cups	6 oz.	5 oz.	3 cups

3. How does your intake (from question 2) compare to how much you should be eating?

Fruits	Vegetables	Grains	Protein	Dairy
1 ½ cups I ate ½ cup too much	2 ½ cups I ate the correct amount	6 ounces I ate the correct amount	5 ounces I ate the correct amount	3 cups I ate the correct amount

4. Identify two ways you can eat more healthfully.

Multiple responses possible.

Example: I should try not to eat potato chips because they are empty calories. I could drink water instead of Gatorade. I should try to eat about ½ cup less fruit per day. I could have yogurt instead of ice cream for dessert at dinner

5. How do your personal values/beliefs influence your food choices?

Multiple responses possible. I think being healthy is very important, so I try to eat the correct amount of each food group; and I try not to eat too many sweets.

6. How do your friends influence your food choices?

Multiple responses possible. Sometimes my friends influence me to eat candy and drink soda.

7. Name 3 benefits of healthy eating.

Multiple responses possible. Healthy weight; reduced risk of chronic disease; higher energy level; improved mental capacity

8. Identify 3 consequences of not eating healthfully.

Multiple responses possible. Weight gain; dental cavities (from too much sugar); develop heart problems; high blood pressure; other chronic diseases (diabetes, stroke, etc.)

TRY THIS AT HOME:
Magnificent Menu

Can you plan a lunch or dinner menu using FoodMASTER recipes?

Try planning breakfast, lunch, and dinner for using the recipes you've learned from FoodMASTER. Make sure to include a variety from each food group in your meals. Try to make sure your menu has a variety of shapes, colors, textures, and tastes. Be sure to choose foods that will taste good together and that your guests will enjoy. Have an adult help you make your meals. Enjoy planning and preparing your menu!

MEAT, BEANS & EGGS

Turkey Quesadillas (Chapter 6)
Fluffy Vegetable Omelet (Chapter 7)
Grilled Chicken
Turkey Breast

GRAINS

Whole Grain Trail Mix (Chapter 7)
Whole Wheat Toast
Whole Wheat Roll

VEGETABLES

Pita Pocket Vegetable Bouquet (Chapter 3)
Mixed Baby Greens with Mustard Vinaigrette (Chapter 9)
Steamed Vegetables

FRUITS

Fruit Salad (Chapter 4)
Fruit Juice (Chapter 8)
Fresh Fruit

MILK & CHEESE

Fresh Yogurt (Chapter 5)
Simple Cheese Sauce (Chapter 5)
Milk