Topic 4: Energetics – 4b. Calorimetry

Resources: Campbell, N. et al. *Biology: Exploring Life*. Prentice Hall, pp. 135-142.

Campbell, N. et al. *Biology: Concepts and Connections*, Pearson, pp. 88-92.

Miller and Levine. *Biology.* Prentice Hall, pp. 221-232.

Building on: Cells need energy to live. Basic biochemistry including chemical reactions, bonding, enzymes and activation energy should have already been discussed. Also, cell parts and functions should have been taught so that you can refer back to the mitochondria as the "powerhouse of the cell." Students will also be familiar with dietary calorie usage from health class and grade school.

Links to Chemistry: Heat energy/calorimetry
Chemical bonds
Chemical reactions
Organic chemistry

Links to Physics: Kinetic and potential energy

Stories: Although people are "counting calories" more and more, it seems, students are very uninformed about the number of calories in food. Also, there is a discrepancy between the lab data that they obtain and the "real world" labeling of foods. The calorie data in the lab follows the textbook definition of a calorie: it is "the amount of energy required to raise one gram of water 1 ^{o}C." Using this definition, a Cheeto may be found to have approximately 500 calories or more. This is very surprising to the students (as it should be) because the calories labeled on food say that a serving of Cheetos has about 150 Calories. The difference lies in the subtle change in capitalizing the "c" in "Calorie." The "capital C" Calorie is actually a kilocalorie! American food makers are not interested in explaining this change to their consumers, or else a 2,000 Calorie per day diet would actually be a 2,000,000 calorie per day diet! Using this altered definition, an individual Cheeto has only 0.5 Calories if it was measured to be 500 calories with our calorimeter. If you can obtain a food item from Europe with dietary information on the package, you may find that a serving of food is labeled as 150 kilocalories.

Lab Instructions and Materials for the Teacher:

Calorimeters can be easily made with an aluminum can and a ring stand. I poke a small hole through the top of the can with a straight dissecting probe and then suspend it from the ring stand using a large, straightened paperclip. The burning stand can be made by pushing a dissecting pin into a cork stopper and then covering it with aluminum foil; I push the pin in backward by using a paperback book. You can burn almost any food item, but greasy is

better than dry—so use oily peanuts, not dry-roasted. I have also substituted Slim Jim beef sticks for the peanuts (ask your students ahead of time if they have a peanut allergy) and marshmallows work well for burning. Try to place the burning material close to the bottom of the aluminum can (within 1 cm), but not so close that the air cannot reach it. Have the students relight the food until it is burned as thoroughly as possible. Aim N Flame lighters work well, but they are expensive (and the students will waste the fuel). The instrumentation is crude for this lab, but careful lab procedures will yield decent results.

The Calorie Lab – Food Energy

Purpose:
In order to live, organisms require some form of energy. The food you eat is one source of this energy. The amount of energy available in food is measured in calories. In this experiment, you will approximate the number of calories stored in various foods.

Please Remember: Your skills will be challenged in areas of:

a. Organization
b. Careful lab procedures
c. Data taking
d. Data analysis
e. Problem solving

Materials:

- 1 calorimeter
- 3 peanut halves
- 3 Cheetos
- 12 drops of oil (4 drops x 3 trials)
- 1 thermometer

Method:

- Figures 1 and 2 represent the apparatus needed to burn the foods that are to be tested.
- Each food will be tested three times and an average number of calories given off will be calculated.
- The peanut and cheeto will be burned on a pin as diagrammed below in Figure 1.
- The oil will be burned in the aluminum foil tray using a pipe cleaner for a wick as in Figure 2.
- Figure 3 details the equipment setup and procedure.

Figure 1

←Peanut

←Pin

←Cork stand

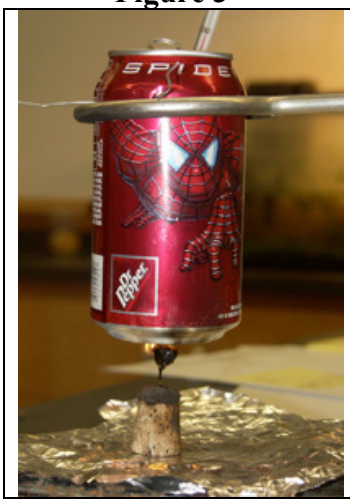
Figure 2

←Dropper for oil

←Pipe cleaner wick

←Aluminum foil tray (Drop oil onto wick.)

Figure 3



←Thermometer
Do not leave the thermometer in the can; it can tip.
(Read the temperature in the water—not touching the metal.)

←Can calorimeter
Add 25 ml of fresh cold water to the calorimeter for EACH trial. (Empty the heated water and add a new water sample.)

←Burning food
Lower or raise the calorimeter so the distance is fairly close, but not touching the food sample. (About 1.5 cm)

Sample	Mass of Sample (Grams)	Initial Temp. (Deg C)	Final Temp. (Deg C)	Temp. Difference (Deg C)	Calories	Calories Per Gram	Average Calories Per Gram
1/2 Peanut							
1 Medium Cheeto							
4 Drops Oil							

Discussion:

1. Compare your results to the listed results as given by your teacher.

Sample	Your Results	Actual Results	Teacher Initials
Peanut	_____	_____	_____
Cheeto	_____	_____	_____
Oil	_____	_____	_____

2. Discuss the possible sources of error in the data. How could they be remedied? (Where did inaccurate measurements or procedures lead to data that may not be perfect?)

3. Which column gives the most accurate comparison between the three foods? Why????

4. The samples you used are representatives of the three main food groups.
   a. Write the food sample next to its appropriate group.
   b. Place a number 1, 2 or 3 next to each item below ranking the energy content. (1 = highest)

   Carbohydrate _____ ___

   Protein _____ ___

   Fat (lipid) _____ ___

5. What is it about the highest energy food that makes it have more energy?

6. What type of food is your body designed to run on:

   For energy? _____

   For growth? _____

   For energy storage? _____

7. What vital gas is needed before your body can release the energy in foods?

8. What two gasses are released as the food in your body is burned?

9. Give the formula for **calculating** the amount of calories given off when 25 ml of water is used.

10. Give the **definition** for a calorie. (It is not the same as #9, but you knew that.)

11. Name the special class of chemicals in your body that cause the food to burn at a low temperature so that the cells will not be damaged.