Burning Calories—Literally!

Name: _____

Date: _____

Group members: _____

Student worksheet

Directions: Finish the assignments below in preparation for the experiment.

1. Your teacher will show you 100 grams of the different food items you will study later in this lesson. Make a prediction and add arguments for your predictions.

   Which food item do you think contains the most energy (or Calories) for the 100 grams of food?

   Food item:

   Reasoning:

   Which food item do you think contains the least energy (or Calories) for the 100 grams of food?

   Food item:

   Reasoning:

2. Design a calorimeter.
   a. Brainstorm ideas on:
      - how you can release the food energy in your calorimeter
      - how your calorimeter will capture the released energy
      - what you can measure
      - how this measurement can give you a measure of the food energy
   b. Narrow the ideas down to something that is possible with the materials you are given.

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Directions: Finish the assignments below in preparation for the experiment.

Make a sketch of what the calorimeter will look like.	**Label the following items in your sketch:** ☐ Food item ☐ Water reservoir to capture released energy ☐ Materials used
Explain how this calorimeter will work.	**Checklist** Did I include: ☐ How food energy is released ☐ What happens to the released energy ☐ What is measured

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Directions: Finish the assignments below in preparation for the experiment.

3.

Sketch the calorimeter the class will build.	**Label the following items in your sketch:** ☐ Food item ☐ Water reservoir to capture released energy ☐ Materials used **Checklist:** ☐ Food items are accessible. ☐ Food will burn up completely. (Note: Fire needs air in addition to fuel.) ☐ The water in the reservoir captures most of the released energy. ☐ You can measure the temperature change of the water in the reservoir.
Provide a short answer: How is food energy released in this calorimeter? What will you measure to quantify the released food energy?	

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Directions: Finish the assignments below in preparation for the experiment.

4. State the independent dependent, and control variables of your calorimeter.

   Independent variables:

   Dependent variables:

   Control variables:

5. The calorimeter functions because energy changes from one form to another.

   Add labels to the calorimeter you drew in question 3 that show:

   - where chemical energy is stored
   - where thermal energy is stored

   Add an arrow showing how energy is transferred (as heat) from the chemical energy to the thermal energy reservoir. Label this arrow “heat.”

6. Briefly explain the processes that allow a calorimeter to measure the energy stored in food. Use the words *chemical energy*, *thermal energy*, and *heat* in your explanation.

	Checklist Did I include: ☐ How chemical energy is released ☐ What happens to the released energy ☐ What is measured

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Name: _____

Directions: Follow the steps below to conduct the experiment and record the data.

SAFETY INFORMATION

Remember to obey these safety rules at all times while performing the experiment:

- Work on a non-flammable surface.
- Long hair needs to be tied back.
- All students must wear safety glasses.
- Always use oven mitts to handle items that may be hot.

Data Table 1: Measurements

Food Item	Food: M_i (g)	Food: M_f (g)	Water: T_i (°C)	Water: T_f (°C)	Food: $M_i - M_f$ (g)	Water: $T_f - T_i$ (°C)

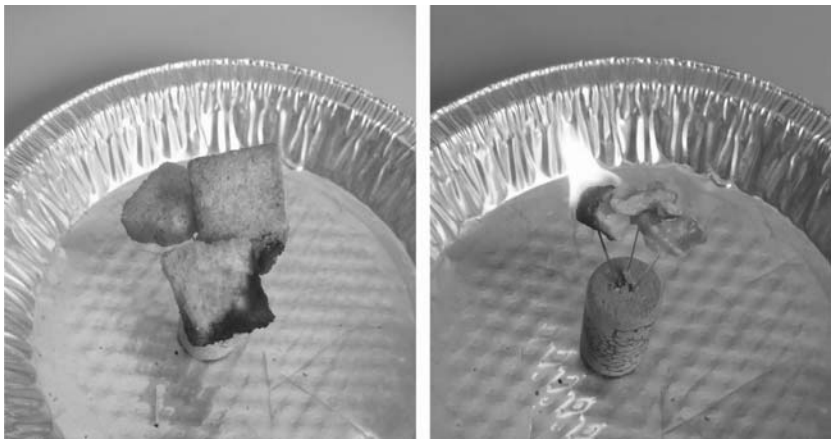
7. Note the amount of water contained in the reservoir: _____ milliliter (mL).
   Note: the mass of 1 mL of water is 1 gram.

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Name: _____

Directions: Follow the steps below to conduct the experiment and record the data.

8. Perform a trial:
    a. Select a few pieces of the same food item; using a few pieces (not just one) allows you to burn a larger mass.
    b. Weigh the food pieces to be burned and record the initial total mass in the "Food: *Mi*" column.
    c. Put the pieces of food in place. Make sure all the pieces touch. This will allow the flame to go from one piece to the next.
    d. Place your thermometer in the small can, so it can adjust its temperature to the water inside.
    e. Light the food with the long matches, Bunsen burner, or lighter.
    f. *Instantly* stir the water in the small can and read the initial temperature (*Ti*). Record this temperature in the "Water: *Ti*" column. Remove the thermometer from the can as the metal might get hot.
    g. Allow the food to burn itself out. If smoke is coming out, the burning is still in progress. Hints: If the food stops burning too early, experiment with putting it in with a real flame instead of smoldering, as shown in the figure. Increasing the air flow can help keep the fire going, too.



    h. As soon as the food stops burning, carefully stir the water and measure the final temperature (*Tf*). Make sure the thermometer has reached a steady level before reading the temperature. Record the value.
    i. Weigh the remains of any food that was not completely burned (not including ashes). Record the mass in the "Food: *Mf*" column. If all the food burned up, record a final mass "Food: *Mf*" of 0 g.
    j. This completes one trial for this food item.

Name: _____

Directions: Follow the steps below to conduct the experiment and record the data.

9. Calculate the change in mass (*Mi* - *Mf*) and change in temperature (*Tf* -*Ti*). Write these values down in Data Table 1.
10. Repeat steps 8 and 9 for each food item. The extra rows in Data Table 1 can be used for extra trials. Do not erase data if you mess up a trial; just take a new row and try again.
11. Clean up the workspace.
12. Use the measured values and the formulas given to calculate the energy used to heat up the water (Q_{water}), the energy released by the food (Q_{Food}), and the energy contained in 1 gram of food ($Q_{Food,\,1g}$). Write the results in data table 2.

Formulas	*Variables*
$Q_{water} = m_{water}\, c\, (T_f - T_i)$	Q_{water} : heat captured by the water when heated (Cal) m_{water} : mass of the water that is heated (g) c : specific *heat capacity* of water (0.001 Cal/(g°C)) T_i : initial temperature of the water (°C) T_f : final temperature of the water (°C) Q_{Food} : energy released when burning the food (Cal) $Q_{Food,1g}$: energy released when burning 1 gram of food (Cal/g) M_i : initial mass of food burned (g) M_f : final mass of food burned (g)
$Q_{water} = Q_{Food}$	
$Q_{Food,1g} = \dfrac{Q_{Food}}{(M_i - M_f)}$	

Data Table 2: Calculations

Food Item	Q_{water} (Cal)	Q_{Food} (Cal)	$Q_{Food,1g}$ (Cal/g)

Name: _____

Directions: Follow the instructions below about your experiment.

13. Collect data from other groups and calculate the average.

Data Table 3: Results $Q_{Food,1g}$							
Food Item	**Group 1 (Cal/g)**	**Group 2 (Cal/g)**	**Group 3 (Cal/g)**	**Group 4 (Cal/g)**	**Group 5 (Cal/g)**	**Group 6 (Cal/g)**	**Average (Cal/g)**

14. Graph the average measured $Q_{Food,1g}$.

Checklist

Did I include:

- ☐ The horizontal axis displays the independent variable
- ☐ The vertical axis displays the dependent variable
- ☐ The graph has a title
- ☐ Axes are labeled
- ☐ All food items are included

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Directions: Follow the instructions below about your experiment.

15. Use the food label provided by the teacher for the following assignment.

    List the Calorie content per serving ($Q_{Food,1\ serving}$) and calculate the Calorie content per gram ($Q_{Food,1g}$) for the food item.

$$Q_{Food,1\ serving} = \frac{Q_{Food,1\ serving}}{\text{Mass of 1 serving in g}}$$

$Q_{Food,1\ serving}$ = _____ $Q_{Food,1g}$ = _____

16. Collect data from other groups to complete Table 4.

Data Table 4: Values calculated or copied from food labels		
Food Item	**$Q_{Food,1\ serving}$ (Cal/serving)**	**$Q_{Food,1g}$ (Cal/g)**

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Name: _____

Directions: Follow the instructions below about your experiment.

17. Create a new graph containing the average experimentally determined $Q_{Food,1g}$ as well as the $Q_{Food,1g}$ obtained from information listed on the food labels and listed in Table 4.

	Checklist
	☐ The horizontal axis displays the independent variable ☐ The vertical axis displays the dependent variable ☐ The graph has a title ☐ Axes are labeled ☐ All food items are included ☐ Legend included

18. **Claim:** Our homemade calorimeter has a low efficiency, which means its measured values are lower than the actual Calorie content.

    Is the graph made in question 17 evidence for this claim? Why or why not?

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Directions: Follow the instructions below about your experiment.

19. Based on your experiment, draw a new sketch of how energy flows through the calorimeter that includes energy loss.

	Label the following items in your sketch: ☐ Food energy or chemical energy ☐ Thermal energy ☐ Heat ☐ Energy loss ☐ Arrows to indicate energy flows