Burning Question: Which Foods Should We Take To Mars?

Background

How do we determine how much energy a food will provide? We burn it. More than 100 years ago, Wilbur O. Atwater, a nutritional chemist, invented a device that could be used for measuring the relationship between energy input (food) and heat output of a person doing exercise. His work inspired the development of the basal metabolism rate (BMR) measurements students explored in the first activity. Incidentally, Atwater concluded that Americans consumed too much fat and too many sweets.
(Where have we heard that before?)

The determination of the energy content in food is determined by a device called a calorimeter. It measures the amount of heat given off by foods when they are burned. The food is placed inside the calorimeter and ignited. Heat is produced in units called calories.

Professional laboratory "bomb" calorimeter.
Source: http://en.wikipedia.org/wiki/Calorimeter

Calorie - the amount of heat needed to raise 1 milliliter of water 1 degree Celsius. (In the metric system, a calorie is equal to 4.2 joules.)

When you read the nutritional label on a package of food, you will find a listing for the number of calories the food provides per serving. The labeling is in part based on Atwater's work. However, not mentioned on the food label is the fact that the units are kilocalories (1,000 calories), but labeled as "Calories." Presumably, this is done to make things look less scary. A 1/2 cup serving of ice cream might provide 160 calories. That's actually 160 kilocalories or 160,000 calories! (You don't want to know what's in the whole pint.)

Back to Mars. Mission planners will determine the kilocalorie needs of the crew (about 3,000 for males per day and 2,400 for females per day). Then, they calculate the mission needs. The equation will be something like this.

M = number of males
F = number of females
D = days in flight

[(M x 3,000) + (F x 2,400)] x D = number kilocalories

Figuring things out gets harder. Every food type provides different amounts of energy and has different mass and takes up different amounts of space. Then, the dietary nutrients need to be considered. Food provides more than just energy - fats, sugars, proteins, minerals, etc. (You can't take only chocolate bars even if they have nuts!) The last part gets really tough. Food choices have to be those that each astronaut will actually like and eat!

In this extension, students construct a simple calorimeter and use it to determine the energy content (calories) of several small bits of food.

Safety Note - Flames:
This activity involves flames and should only be conducted in a well-ventilated area, preferably a science laboratory. Be sure to follow basic fire safety precautions and discuss these with the students beforehand.

- All students should wear safety goggles and avoid breathing any smoke produced. (The calorimeter design confines the flame in a small chamber.)
- When teams have completed their setup for a run, ignite the food item for them.

Investigation: Burning Question - Which Foods Should We Take to Mars?

Materials: per student team

- Two pot pie tins
- Copper or aluminum wire (non- coated) approximately 45 cm long
- Two small metal binder clips
- Soft drink can (top removed by using a can opener – teacher prepared)
- Beam balance (teams can take turns using it)
- Thermometer - Celsius scale
- Graduated cylinder Water 50 ml per test
- Ruler
- Scissors
- Safety goggles

- Teacher - Butane lighter (long nozzle)

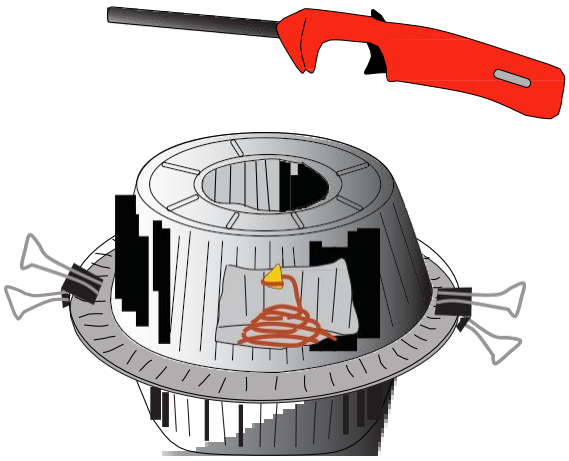
Food items: three food items from the categories below per student team

- Categories
- Peanuts - dry roasted, cocktail, and raw
- Other Nuts - pecan and walnut
- Dried Beans - navy, pinto, lima
- Misc. Foods - Cheerios®
- Stale miniature marshmallows

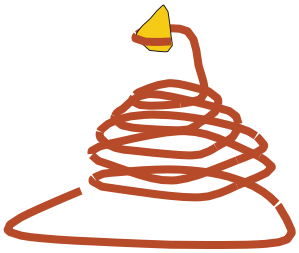
Allergy Alert:
The food item categories include peanuts and other nuts. If you have students with nut allergies, use the other suggested items such as beans, cereal, etc.

Procedures:

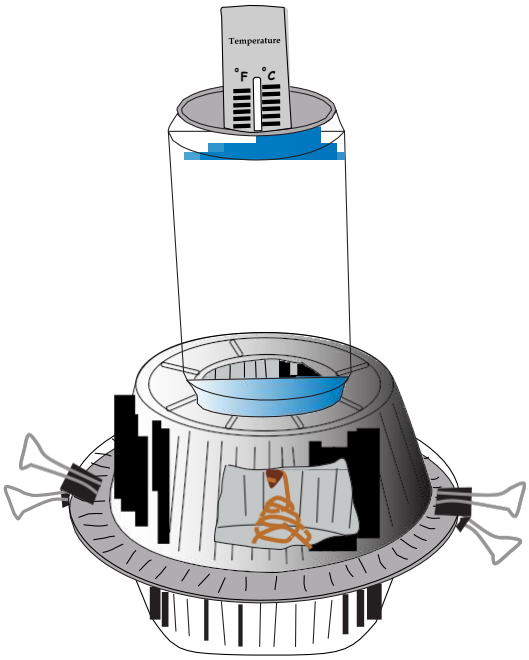
1. Divide students into teams of three.
2. Before beginning the activity, discuss safety procedures with the student teams. While students will not be lighting the food items, there will be small flames and a small amount of smoke. All students must wear eye protection and avoid breathing the smoke.
3. Have teams cut a hole in the top of one pot pie tin. The hole should be smaller than the soft drink can bottom. Teams will cut a circular or rectangular viewing window from the side of the same pot pie tin. See diagram on Page 12.
4. Have students bend the wire into a stand for holding the food item. See diagram. Wrapping the wire around an object such as a small funnel or large marker will help form the stand.
5. Have students weigh their three food items using the beam balance so that all three are the same. If an item is heavier than the others, teams should break off a small amount of the item. Tip: Use half peanuts rather than whole to reduce the burning time and still give excellent data.
6. Before igniting the food, students should secure the food item to the top of the wire by simply pressing the wire around the item.
7. Be sure to explain to the students the importance of having each item the same distance from the can when burning. This can be accomplished by measuring the height of the coil before each test.
8. The students will place the stand and food item in the middle of the lower pot pie tin. Gently place the cut tin on top. Clamp the top and bottom together with the binder clips. See diagram on page 12.
9. Have students measure 50 ml of water and pour it into the can. Have them measure and record the initial temperature before starting the next part of the experiment. This step is repeated for each item burnt.
10. Students will gently place the cola can with the thermometer inside on top of the pot pie tin, covering the hole.
11. Once the apparatus is ready, ignite the food items for each team. Students should observe the burning. When the flame goes out, they measure and record the water temperature.
12. The water should be replaced and steps 6-11 should be repeated for the next two items. The bottom of the can gets covered in soot, so have students avoid touching the bottom if possible to avoid getting soot on their hands and clothes. Also have students wait 5 minutes because the top part of the wire stand will be hot.



Calorimeter setup. The round hole in the top tin is smaller than the diameter of the soft drink can bottom. The window cut through the top tin allows for lighting the food and for observation. Binder clips hold the calorimeter together.



Bend the wire to form a conical spring. Wrapping around something circular will help form the shape. Foods to be tested are held by bending the wire at the top around them.



Fully assembled and ready.

Assessment:

- Review the data and the answers to the questions on the student pages.
- Have students discuss the importance of sending energy-packed foods on a Mars mission.
- Ask students to define calorie and kilocalorie.
- Have students write about the challenges of providing food for extended space missions and propose ideas for meeting those challenges.

Extensions:

- Show the nutritional labels of several food products and explain how to read the labels. Discuss the relationship between serving size and calories. Discuss the other numbers on the label and what they mean (e.g., fat calories, sodium, sugar, etc.). Information on reading food labels can be found at the following sites:

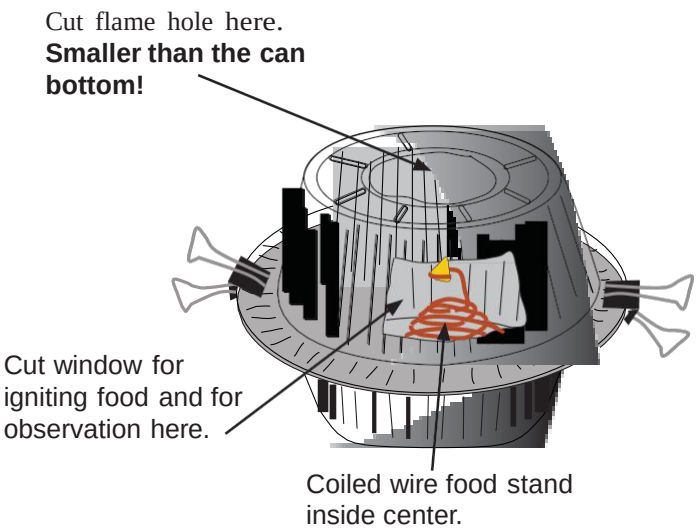
  http://www.fda.gov/Food/LabelingNutrition/ConsumerInformation/ucm078889.htm

- In addition to selecting high-energy foods for space missions, discuss other space food issues. How long will the food keep? (Raisins and nuts keep a long time but bananas start spoiling in a few days and the peel will release odors. However, dried banana slices will keep a long time.) How will the food be packaged? How much storage space will the food packages take and how much waste will be generated? (Demonstrate the volume of a cereal box versus the actual volume of cereal.)
- Have students experience the challenge of selecting food for a space mission by asking them to determine how much food they could fit into a standard-sized shoebox. Ask them to determine the combined nutritional value of the foods and estimate how many people it would feed for how many days.

Burning Question: Which Foods Should We Take To Mars?

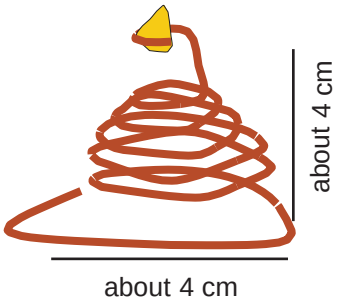
Directions: Constructing your calorimeter. Refer to the diagrams at right on how to construct and set up your calorimeter.

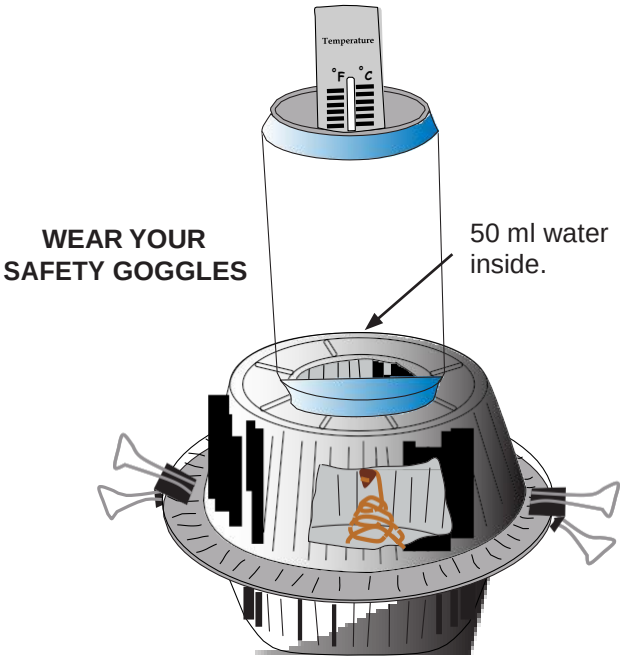
1. Cut a 4-cm diameter hole through the bottom of one pot pie tin.
2. Cut an observation window in the side of the same pot pie tin. Do not cut the lower tin.
3. Coil the wire to make a food stand.



Directions: Using your calorimeter

1. Measure the mass of your three food items. Pinch or cut off small pieces until all three have the same mass. Record the mass on the data table.
2. Attach the first food item to the top of your stand by pressing the wire around the food to hold it securely.
3. Measure and record the height of the stand and food item. Adjust the stand so that the height is the same for each test.
4. Place the coil in the center of the lower tin and cover with the top tin.
5. Carefully clip the tins together as shown.
6. Measure 50 ml of water and pour it into the can. Measure and record its temperature.
7. Gently place the can with the thermometer over the center hole.
8. Raise your hand to let your teacher know you are ready to light the food.
9. Observe the burn. (Safety Goggles.) When the flame goes out, measure and record the water temperature again.
10. Pour out the water and repeat steps 2-9 for the next two food items. Be sure your coil remains the same height.





Calorimeter ready for first test.

Burning Question: Which Foods Should We Take To Mars?

Student Names:

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Calorie - The amount of heat energy needed to raise 1 milliliter of water 1 degree Celsius.

Kilocalorie = 1,000 calories

Determining how many calories each food item contains.

1. Calculate the difference between the initial and final water temperature for each food item.

2. Multiply the temperature difference for each item by 50. This gives the number of calories each item contains.

	Mass of Food Item	Initial Water Temperature	Final Water Temperature	Temperature Difference	Number of Calories
Food Item #1 _____					
Food Item #2 _____					
Food Item #3 _____					

Which food item will be the best choice for packing energy for a mission to Mars?

Why is it important that the food items be supported at the same distance from the can?

Explain why you had to multiply your answer by 50.