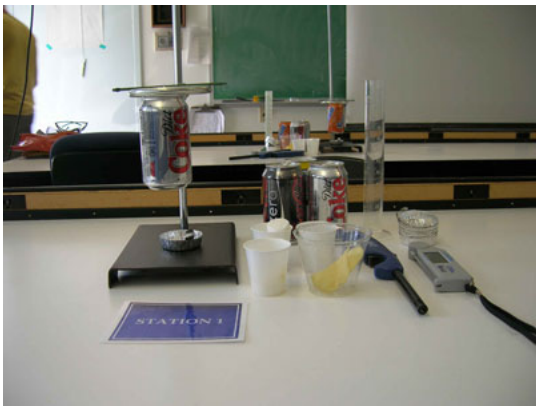
TEACHING SCIENCE BY OCEAN INQUIRY
Energy and Food Webs

1. Homemade Calorimeter

(modified after "Burning" Calories at
http://bioweb.usc.edu/courses/2004-fall/documents/bisc150-lab_burningcal.pdf)



Materials (per group):

- Homemade calorimeter (small soda can and wood/glass rod)
- Digital thermometer
- Lighter
- Graduated cylinder (100 ml)
- Aluminum weighing boats
- Ring stand
- Scale
- Food to burn (e.g., cashews, marshmallows, chips)

Instructions:

1. Of the two food items you will be testing, predict which one will have more Calories. Discuss your prediction with your group.
2. Obtain a weigh boat and food item. Record the initial weight (W_i) = food item + weigh boat.
3. Measure out 100 ml of water and pour it into the soda can. Measure the initial temperature of the water (T_i).
4. Place the weigh boat + food item on the ring stand base. Ignite the food item.
5. As soon as the item catches fire, lower the can so it rests just above the flame.
6. Once the item has finished burning, use the thermometer to carefully stir the water and measure the final temperature (T_f). Caution! **The can & water will be hot!**

7. Allow the burnt food item to cool then weigh the remnants (W_f) = food item + weigh boat.
8. Repeat steps 1-7 for each food item. Make sure you use a new soda can and fresh water for each repetition of the experiment. Record data in the following table.

Food Item	Weight (Mass) of Food (g)			Temperature of Water (°C)		
	Initial Weight (W_i)	Final Weight (W_f)	Mass of Sample Burned ($\Delta W = W_i - W_f$)	Initial Temperature (T_i)	Final Temperature (T_f)	Change in Temperature ($\Delta T = T_f - T_i$)

Determine the Calories of the food items:

$Q_{food} = Q_{water}$

$Q_{water} = (m)(c)(\Delta T)$

where m is the mass of water (grams; 1g = 1ml), c is the specific heat capacity of water (1 calorie/g °C), and ΔT is the change in temperature (°C)

Food Item	Calories (Cal)	Calories (Cal) or Kilocalories (kcal)	Cal/g

***Questions*:**

1. How many Calories per gram (Cal/g) were in each food item you burned (1 Cal = 1000 cal = 1 kcal)? Did your predictions in (1) hold true?
2. How well does the Calorie content you calculated compare to what is listed on the package? Were you able to determine the entire Calorie content of each item? If differences exist, what may account for these differences? How are some of the sources of energy "loss" in the experiment similar to those observed in nature (e.g., biological processes)?
3. How could you improve the experimental design so the results would be more consistent with the packaged values?

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2. Energy Transfer in Ecosystems

(Modified after “The Root Beer Activity” from the Utah State Office of Education at http://www.usoe.k12.ut.us/curr/science.sciber00/8th/energy/sciber/ecosys.htm)

Materials:

- Candy (1000 g)
- Four large beakers (4 trophic levels/organisms)
- Scale

Instructions:

1. Put 1000 g of candy in the first beaker, this represents the amount of available energy. Note: you can either use this as a demonstration in front of the class, or use students as volunteers to represent each trophic level or organisms in a food chain.
2. Now pass 10% of the candy (hint: you can use the scale) or “available energy” to the first trophic level or empty beaker. What trophic level does this represent?
3. Repeat the process for the remaining trophic levels.
4. Why aren’t there food chains that support an infinite number of links?

ENERGY/FOOD WEBS: EXPLANATIONS FOR LAB ACTIVITIES

1. Homemade Calorimeter

Actual Cal/g: cashew = 160 Cal/28.3g = 5.63 Cal/g; Sun Chip = 140 Cal/28g = 5 Cal/g

Answers to Questions:

1. Answers will vary.
2. A calorimeter can be used to measure the chemical potential energy in food. A combustion reaction releases chemical energy stored in the molecules of fuel in the form of heat. This reaction raises the temperature of the surrounding objects. If the reaction is the system, and everything is the surroundings, then energy in the form of heat is transferred from the system to the surroundings.

   However, not all of the potential energy in food is available to do work (see from our experimental calorimeters, a lot of heat is lost and not all of material is burned). Some of the energy went in to heating the soda can, some to heat the water, and a lot was “lost” to the surrounding environment. This is similar to nature in that it reinforces the 1st and 2nd Laws of Thermodynamics, which state that no energy conversion is 100% efficient and that any energy that is lost from the system (calorimeter) is gained by the surrounding environment.

   What we observed was more of an “open” system, rather than a “closed” system created with a “real” bomb calorimeter. But we can apply what we observed and the lack of efficient energy transfer in our experimental calorimeters to how energy moves through ecosystems (food chains and webs in particular).

In the context of food webs, the available or usable energy than can be transferred from one trophic level to the next is limited because of this lack of energy transfer efficiency. The transfer of energy in food webs or from one trophic level to another is only 10% efficient. When food is ingested, some of the potential energy is lost from the "system" as waste (non-digestible), some is lost as heat, some is used for general body maintenance, and some of the assimilated energy is used for growth (biomass).

As we stated previously, the energy isn't lost, it is still in the "system" or environment, but it isn't readily available as biomass to pass on to higher trophic levels. This "loss" of useable energy limits the length of food chains.

3. Try to decrease the "loss" of heat to the surrounding environment by creating more of a closed system. Add an outer can or something that could help insulate the soda can and water.

2. Energy Transfer in Ecosystems

Why aren't there food chains that support an infinite number of links? There isn't enough energy available at higher trophic levels to support a large abundance or populations of organisms.