Burn Calories Burn!

Jocelyn Eckerman
Katherine Stinson Middle School
San Antonio, TX
Summer 2000

Research Host:
Roger McCarter, Ph.D.
University of Texas Health Science Center

Burn Calories Burn!

Suggestions for Teachers

Purpose:
The purpose of this activity is to introduce students to the concepts of metabolism and metabolic rate and to test various factors affecting metabolic rate.

Objectives:
Students will be able to:

Estimate their own basal metabolic rate and caloric needs
Design and carry out an experiment to test one factor affecting metabolic rate
Learn and practice a method for indirectly measuring metabolic rate
Work with small animals in the lab
Record, graph, analyze and communicate findings
Work with a partner or in a cooperative group
Measure O_2 or CO_2 levels with computer based sensors (optional)

Materials:
For instructional lab and student experiments:

Option 1 – Metabolism Chamber

2 purchased metabolism chambers (one holds the test animal; one serves as a control) per 4-student group; *fewer sets of metabolism chambers can be used if students conduct their experiments in rotation at designated stations.*

2 small containers of NaOH or KOH (powdered or liquid) per group

1 – 2 small animals per group (earthworms, mealworms, crickets, flies); NOTE: need animals of various sizes for groups who may choose to test the affect of body size on metabolic rate

Hot, cold, and room temperature water

Small aluminum pans (to serve as water bath for temperature regulation)

Colored water or index solution

Thermometers

Food appropriate for animal chosen

Temporary habitat for animal chosen

Option 2 – Computer-Based

Note: This option does not require the use of a caustic substance such as NaOH or KOH as either CO_2 levels or O_2 levels are measured directly with a calibrated sensor.

O_2 or CO_2 sensor and computer interface, plastic or glass chamber with stopper to fit O_2 or CO_2 sensor

Computer with appropriate data collection software

5 – 6 small animals per group

Hot, cold, and room temperature water

Container for water bath (large enough for immersion of plastic or glass chamber)

Thermometers

Food appropriate for animal chosen

Temporary habitat for animal chosen

Preparation and Procedures:

1. **Option 1**: Purchase or construct the metabolism chambers.

   A metabolism experiment kit can be purchased from *Lab-Aids* for approximately $25.50. The kit contains the necessary metabolism chambers and capillary tubing, and enough colored index solution, carbon dioxide absorbent, and data charts for 10 students. The kit also contains an instruction manual. Their address and web site are listed below:

   Lab-Aids, Inc.
   17 Colt Court
   Ronkonkoma, NY 11779
   1 –800-381-8003
   http:\\www.lab-aids.com

   The aluminum trays can be used with this set up to allow for temperature variation with a water bath. Simply cut notches in the sides of the aluminum tray so the metabolism chambers and attached capillary tubes lay across the tray and the chambers are sitting in the water about half way. Make sure the chambers are level.

   Instructions for constructing an inexpensive metabolism chamber with a built in water bath can be found in the book *Experiments With Plastic Syringes*, by Paul D. Merrick published by Educational Science Consultants (1968). If this set up is used the aluminum pans can be eliminated from the list of materials.

Option 2: Purchase O_2 or CO_2 sensor and interface

Both O_2 and CO_2 sensors are available from *Vernier* www.vernier.com along with the necessary software and experiment setups to allow for ease of sensor calibration and data collection.

Respiration/metabolism experiments using these sensors are also described in *Biology for Computers* by David Masterman and Scott Holman, also available from *Vernier*.

2. Engage students by having them complete the activity *How many calories have you burned today?*

3. After students have completed the activity have them share the results and discuss where in the body these calories are "burned." During this discussion introduce the concepts of metabolism and metabolic rate. Have students estimate their basal metabolic rate (BMR), or how many calories they burn while just sitting doing nothing, and their active metabolic rate (AMR) by using the formulas below:

BMR:
Bodyweight (in kilos) x 14.7 + 496 = basal metabolic rate (calories per day)
AMR:
sedentary (fairly inactive, not involved in any regular sporting activity)
BMR x 1.4 = AMR
moderately active (sedentary overall but do have active hobbies)
BMR x 1.7 = AMR
very active (involved in regular exercise more than four days a week)
BMR x 2 = AMR

NOTE: These formulas are purely estimates as metabolic rate depends on age, gender, height, weight, activity level, etc. Using these formulas will merely give the students a rough idea of their BMR and AMR.

If Internet access is available a web site titled Nutrition for Teens (http:\\library.thinkquest.org/10991.bmr.html) has a metabolic rate calculator that is fun and easy for students to use.

4. Explore the concept of metabolic rate further by using the metabolism chambers or computer sensors to indirectly measure the metabolic rate of a small animal such as an earthworm or cricket. The animal you choose may or may not be the same one the students will later use to develop their own experiment concerning metabolic rate. Measuring metabolic rate before the students develop an experiment to test factors affecting it provides an opportunity for them to learn how to set up and use the equipment and how to properly handle the animals.

5. Once the students have collected the metabolic rate data, have them share and compare their results. Some variation between animals should be evident depending on the size, activity level, environmental temperature, and recent food intake of each animal. Discuss these variations and the factors that could be causing them.

6. Provide students with background information on metabolic rate and the factors that can affect it in the form of reading material, lecture notes, or videos. An excellent resource is the section *Energy balance and the control of metabolic rate* in Human Physiology: The Basis of Medicine by Gillian Pocock and Christopher D. Richards published by Oxford University Press (1999).

7. After students have researched metabolic rate and the factors that can affect it divide students into groups of 3 or 4 to choose a factor to test (size, temperature, diet, type of food intake, time of food intake, etc.), develop an hypothesis, and design and carry out an experiment to test their hypothesis. You may set the type of animal students are to use or you may give them a choice between two or three different animals.

8. Once the experiments are complete students should communicate their findings in a lab report or in a presentation to the class.

Safety:

Students should wear gloves and goggles while conducting the experiment using metabolism chambers to avoid direct contact with the carbon dioxide absorbent and the animals. The carbon dioxide absorbent is not needed with the O2 or CO2 sensors so gloves are not essential but students should still wear goggles. Students should be cautioned to handle the animals carefully and gently to avoid any injury or unnecessary agitation to the animals.

Questions to Ask:

Before the experiment:

1. Which factor are you going to test and why did you choose this factor?

2. What do you think will happen? What is your hypothesis?

3. What information or observations about metabolic rate are you using to support your hypothesis?

4. How will you test this factor as accurately as possible given the equipment available?

5. Should you do repeated trials in your experiment? If so, how many and why?

6. What materials will you use in your experiment?

7. What are the most important things to consider in order to keep your experimental animals safe and unharmed during the experiment?

8. What safety precautions must you follow in your experiment?

After the experiment:

1. Do you feel the experiment was a "success" and why?

2. Did the data support your hypothesis or not? Why do you think it turned out this way?

3. What kinds of human or equipment error could have occurred (or did occur) during your experiment?

4. Would you do anything differently if you repeated the experiment? If so, what would you do?

5. What did you learn from this activity about metabolism and metabolic rate?

6. How can you apply what you learned to your own life and health?

Where to go From Here:

Possible extension activities include:

Fuel for the Fire – Have students keep a daily food log for several days to determine their average caloric intake and compare that with the BMR and AMR figures they calculated at the beginning of the unit. Do their caloric requirements and their average intake match up? Discuss what happens if their intake is much higher than their requirements or vice versa and what they can do to bring the two levels into balance, such as increase or decrease their food intake, increase or decrease their activity level, alter eating times, etc.

What is my Nutritional Grade? – Using the same food logs have students determine what percentage of their total caloric intake comes from carbohydrates (optimum is about 60%), fats (optimum 30%), and protein (optimum 10%). Compare their percentages to the optimum and develop their "nutritional grade." Discuss how they can alter their diet to better meet the optimum percentages.

May I Have a Happy AND Healthy Meal, Please? – Using the optimum percentages presented in the previous activity and information from the food pyramid, have students develop a one-day menu (breakfast, lunch, dinner, snacks) that would appeal to teens, as well as meet the total (average) caloric requirements and optimum percentages for carbohydrates, fats, and proteins. Check the menus for accuracy and duplication then compile all the appropriate daily menus into a "diet handbook for teens" and distribute to the whole class.

References and Resources:

Student reading material: Pocock, Gillian and Christopher Richards. *Energy balance and the control of metabolic rate*. Human Physiology: The Basis of Medicine. New York, Oxford University Press, 1999.

Lab Procedures: Instructional manual for *The Metabolism Experiment*. Lab-Aids, Ronkonkoma, NY.

Metabolism Chambers: *D1(2) Respirometer*. Guidebook to Constructing Inexpensive Science Teaching Instruments. Eisenhower National Clearinghouse for Mathematics and Science Education.

http:\\timss.enc.org/classroom/lessons/docs/001868/nf_1868_273.html. July 25, 2000 (this site is no longer available in this form but the instructions it included were adapted from the book *Experiments With Plastic Syringes* by Paul D. Merrick, published by California Educational Science Consultants (1968)).

CO2 and O2 sensors: Masterman, David and Scoot Hollman. *The Effect of Temperature on Cold-Blooded Organisms.* Biology for Computers. Portland, Oregon, Vernier Software, 1997.

Metabolic calculators: *Nutrition for Teens* http:\\library.thinkquest.org/10991/bmr.html

Metabolic formulas: How to give your metabolism a boost!
http:\\www.users.dircon.co.uk/~floyd/upmetabo.html. July 13, 2000

Suggestions for Assessment:

Groups can be assessed on an oral presentation of their findings to the class as well as a graded lab report. In addition, extension activities can be used as an assessment of student understanding and information acquisition.

Burn Calories Burn!

Student Activity Sheet

Complete the chart below to estimate how many calories you have burned up so far today.

Activity	Time Spent	Rate of Energy Use	Calories Used
Sleeping	( ) hours x 60 = ( ) mins	1.1k/cal per min. x ( ) min. =	
Sitting	( ) hours x 60 = ( ) mins	1.5k/cal per min. x ( ) min. =	
Standing	( ) hours x 60 = ( ) mins	2.5k/cal per min. x ( ) min. =	
Slow Walking	( ) hours x 60 = ( ) mins	2.8k/cal per min. x ( ) min. =	
Fast Walking	( ) hours x 60 = ( ) mins	5.2k/cal per min. x ( ) min. =	
Cycling	( ) hours x 60 = ( ) mins	6.2k/cal per min. x ( ) min.=	
Running	( ) hours x 60 = ( ) mins	13.8k/cal per min. x ( ) min. =	
		Total Calories Burned =	

EXAMPLE:

Activity	Time Spent	Rate of Energy Use	Calories Used
Sleeping	(**8**) hours x 60 = (**480**)mins	1.1k/cal per min. x (**480**) min. =	**528**

Once you have completed the chart answer the questions below:

1. How many calories have you burned today?

2. Which activity burned the MOST calories and which burned the LEAST calories?

3. Why do you think you burn calories even when you are just sitting or sleeping?

4. Based on this estimate of how many calories you have burned so far today, how many calories do you think you should eat today?

Names of all group members:_____

_____

Burn Calories Burn!

Group Activity and Record Sheet

I. The **independent variable (IV)** in this experiment is _____ while the **dependent variable (DV)** is _____.

II. **Question:** What is the effect of _____ on _____?
(IV) **(DV)**

III. **Background Information:**

IV. **Hypothesis:** If we _____ then the metabolic rate will _____ _____ because _____ _____.

V. Materials -- List all the materials, including animals, you will need for your experiment. Be sure to include amounts needed:

_____	_____
_____	_____
_____	_____
_____	_____

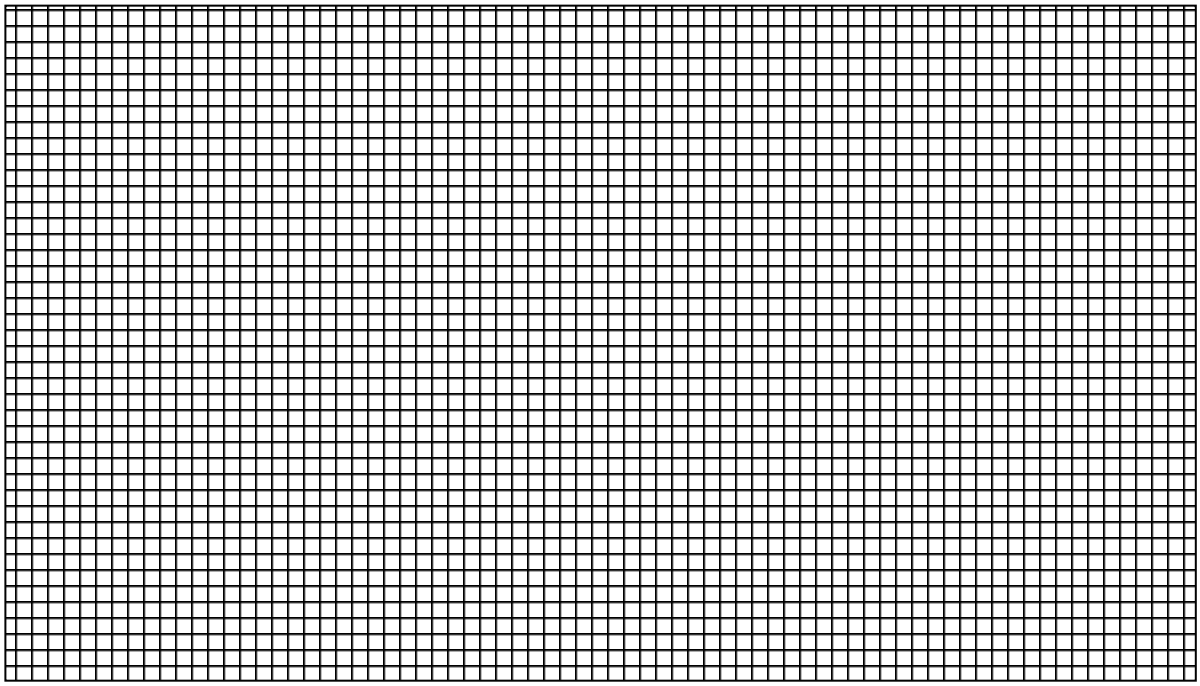
VI. Procedures -- Write out your procedures step by step using complete sentences and command language. Be sure to number your procedures.

VII. Data Table – Using a ruler, design a data table to collect your data. Be sure to include a title that incorporates the IV and DV:

_____ Experiment design approved by teacher

VIII. Observations – Record any interesting or important observations you make about the outcome of your experiment or the procedures you use:

IX. Results – Create a graph to illustrate your data. Be sure to use the appropriate type of graph (line or bar) and include the appropriate IV/DV labels and units along with a title:



X. Conclusion – Write out your conclusion being sure to restate your question and hypothesis, review and analyze your results, and answer your question: