Cornell Institute for Biology Teachers

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Title: **Respirometry Part II: Determining Metabolic Rate**

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Appropriate Level: Regents Biology and Advanced Biology.

Abstract: This module uses the Collins respirometer to measure oxygen consumption and relates this volume to rate of metabolism when the subject is at rest.

Time Required: **Preparation time:** 5 to 10 minutes to set up each respirometer.

Class time: Introduction and instructions to the class will require 5 to 10 minutes. To collect data will take approximately 5 minutes per student tracing.

Special Notes: Special Material: Collins respirometers, spirometry paper (1 per student), disposable mouth pieces (1 per student), nose clamps, a chair for each subject to sit, tape, 1 gallon water container.

Additional Teacher Information

Objectives:

Upon completion of this exercise, students should:

- better understand the factors controlling oxygen consumption.
- better understand how personal actions can affect metabolic rate and food intake.
- be aware that clinical trials are conducted under **very** different conditions than those done in this exercise.
- be aware that calorie requirements are related to body size.

Tips for Teachers

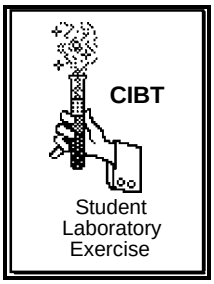
- It is suggested that subjects close their eyes during the recording.
- Some students may be surprised by their metabolic rate. It is important to stress that this rate does not take into account many factors such as growth, movement, etc. It reflects merely one estimate of the resting basal metabolic rate, the minimum amount of energy to maintain life activities at rest, and is not a clinical value.
- This activity may be used as a basis for discussing other related topics such as eating disorders, dieting and endocrine regulation of metabolic rate including thyroid hormone and thyroid disease states.

References

Campbell, N. A. *Biology*, 2nd ed. Benjamin/ Cummings Publishing Co.

Selkurt, E. W., ed. *Physiology*, 3rd edition. Churchill/Livingston Publishers, 1971.

Determining Metabolic Rate



Introduction

As you know from the lab "Lung Volumes and Capacities", the respirometer is a machine that can be used to measure lung volumes and breathing rates. In this lab we will use the respirometer to measure how much oxygen (O_2) our body is using. This information will help us to learn something about our metabolism -- the chemical reactions needed to sustain life.

Metabolic processes are either anabolic (synthetic) or catabolic (degradative). Anabolism includes such things as protein synthesis, glycogen synthesis, lipid synthesis, nucleic acid synthesis, etc. In all these reactions large molecules are built from smaller ones. Catabolism involves processes that break large molecules into simpler ones. Digestion is an example of a catabolic process. All these metabolic processes require energy to proceed.

Oxygen is required for our bodies to break down glucose and release ATP (energy). The amount of O_2 we consume is directly related to the number of Calories we are burning. If we were to measure the amount of energy our body needs to perform only its most essential activities, we would be measuring what is known as our "Basal Metabolic Rate" (BMR). This would be the amount of energy needed to fuel basic processes such as breathing, heartbeat, neural, kidney and liver functions.

In clinical tests for humans, BMR is determined after a fast of 12 to 14 hours, in the morning after at least 8 hours of sleep, with no voluntary muscle movement at least a half an hour before the test. The subject is to be both physically and mentally unstressed. Under these conditions, the average for adult females is 1300-1500 Calories per day and the average for adult males is 1600-1800 Calories per day.

Since we are unable to follow the strict clinical guidelines for BMR, we will measure our **current** metabolic rate. It is important to remember that many factors -- such as age, gender, stress, hormones, to name just a few -- affect our metabolic rate.

Coaching

This activity is not a solo effort. The coaches' careful monitoring of the tracing is critical to the accurate collection of data.

Procedure

1. Refresh the air in the respirometer. Pull up on the holder on top of the drum, and remove the entire drum to install paper. Position the bell so that the pen is resting on or above the 2 liter line.

2. The subject installs a new disposable mouthpiece on the spirometer hose and puts on the nose clamp to prevent nasal breathing. He or she should sit comfortably and adjust the hose for him/herself. The wet and juicy part of the lips should be in contact with the mouthpiece. No leakage of air should occur!

3. Set the drum speed to the lowest speed or 32 mm/min. If an on/off switch is present--turn it on. It takes 1 minute for the pen to move across one vertical column at this speed.

   The coach should have the breather close his/her eyes and should make certain that the breathers eyes remain closed during the recording.

4. Record for 3 minutes. If after 1 minute, the "tendency" line on the tracing is not rising, **STOP.** Refresh the air and start over.

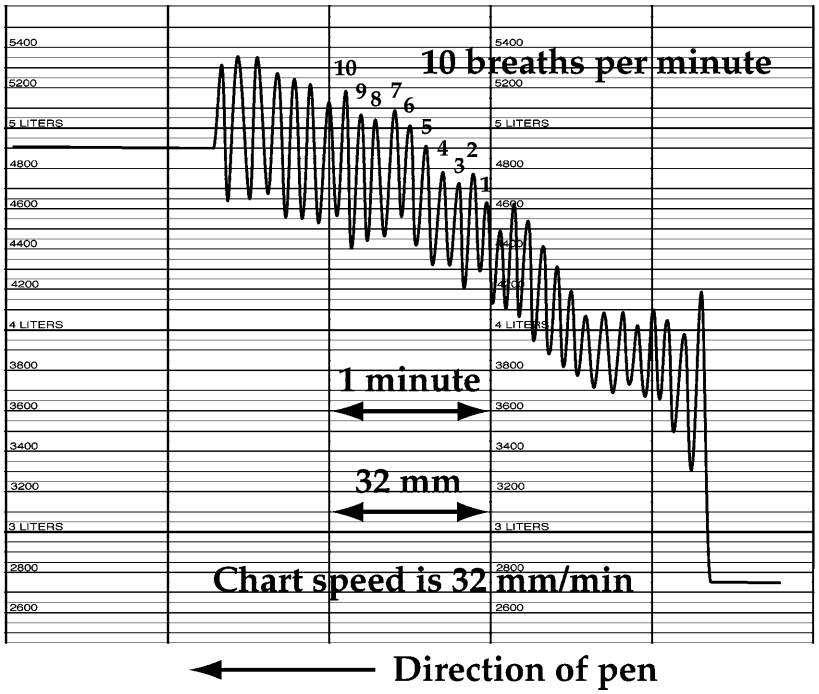
5. Turn the drum off, label the breather's name. Repeat procedure for others in your group. Try to fit 2-3 tracings on a sheet of chart paper.

How to Determine Your Metabolic Rate

Using your knowledge from the "Lung Volumes and Capacities" lab, answer the following questions and **show all calculations. Label units!!**

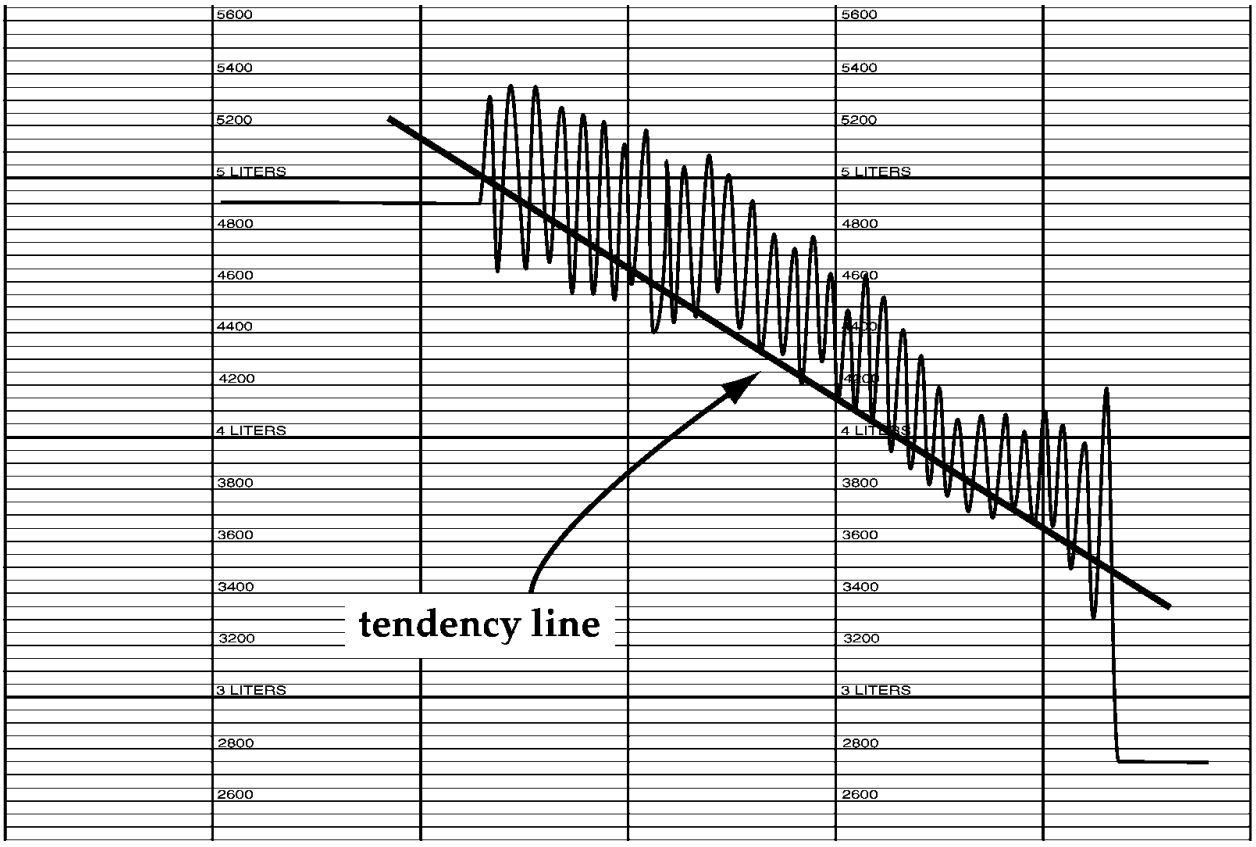
1. Use your tracing to determine your breathing rate in # breaths/min. _____

Example:



2. To determine the rate of oxygen consumed in 1 minute:

   a. Use a ruler to draw the "tendency" line of your breaths. (Just do it! Make the best slope of the line that you can.)



c. Calculate the oxygen consumed by subtracting the volumes indicated at the circles. _____ ml.

d. Express this measurement as a rate: this O_2 was consumed in 1 minute.
_____ ml./min.

So, what does oxygen consumed have to do with Calories, anyway?

Each ml. of oxygen consumed corresponds to 0.005 Calories burned. To convert the oxygen consumed per minute to calories burned per minute, it is necessary to multiply the oxygen consumed by a **conversion factor**:

(? ml. of oxygen/ min.) multiplied by (0.005 Cal./ml. oxygen) = ? Cal./min.

Example: (500 ml. oxygen/min.) multiplied by (0.005 Cal./ml.) = 2.5 Cal./min.

3. Now, from your data, determine the number of Calories you burn in one minute.

_____ Cal./min.

4. Now you know how many Cal. you burn in one minute, determine the Calories you use in one hour, and in one day.

_____ Cal./hr.

_____ Cal./day

5. In the space below, discuss how we might improve the accuracy of this measurement.

6. What factors might affect metabolic rate? List 5.

7. How much of this candy bar (wrapper info below) would you need to energize yourself for one hour? (Use your answer to Question 4.)

Nutrition Facts	Amount/serving	%DV**	Amount/serving	%DV**
Servicing Size 1 Pack	**Total Fat** 13g	20%	**Total Carb.** 30g	10%
Calories 250	Sat. Fat 5g	25%	Fiber 2g	7%
Fat Calories 120	**Cholest.** 5mg	1%	Sugars 25g	
**Percent Daily Values	**Sodium** 25mg	1%	**Protein** 5g	
(DV) are based on a	Vitamin A*`	Vitamin C*	Calcium 4%	Iron 2%
2,000 calorie diet.	Thiamine 2%	Riboflavin 4%	Niacin 8%	
	*Contains less than 2 percent of the Daily Value of these nutrients.			

8. Look at the chart below. What activity most closely reflects the energy usage you have measured for yourself today (Question 4)?

Energy Expenditure per Hour During Different Types of Activity For a 70 Kilogram Man

Form of Activity	Calories/Hr.
Sleeping	65
Awake lying still	77
Sitting at rest	100
Standing relaxed	105
Dressing and undressing	118
Tailoring	135
Typewriting rapidly	140
"Light" exercise	170
Walking slowly (2.6 miles per hour)	200
Carpentry, metal working, industrial painting	240
"Active" exercise	290
"Severe" exercise	450
Sawing wood	480
Swimming	500
Running (5.3 miles per hour)	570
"Very severe" exercise	600
Walking very fast (5.3 miles per hour)	650
Walking up stairs	1100

Extracted from data compiled by Professor M. S. Rose.