Assembling and Computerizing an Indirect Calorimeter

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Abstract

Metabolic disorders affect millions around the world. The disorders are a result of aberrant activities in the metabolic pathways, specifically the aberrant activities of the genes present in the pathways. Indirect calorimetry (IC) is a valuable tool to monitor the effects that phenotypic changes induce in metabolism. Our group worked to assemble an indirect calorimeter using the equipment provided, as well as to determine the equipment and methods which need to be employed to make the calorimeter functional.

Indirect Calorimetry

IC is used to determine the oxygen consumption (VO_2) and carbon dioxide production (VCO_2) of an organism via analysis of expired gas. A number of useful calculations can be made from these values including:

- Respiratory Exchange Ratio (RER) = VCO_2/VO_2
  An indicator of which fuel, carbohydrate or fat, is being used to supply the body with energy.
- Resting Energy Expenditure (REE)
  RER = [VO_2 (3.941) + VCO_2 (1.11)] 1440 min/day
  Estimates the total amount of energy consumed during a 24 hour period with minimal physical activity.

Motivation

- The tremendous variability in resting energy expenditure makes efforts to predict caloric requirements difficult.
- It provides a valuable tool in assessing energy expenditure, evaluating the way in which the body uses nutrient fuel, and designing nutritional regimens that best fit the clinical condition of the patient.
- Its has the potential to be cost saving by avoiding unnecessary nutritional support and in providing a means for groundbreaking clinical research.

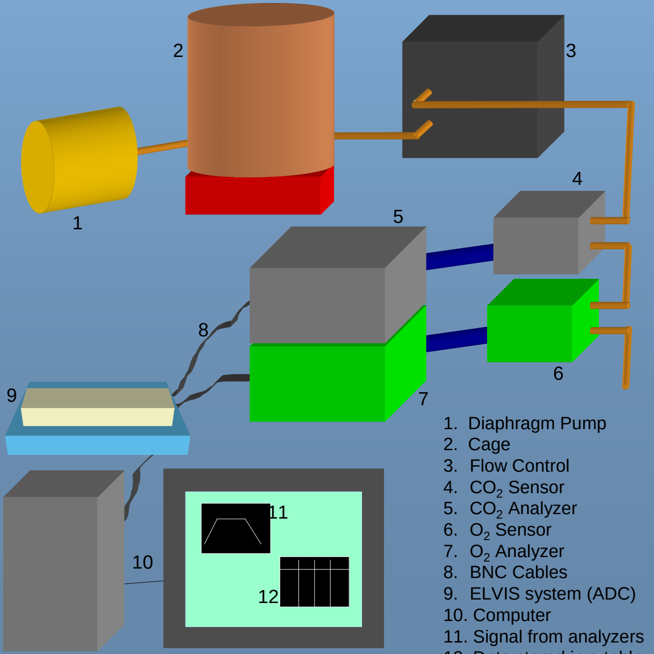
Design Constraints

- Gas measurements should be taken every 5 minutes and be measured in mL/min.
- Two identical cage systems, each with 4 cages for mice and 1 for reference. One system will house the experimental "knockout" mice while the other system will house control mice.
- Both systems must fit on a rolling cart for transportation to Dr. Cai's animal testing room.
- Should be usable with only minor repairs for at least 2 years.
- Cost should stay under $2,000 if the analyzers do not need to be replaced.

Project Timeline

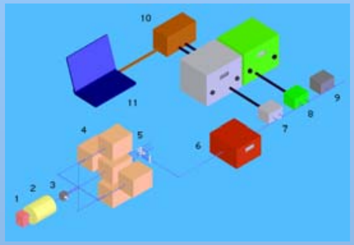
- Calibration and testing of pre-existing O_2 and CO_2 analyzers and sensors
- Testing of pumps, flow meters, and water dehumidifiers
- Building of the one cage setup
  Pump → Cage → CO_2 → O_2
- Determining of optimal flow rates through the cages.
- Data Acquisition from IOtech DBK80 (Voltage Input Card) to DAQBoard/2000 (data acquisition system) to DasyLab software
- Incorporation of the solenoid valves through the use of the DBK25 Relay-Output Card
- Programming of DasyLab software to control solenoid valves
- Connecting of equipment as seen in final design and mount the equipment on the cart

Prototype



1. Diaphragm Pump
2. Cage
3. Flow Control
4. CO_2 Sensor
5. CO_2 Analyzer
6. O_2 Sensor
7. O_2 Analyzer
8. BNC Cables
9. ELVIS system (ADC)
10. Computer
11. Signal from analyzers
12. Data stored in a table

Final Design



1. Diaphragm Pump
2. Air expansion chamber
3. Manual flow control
4. Animal chambers
5. Solenoid valve/relay system
6. Dehumidifier
7. CO_2 sensor and analyzer
8. O_2 sensor and analyzer
9. Pump
10. Data acquisition device
11. Computer for analysis

Figure 1. A layout of the proposed final design. The first pump pushes air through the cages. The second pump pulls air through the sensors for analysis. Solenoid valves control which cage's air is being measured.

Competition

Figure 2. CLAM system – state of the art indirect calorimeter for small animals.

Cost List

Items required:	
Tygon Tubing 1/8" ID (50 ft)	$15.80
Gas tanks for calibration (MDS)	<$100.00
Movement cart for system to be placed on	~$400.00
Items needed if non-functional:	
Thomas Industries 107CAB18 Diaphragm pump	$179.95
Sable FC-10a Oxygen Analyzer/sensor	$5,745.00
Sable Ca-10a Carbon Dioxide Analyzer/sensor	$5,995.00
Omega FMA6500 Series Mass Flow Control	$1495.00
Humphrey Model 31E1-12VDC solenoid valves	$221.75
Swagelok SS-OVS2 manual valves	$361.20
Dwyer Instruments VA10411 Flow meter	$101.00

Acknowledgements

Much thanks to Dr. Keesey for sharing his experiences of working with an indirect calorimeter. We would also like to thank Dr. Gentry for his continuous support.

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