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 (VO2) and carbon dioxide production (VCO2) of an organism via analysis of expired gas. A number of useful calculations can be made from these values including:

- Respiratory Exchange Ratio (RER) = VCO2/VO2
  An indicator of which fuel, carbohydrate or fat, is being used to supply the body with energy.
- Resting Energy Expenditure (REE) = (VO2 x RER) + (VCO2 x 0.8)
  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.
- It 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.
- They 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

<table>
<thead>
<tr>
<th>Task</th>
<th>Completion Date</th>
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<tbody>
<tr>
<td>Calibration and testing of pre-existing O2 and CO2 analyzers and sensors</td>
<td>January 10th</td>
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<tr>
<td>Testing of pumps, flow meters, and water defumidifiers</td>
<td>January 15th</td>
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<tr>
<td>Building of the one cage setup Pump/Case/CO2/O2</td>
<td>January 20th</td>
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<tr>
<td>Determining of optimal flow rates through the cages</td>
<td>January 25th</td>
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<tr>
<td>Incorporation of the solenoid valves through the use of the DBK25 Relay/Ouid Card</td>
<td>February 10th</td>
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<tr>
<td>Programming of DasyLab software to control solenoid valves</td>
<td>February 15th</td>
</tr>
<tr>
<td>Connecting of equipment as seen in final design and mount the equipment on the cart</td>
<td>February 20th</td>
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</tbody>
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Prototype

1. Diaphragm Pump
2. Cage
3. Flow Control
4. CO2 Sensor
5. CO2 Analyzer
6. O2 Sensor
7. O2 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. CO2 sensor and analyzer
8. O2 sensor and analyzer
9. Pump
10. Data acquisition device
11. Computer for analysis

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-CSV2 manual valves $361.20
  - Dwyer Instruments VA10411 Flow meter $101.00

Acknowledgements

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References

Extended Summary: