1. Metabolism
2. Thermal Physiology
3. Etc.

Text:
(skim 5-7)
(skim 8+9)

- Oral Presentations
  (PPT files to KEB)
  (most on 07 Dec, four on 06 Dec in lecture)
- Wrap-Up

Metabolism
- Chemical reactions in the body
- Temperature dependent rates
- Not 100% efficient, energy lost as heat
  (not ‘lost’ if used to maintain Tb)

1. Anabolic
   - creation, assembly, repair, growth
     (positive nitrogen balance)

2. Catabolic
   - energy release from complex molecules
     (carbos, fats, proteins)
   - energy storage in phosphate bonds (ATP) and
     metabolic intermediates (glucose, lactate)

Metabolic Rate
- measurable conversion of chemical energy into heat
- used to understand:
  - energy budgets
  - dietary needs
  - body size implications
  - habitat effects
  - costs of various activities
  - mode of locomotion
  - cost of reproduction

World Class Human Runners

(Hill et al. 6.9)
Metabolic Rates

- Basal Metabolic Rate, BMR
  - minimal environmental and physiological stress
    (appropriate ambient temperature, post-digestive, resting etc.)

- Standard Metabolic Rate, SMR
  - similar to BMR, but at a given Tb

- Field Metabolic Rate, FMR
  - average metabolic rate of animal in natural setting
    - hard to measure

Metabolic Rates

Basal Metabolic Rate, BMR
- important components:
  1. Membrane form and function
     maintenance of electrochemical gradients
     - proton pumps in mitochondrial membranes
     - Na/K-ATPase pumps in plasma membrane
  2. Protein synthesis
  3. ATP formation

Oxygen Debt
- repay anaerobic contribution to elevated metabolism
- oxidize anaerobic products (e.g., lactate)

VO₂ Measurement - Before, during, and after exercise

Desert Iguana

Activity and Associated Oxygen Consumption

EEOC: Excess Exercise Oxygen Consumption
EPOC: Excess Post-exercise Oxygen Consumption

\[ \text{TEOC} = \text{EEOC} + \text{EPOC} \]
Energy Budget Implications

Costs for Exercise and Recovery:
- A Single Bout: 15 seconds at Maximum intensity

- Traditional Estimates:
  0.7% of daily energy expenditure
- Inclusion of EPOC:
  4.6% of daily energy expenditure

Length of Bout is Important:
Phylogenetic Effects

<table>
<thead>
<tr>
<th>FMR (kJ/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100g reptile</td>
</tr>
<tr>
<td>100g mammal</td>
</tr>
<tr>
<td>100g bird</td>
</tr>
</tbody>
</table>

(Nagy, Girard, Brown 1999)

Energy Budgets...
Ecological Role...

Scaling Effects

Allometry - changes in body proportions as animals get larger (mouse vs. elephant)

Metabolic Rate - mass-specific metabolic rate decreases with increasing body mass

(16-8)

<table>
<thead>
<tr>
<th>Linear dimension</th>
<th>1</th>
<th>2(2x)</th>
<th>3(3x)</th>
<th>4(4x)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume</td>
<td>1</td>
<td>8(8x)</td>
<td>27(27x)</td>
<td>64(64x)</td>
</tr>
<tr>
<td>Surface area</td>
<td>6</td>
<td>24(3x)</td>
<td>54(9x)</td>
<td>144(34x)</td>
</tr>
</tbody>
</table>

(a) = elephant freaked out and died (1960’s) in a study of ‘musth’ [elephantine fallacy]

-What is the correct dose?
-Importance of Scaling!

Mouse-to-Elephant Curve

4g shrew eats 2g/day

elephant is 1 million x larger

MR = aM^b

\[ \log MR = \log a + b \log M \]

b = 0.75 (slope)
Hemoglobin dissociation curves and body size

Bohr effect and body size

Capillary density and body size

Thermal Neutral Zone

Isometry is rare

\[
\log M_{\text{skeleton}} = \log a + b \log M
\]

\( b = 1.13 \)

(slope)
Thermal Neutral Zone

**Within TNZ:**
- Vasomotor
- Posture
- Insulation
  - Fluff fur/feathers

**Below TNZ:**
- Increase metabolism above basal

**Above TNZ:**
- Cool via evaporation

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Pyrogens

**Fever**

Endotherms in the COLD...

Countercurrent Heat Exchange

Hot Body, Cool Brain

Keep brain cool during prolonged increased organismal activity:
Much more difficult for water breathing animals to maintain body temperatures above ambient because rate of heat transfer is greater than rate of O₂ transfer in water (high specific heat).

Thank you all for working hard to learn physiology this semester.

Kristen and I have very much enjoyed working with you all.

I would like to thank Kristen for being an exceptional TA, an outstanding colleague, and a talented scientist and educator.

Oral Presentations:

Tom
Amir
Shahin
Brooke