Comparative thermal biology and thermoregulation

In Eckert read these pages in Chapter 17 -
699-700
704-724
729-730

From where, the sun now stands,
I will fight no more forever.
It is cold and we have no blankets.

The little children are freezing to death.

My people, some of them, have run away to the hills, and have no blankets, no food; no one knows where they are—perhaps freezing to death.

I want to have time to look for my children and see how many I can find.

Maybe I shall find them among the dead.

Hear me my chiefs.

I am tired; my heart is sick and sad.

From where, the sun now stands, I will fight no more forever.

Chief Joseph, 1877
Effect of temperature on metabolism

As temperature increases -
- activation energy increases
- structure of proteins changes

van’t Hoff equation

\[ Q_{10} = \frac{R_{t+10}}{R_t} \]

Lethal core temperatures of endotherms

<table>
<thead>
<tr>
<th>Animal</th>
<th>Approximate normal core temperature (°C)</th>
<th>Approximate lethal core temperature (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monotreme (echidna)</td>
<td>30–31&lt;sup&gt;a&lt;/sup&gt;</td>
<td>37&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Marsupials</td>
<td>35–36&lt;sup&gt;b&lt;/sup&gt;</td>
<td>40–41&lt;sup&gt;e&lt;/sup&gt;</td>
</tr>
<tr>
<td>Insectivore (hedgehog)</td>
<td>34–36</td>
<td>41&lt;sup&gt;f&lt;/sup&gt;</td>
</tr>
<tr>
<td>Man</td>
<td>37</td>
<td>43</td>
</tr>
<tr>
<td>Eutherian mammals</td>
<td>36–38&lt;sup&gt;c&lt;/sup&gt;</td>
<td>42–44&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>Bird (kiwi)</td>
<td>38&lt;sup&gt;d&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>Birds, nonpasserine</td>
<td>39–40&lt;sup&gt;b&lt;/sup&gt;</td>
<td>46&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Birds, passerine</td>
<td>40–41&lt;sup&gt;b&lt;/sup&gt;</td>
<td>47&lt;sup&gt;i,j&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<sup>a</sup> Schmidt-Nielsen et al. (1966).
<sup>b</sup> Dawson and Hulbert (1970).
<sup>c</sup> Morrison and Ryser (1952).
<sup>d</sup> Farner (1956).
<sup>e</sup> Robinson and Morrison (1957).
<sup>f</sup> Shkolnik and Schmidt-Nielsen (1976).
<sup>g</sup> Adolph (1947).
<sup>h</sup> Robinson and Lee (1946).
<sup>i</sup> Calder (1964).
<sup>j</sup> Dawson (1954).
**POIKILOThERMY**
Body temperature fluctuates with environment
- Crab, whose body heat derives from and reflects environment
- Benthic fish, in thermally stable environment

**ECTOTHERMY**
Body heat derived from environment
- Kangaroo rat, whose body heat derives from both metabolism and environment
- Hummingbird, showing night-time torpor

**HETEROTHERMY**
- Human, using metabolic heat to maintain constant body temperature

**HOMEOTHERMY**
Body temperature remains constant
- Endothermy: Body heat derived from metabolism
Why many animals do not regulate.

Thermal conductivities

<table>
<thead>
<tr>
<th>Material</th>
<th>$k$ (cal s$^{-1}$ cm$^{-1}$ °C$^{-1}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silver</td>
<td>0.97</td>
</tr>
<tr>
<td>Copper</td>
<td>0.92</td>
</tr>
<tr>
<td>Aluminum</td>
<td>0.50</td>
</tr>
<tr>
<td>Steel</td>
<td>0.11</td>
</tr>
<tr>
<td>Glass</td>
<td>0.0025</td>
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<tr>
<td>Soil, dry</td>
<td>0.0008</td>
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<tr>
<td>Rubber</td>
<td>0.0004</td>
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<tr>
<td>Wood</td>
<td>0.0003</td>
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<tr>
<td>Water</td>
<td>0.0014</td>
</tr>
<tr>
<td>Human muscle</td>
<td>0.0011</td>
</tr>
<tr>
<td>Adipose tissue</td>
<td>0.00051</td>
</tr>
<tr>
<td>Air</td>
<td>0.000057</td>
</tr>
<tr>
<td>Animal fur</td>
<td>0.000091</td>
</tr>
</tbody>
</table>

Regulation of blood flow to body surface.

(a) Response to cold temperature

- Body core
- Skin
- Artery
- Vein
- Shunt
- Blood flow
- Heat transfer
- Vasoconstriction
- Low heat conductance
- Surface vessels

(b) Response to high temperature

- Vasodilation
- High heat conductance
Peruvian Mountain Lizard sun bathing.

Fur versus blubber

(a) Body core Skin Fur
Artery
Vein

(b) Shunt vessels Blubber Surface vessels

Difference in insulation volume
Heat pro. = Heat loss

Hypothermia  Thermal neutral zone  Hyperthermia

Metabolic rate

BMR

Zone of metabolic regulation

Zone of active heat dissipation