With this arrangement of blood vessels, blood loses heat steadily as it flows in and out of the limb, and its temperature steadily declines.

Blood flow without countercurrent heat exchange

Blood flow with countercurrent heat exchange

When the arteries and veins are close together, allowing countercurrent heat exchange to occur, some of the heat lost from the arterial blood enters the venous blood. The temperature of the venous blood thus rises as the blood travels toward the body.
(a) Acclimatization of peak metabolic rate

(b) Insulatory acclimatization

KEY
- Observed
- Extrapolated

ARCTIC
- Polar bear cub
- Arctic fox and larger mammals
- Ground squirrel
- Lemming
- Weasel
- Coati

TROPICAL
- Marmoset
- Jungle rat
- Unclothed human
- Night monkey
- Raccoon
- Sloth

Basal metabolic rate = 100

Air temperature (°C)

Lowest temperature in Arctic

Body temperature
At ambient temperatures that are far below 0°C, the ground squirrels increase their metabolic heat production so as to keep their body temperatures from falling close to ambient.
The decrease in energy consumption brought about by entering hibernation diminishes as mammals increase in body size.

Increased oxygen consumption and heat production in MUSCLE, HEART, LIVER, and KIDNEY.
A Na⁺-I⁻ symporter brings I⁻ into the cell. The pendrin transporter moves I⁻ into the colloid.

Follicular cell synthesizes enzymes and thyroglobulin for colloid.

Intracellular enzymes separate T₃ and T₄ from the protein.

Thyroglobulin is taken back into the cell in vesicles.

Thyroid peroxidase adds iodine to tyrosine to make T₃ and T₄.

KEY
MIT = moniodotyrosine
DIT = diiodotyrosine
T₃ = triiodothyronine
T₄ = thyroxine
### TABLE 21-6 Thyroid Hormones

<table>
<thead>
<tr>
<th>Cell of origin</th>
<th>Thyroid follicle cells</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemical nature</td>
<td>Iodinated amine</td>
</tr>
<tr>
<td>Biosynthesis</td>
<td>From iodine and tyrosine; formed and stored on parent protein thyroglobulin in colloid of follicle</td>
</tr>
<tr>
<td>Transport in the circulation</td>
<td>Bound to thyroxine-binding globulin and albumins</td>
</tr>
<tr>
<td>Half-life and degradation</td>
<td>6–7 days for thyroxine (T₄); about 1 day for triiodothyronine (T₃)</td>
</tr>
<tr>
<td>Stimulus for release</td>
<td>Tonic release</td>
</tr>
<tr>
<td>Control axis</td>
<td>Thyrotropin-releasing hormone (TRH) (hypothalamus) → thyroid-stimulating hormone (TSH) (anterior pituitary) → T₃ and T₄ (thyroid) → T₄ deiodinates in tissues to form more T₃</td>
</tr>
<tr>
<td>Target cells or tissues</td>
<td>Most cells of the body</td>
</tr>
<tr>
<td>Target receptor</td>
<td>Nuclear receptor</td>
</tr>
<tr>
<td>Whole body or tissue action</td>
<td>↑ Oxygen consumption (thermogenesis); protein catabolism in adults but anabolism in children; normal development of nervous system</td>
</tr>
<tr>
<td>Action at cellular level</td>
<td>Increases activity of metabolic enzymes and Na⁺/K⁺-ATPase</td>
</tr>
<tr>
<td>Action at molecular level (including second messenger)</td>
<td>Production of new enzymes</td>
</tr>
<tr>
<td>Feedback regulation</td>
<td>T₃ has negative feedback effect on anterior pituitary and hypothalamus</td>
</tr>
</tbody>
</table>
### TABLE 5.5 Biomasses of populations of selected herbivores living in mixed communities in African national parks

Species are listed in order of increasing individual size. These species were chosen for listing because they are statistically about average in population biomass for their body sizes.

<table>
<thead>
<tr>
<th>Species</th>
<th>Average biomass of whole population per square kilometer (kg/km²)</th>
<th>Average individual body weight (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oribi (Ourebia aurebi)</td>
<td>44</td>
<td>13</td>
</tr>
<tr>
<td>Gray duiker (Sylvicapra grimmia)</td>
<td>62</td>
<td>16</td>
</tr>
<tr>
<td>Gray rhebok (Procapra gutturosa)</td>
<td>105</td>
<td>25</td>
</tr>
<tr>
<td>Warthog (Phacochoerus aethiopicus)</td>
<td>95</td>
<td>69</td>
</tr>
<tr>
<td>Waterbuck (Kobus ellipsoideus)</td>
<td>155</td>
<td>210</td>
</tr>
<tr>
<td>Greater kudu (Tragelaphus strepsiceros)</td>
<td>200</td>
<td>215</td>
</tr>
<tr>
<td>Plains zebra (Equus burchelli)</td>
<td>460</td>
<td>275</td>
</tr>
<tr>
<td>White rhino (Ceratotherium simum)</td>
<td>2400</td>
<td>1900</td>
</tr>
<tr>
<td>African elephant (Loxodonta africana)</td>
<td>1250</td>
<td>3900</td>
</tr>
</tbody>
</table>
O₂ consumption (liter h⁻¹) = 0.676 × $M_b^{0.75}$
O₂ consumption per kilogram (liter h⁻¹ kg⁻¹) = 0.676 × $M_b^{-0.25}$
Lung ventilation rate (liter h⁻¹) = 20.0 × $M_b^{0.75}$
Lung volume (liter) = 0.063 × $M_b^{1.02}$
Tidal volume (liter) = 0.0062 × $M_b^{1.01}$
Blood volume (liter) = 0.055 × $M_b^{0.99}$
Heart weight (kg) = 0.0058 × $M_b^{0.99}$
Respiration frequency (min⁻¹) = 53.5 × $M_b^{-0.20}$
Heart rate (min⁻¹) = 241 × $M_b^{-0.25}$

**Multiple-causes theory**

Multiple underlying processes matter. Each has its own allometric relation to body weight. They combine to create the relation between metabolic rate and weight.

Basal conditions: the top four processes

- Protein synthesis
- Ion pumping by Na⁺–K⁺-ATPase
- Ion pumping by Ca²⁺-ATPase
- Urea biosynthesis

According to the multiple-causes theory, the overall allometric relation is a consequence of allometric relations in multiple underlying processes.

**Fractal theory**

According to the fractal theory, the circulatory system adheres to a fractal model of branching, and this places allometric constraints on internal transport.
Fractales

- **Autosimilitud**

- **Dimensión fractal**

  **Ej: Conjunto de Cantor**

  Número de segmentos:  $N = (Lt / Ls)^D$

  $Lt$: largo total: 1

  $2^n = (1/ (1/3^n))^D$

  $2^n = (3^n)^D$

  $n.log(2) = D.n. log(3)$

  $D = log(2)/log(3) = 0,6313$

  (dimensión fractal del conjunto de Cantor)
La pregunta básica del trabajo es: ¿Por qué es 0.75 el exponente al cuál se encuentra elevada la masa corporal, cuando se la vincula con la tasa metabólica y otras variables relacionadas fisiológicamente? El trabajo toma como variable de análisis el número de capilares (Nc), que es a su vez directamente proporcional a la tasa metabólica y otras variables (Vx) tales como las frecuencias ventilatoria y cardíaca.

- Las premisas básicas del trabajo son:
  - Invariancia en el tamaño de los conductos terminales (capilares)
  - La energía disipada por el sistema circulatorio es minimizada
  - Geometría fractal del sistema circulatorio.

Conclusión:

\[
V_x = a \cdot M^{0.75} = a' \cdot (L^3)^{3/4} = a' \cdot L^{9/4} = a' \cdot L^{2.25} \Rightarrow D = 2.25
\]