BIOL/PHYS 438

Zoological Physics

- Introductions: Jess, Jeremy, Alex & You!
- Logistics & Procedures: Syllabus & Website
- Mini-Lecture (Ch. 1: Introduction)
- Assignment 1: METABOLISM
  - Participatory Experiment: *Hebb Stairs*

PEOPLE

- Jess Brewer (← Boye Ahlborn)
  - Henn 320A, 2-6455, jess@physics.ubc.ca
- Jeremy Goldbogen (← John Gosline)
  - Biosci 3475, 2-2373, jergold@zoology.ubc.ca
- Alex Weber (TA)
  - AMPEL 143, 2-5344, aweber@physics.ubc.ca
- You (See Assignment 1):
  - Please *Email us* a brief explanation of *who you are* and *why you are taking BIOL/PHYS 438*!

BIOL/PHYS 438

Zoological Physics

- Logistics & Procedures:

  Syllabus & Website

Zoological Physics

Ch.1: Information, Matter & Energy

- "Life is remembering the form as matter flows through it." - *Thomas Mann*
  - Enormous complexity!
- "Physics: a wise choice of approximations & corrections." - *Jess Brewer*
  - Implausible simplicity.
- "Science is the belief in the ignorance of experts." - Richard Feynman
  - "Try and see." The proof of the pudding is in the eating.
- The Physicist will try to make up simple models based on rigourous definitions and precise measurements.
- The Zoologist will acquaint him with reality.
- Perhaps we will get somewhere this way.

Notation: a few symbols

X – Any abstract quantity
dX – An infinitesimal change in x
ΔX – A finite change in x
t – Time [s], x, y, z, d, r, R – Distances [m] (usually)
M – Mass [kg]
U – Energy [J] (usually potential energy)
K – Kinetic energy [J]
W – Mechanical Work [J] $P = dW/dt$ = Power [W]
H – Helmholtz Free Energy [J] (usually chemical)
Q – Heat energy [J]
η – Mechanical efficiency of a heat engine
Γ – Metabolic rate [W]

Conservation Laws in Physics

Some things are **rigourously conserved**:

- kinetic energy K + potential energy $U + mc^2$
- electric charge q

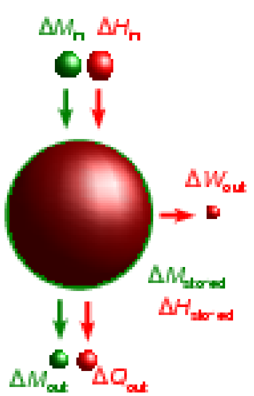
Other things are **approximately conserved**:

- mass M
- work and energy $W + K + U$

Other things are **not conserved at all**:

- entropy σ or $S = k_B \sigma$
- temperature $T = (dS/dU)^{-1}$

Physics Model of an Animal



$$\Delta M_n = \Delta M_{stored} + \Delta M_{out}$$

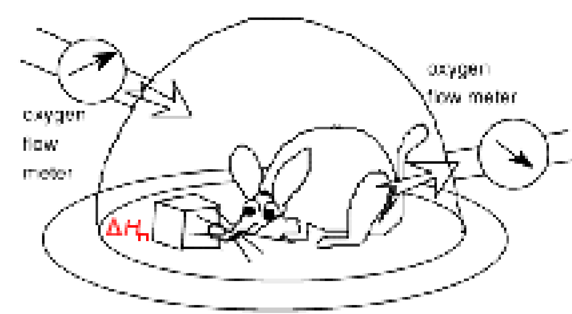
$$\Delta H_n = \Delta W_{out} + \Delta H_{stored} + \Delta Q_{out}$$

In **steady-state**,

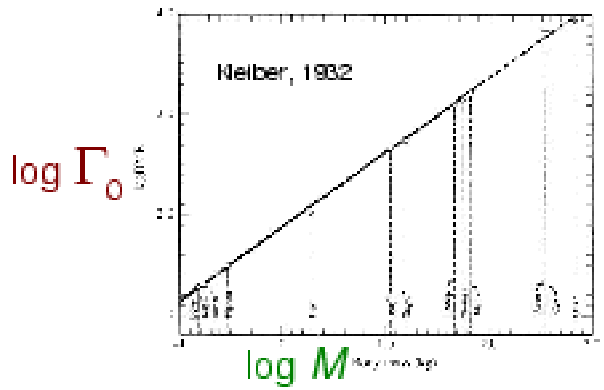
$\Delta M_{stored} = 0$ and $\Delta H_{stored} = 0$

- Mechanical efficiency
  $\eta = \Delta W_{out} / \Delta H_n$
- Resting Metabolic Rate Γ_0
  = *minimum* dH_n/dt *to stay alive.*

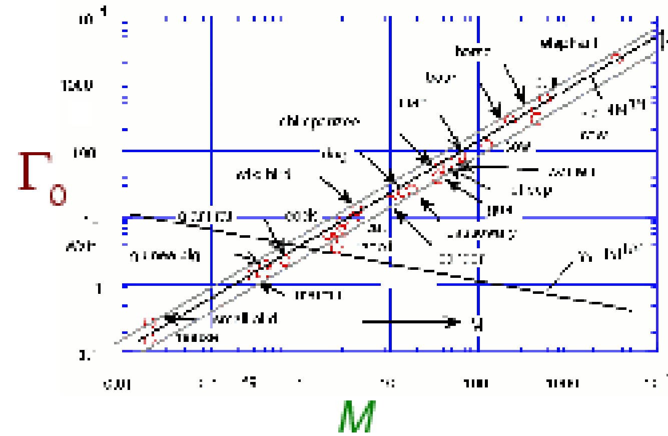
Measuring Γ_0



Allometry: how things *scale* with ***mass***

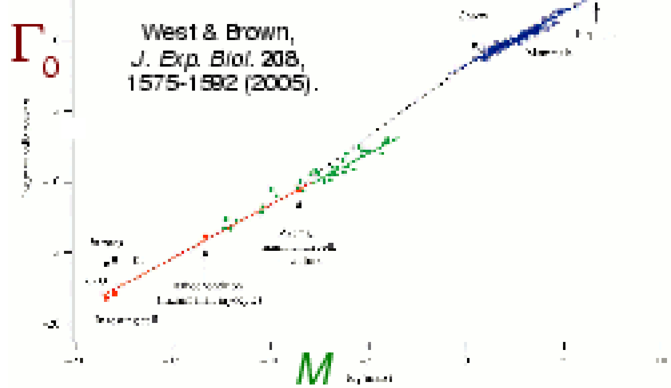


Allometry: Ahlborn, 2004 (Fig. 1.7, p. 12)

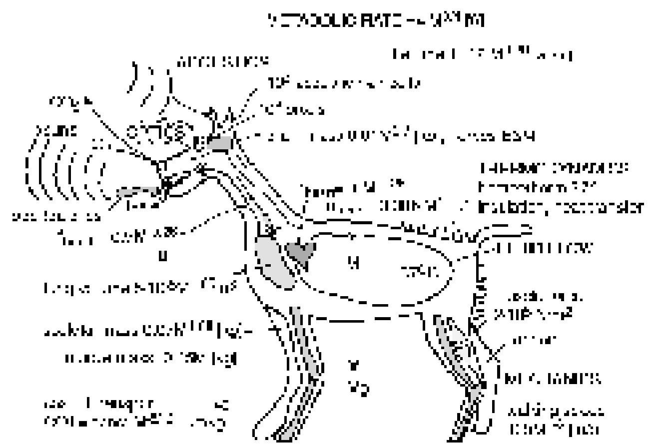


Allometry

West & Brown, *J. Exp. Biol.* 208, 1575-1592 (2005).



Improved Model (but still just a model)



Let's go do an Experiment in Allometry!

(Hebb Staircase Olympics)

The Emergence of Mechanics

(a mathematical fantasy)

- Newton's Second Law: $F = m\,a = dp/dt \equiv \dot{p}$

  [Dot Notation for Time Derivatives]

- Time Integral: $\int F(t)\,dt = \Delta p$

  [Impulse changes Momentum]

- Dot Product with r & Path Integral: $\int F(r) \cdot dr = \Delta(\frac{1}{2} m v^2)$

  [Work changes Kinetic Energy]

- Cross Product with r: $r \times F \equiv \Gamma = r \times \dot{p} = \dot{L}$

  [Torque changes Angular Momentum]