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)
10% Rule

Hill et al. 2004, Fig 4.9

Energy Available for:
- Growth, Maintenance, Reproduction
- SDA (specific dynamic action)

Metabolism

Male emperor penguin
>100 days w/o food when incubating eggs

Metabolism and Ecology

Metabolism

K vs. r selected (logistic curve)
- Larger animals invest proportionally less in reproduction
- Sperm is cheap
- Direct and indirect costs

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

Fetal teeth in caecilians

Metabolism and Ecology

Knut Schmidt-Nielsen 1997

Metabolism and Ecology

McGill University
Reproduction

(Hill et al. 5.5)
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).

Fish Example:
- Differences in vascular organization
- Tuna with warm, aerobic muscle medially
- Countercurrent blood flow (don’t lose heat to cold water across gills)

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
Metabolic heat production (chemical energy ‘lost’ as heat during metabolism)
- Endotherms
- Surface area to volume ratio
- Larger ectotherms can be heterothermic
  - Leatherback (Dermochelys coriacea)
  - Pythons (female brooding clutch)
  - Tuna and increased core temperature

Digestive Systems
- Transit time (time to digest), cost, and anatomy variable:
  - Food quality
  - Body size
  - Temperature (ectotherms)

Gut Plasticity
- Alter gut size, activity (reversible)
  - Sustained increased metabolism can increase bird gut length by 1/5
  - Mammals increase GI tract mass 3-4x post-hibernation

- Some infrequently-feeding snakes:
  - Intestine 2x larger within 2 days
  - Microvilli length and area up 400%
  - Glucose transport rate up as much as 22x
  - Other transporters also up-regulated (e.g., a.a. absorption)