Body temperature and heat flux pathways

- 2 Internal fluxes
- 4 External fluxes
  - Direction varies, or can be two-way.
SHIVERING → AN INEFFICIENT MECHANISM OF HEAT PRODUCTION

WHY INEFFICIENT?
'Heater' tissue in swordfish
modified muscle cells that have lost contractile machinery

↑ Efficiency as heat producers b/c chemical energy does not go to mechanical work
METABOLIC HEAT PRODUCTION

Brown Fat - Vascularized
- Dense Mitochondria
- Modified Mitochondrial Function

2NADH → ATP → ATP → ATP

\[ \frac{1}{2} \text{O}_2 \rightarrow \text{H}_2\text{O} + 2\text{NAD} \]

Normal: 3 ATP
 Trap 21 Kcal
 of 52 Kcal/mol

Rate of Catabolism

Progression Along E.T.C.
Conductance $= \frac{1}{\text{Insulation}}$

Autonomic response alters conductance via capillary dilation/constriction
HEAT CONVECTION

Piloerection alters dh due to conv. and cond.

'Frizzled chickens'
- Bred for feather structure.
- K
- BMR in response.
In both directions at once

Emissivity affects both emission and absorption

Temperature affects emission
**Evaporative Cooling: Sweat/Pant**

- Works only 1-way.
- Relationship w/ thermoreg. & osmoreg.

**Dik Dik Exp.**

- **NORMAL**
- **DEHYDRATED**

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**FIG 8.9**

**A. Exocrine glands**

- Blood
- Secretery tissue
- Primary fluid (ions + water)
- Acinis
- Reabsorption of ions
- Duct
- Vesicles

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**Figures**

1. Heat loss by sweating (W) vs. internal temperature (°C)
   - Low-humidity surrounding
   - High-humidity surrounding

2. Temperature vs. ambient temperature

3. Respiration rate vs. ambient temperature

4. Cutaneous evaporation vs. ambient temperature
Exploiting cool nasal passage: counter-current heat exchange

Thomson's Gazelle

Cool venous blood
Evaporation
Cooled blood to brain (~4°C)
Blood from heart (~43°C)

(CAROTID ARTERY)

CAROTID RETE

Thompson's gazelle
Carotid artery
Brain

Air 25°C 24% rh

Run 40 km h⁻¹

Temperature °C

0 10 20 30 40 50

Time (minutes)

25 mph for 15 minutes
Interaction between evaporative cooling and gas exchange / pH

Fig 16.31

↑ resp. rate
↑ CO₂ clearance
↑ blood pH

Fawing
Birds
Source of heat / type of temp. regulation

- **Endotherm**
- **Homeotherm**

- **Ectotherm**
- **Poikilotherm**

An ectotherm, but note that T_b can be held constant.

**16°30**

- Cat
- Opossum
- Platypus
- Echidna
- Lizard

Relation of T_b to metabolism.
HETEROTHERMY

TEMPORAL → CONSERVES H₂O + ENERGY

A

Dehydrated

Rectal temperature (°C)

Watered

Time (days)

B

Body temperature (°C)

Antelope ground squirrel

Dromedary camel

Time

M.12

Air = -16°C

- REGIONAL

CONSERVES ENERGY / H₂O

PROTECTS CORE
Warm Blooded/Cold Blooded Trade-off

Body Size → S/V

**Weasel**
*Mustelafromata*

**Wood Rat**
*Neotoma lepida*

**Spherical Animals**
- Not such a stupid assumption
- Two ways to ↓ S/V behaviorally
Body size as limit on endothermic homeothermy activity patterns

Increase in M.R. to balance

Oxygen consumption in relation to body weight in some small mammals. (After Pearson, 1948.)

Bergmann's rule

Wing length (≈ body size) in donny woodpeckers
WB/CB TRADE OFF: ENERGY = FOOD AVAILABILITY

POSITIVE FEEDBACK

ACTIVE HEAT PRODUCTION + CONS.

PASSIVE MECHANISMS
(A CONDUCTANCE)
(A CONVECTION)

ACTIVE HEAT LOSS

T_{\text{set}}: NO CORRECTION NEEDED

Upper curve = body temp
Lower curve = Met. rate

BMR of Endotherm > BMR of Ectotherm given equal size
BMR \Delta can be 17x, depends on T_b - T_a
1) **Direct Loss of H₂O in Homeotherms by Evap. Cooling**

2) **Indirect Effect**: BMR ↑ in Endotherms. High BMR → ↑ Respiration Rate → ↑ Resp. H₂O Loss

This interacts with body size effect so that small size limits being W:B, particularly if H₂O is limited.
WB/CA TRADE-OFF: AQUATIC VS. TERRESTRIAL ENVIRONMENT

AQUATIC MAMMALS - BLUBBER
HETEROTHERMIC FISH - SOLVING THE O₂/HEAT CAPACITY PROBLEM OF WATER

A Ectothermic

ECTO

B Heterothermic

HETEORO
Heterothermic fish: Bluefin tuna

Heat exchange by Reti Mirabile

Bird regional heterothermy.

Maximum muscle temperature (°C)

Water temperature (°C)

Water 13.3°

27.3°

23.3°

21.3°

23.3°

27.3°

31.4°

31.4°

38.3°

38.3°

38.3°

38.3°
Effect of Temp on rxn rates + M.R.

Q_{10} not constant w.r.t. T_a

Q_{10} typically 2 to 3
HYPOTHALAMIC CONTROL OF Tb AND HEAT FLUXES

1. SET POINT
2. INTEGRATION: CENTRAL + PERIPHERAL + SENSATION
3. NEG. FDBK
4. EFFECOR MECHANISMS
5. PROPORTIONAL CONTROL