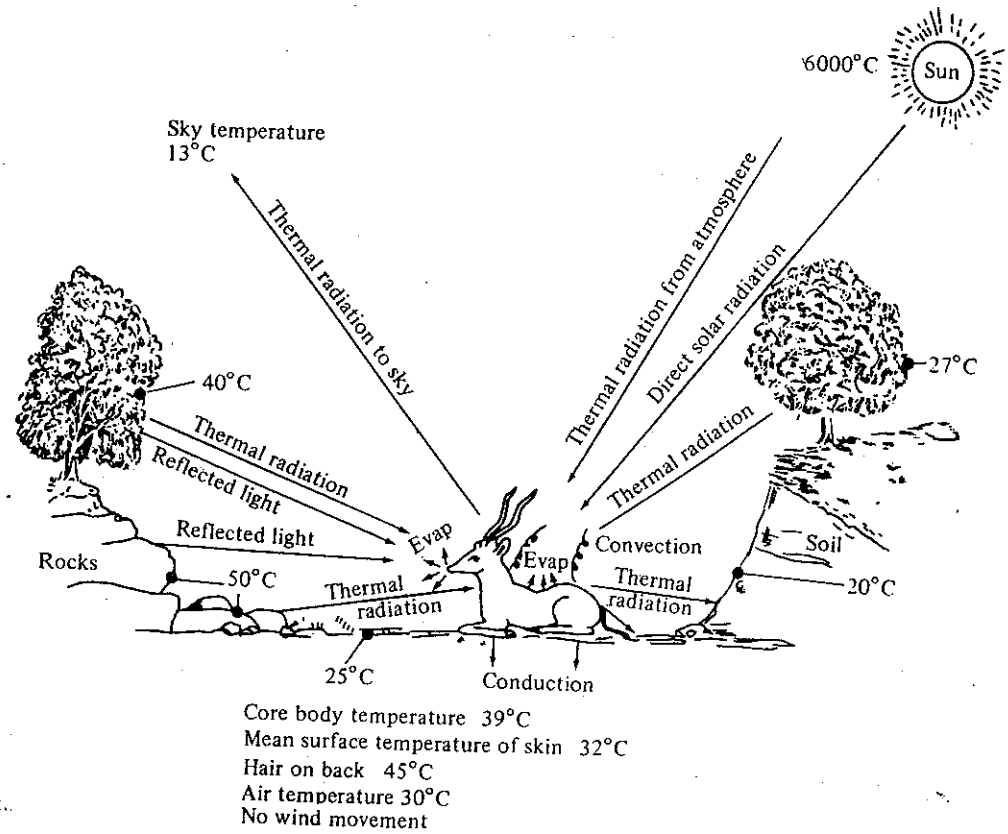
411: Thermoregulation

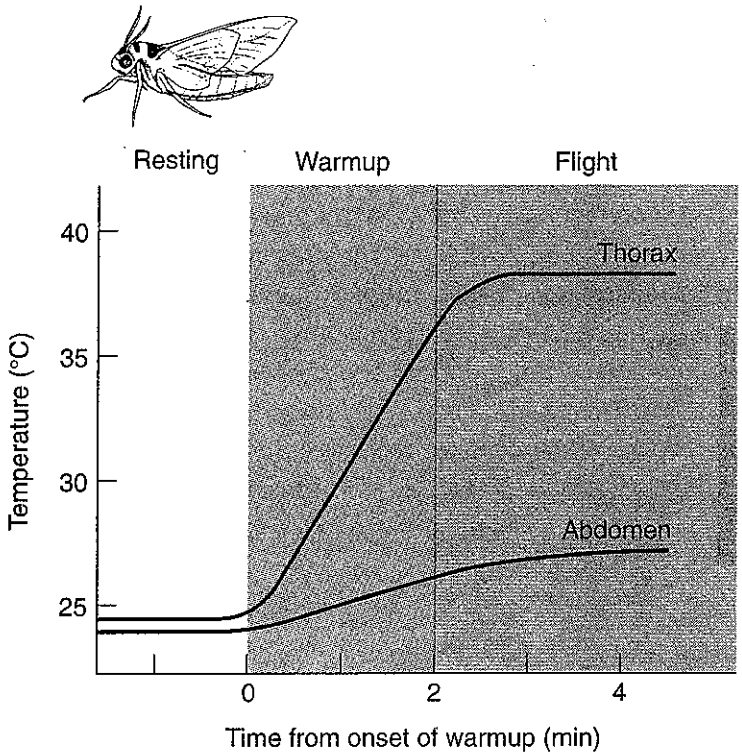


BODY TEMPERATURE AND HEAT FLUX PATHWAYS

- 2 INTERNAL FLUXES
- 4 EXTERNAL FLUXES
  - DIRECTION VARIES, OR CAN BE TWO-WAY.

Metabolic Heat Production

Fig 16.22

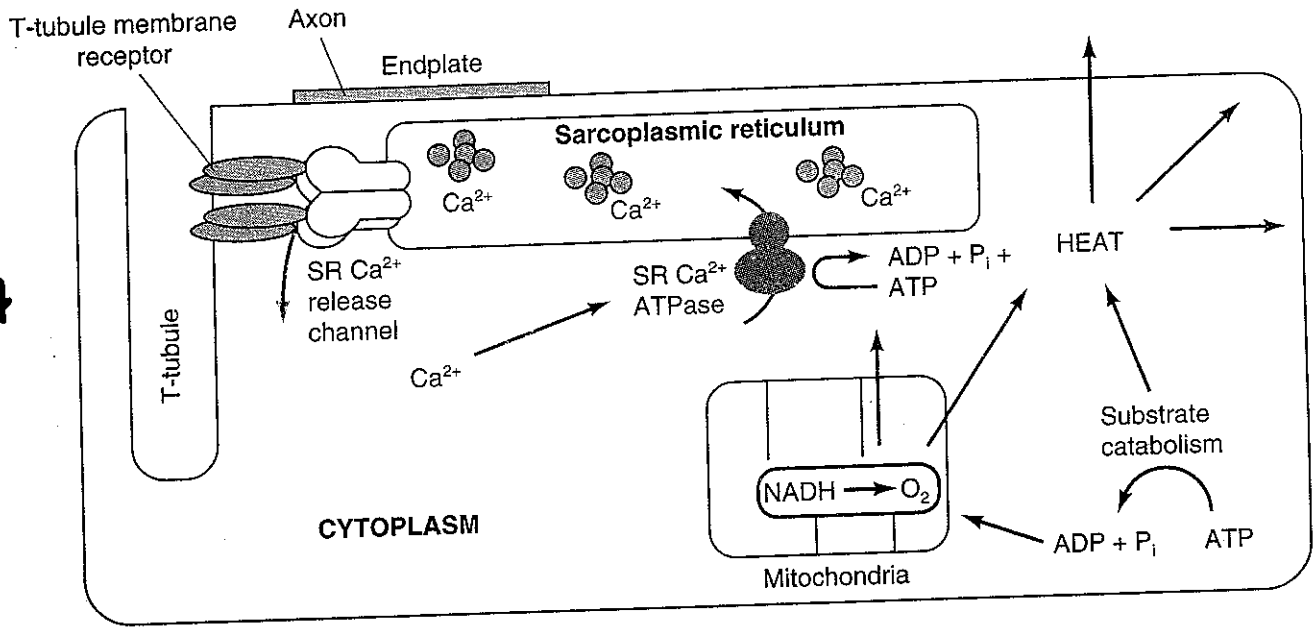


SHIVERING → AN INEFFICIENT MECHANISM OF <u>HEAT</u> PRODUCTION

WHY INEFFICIENT?

METABOLIC HEAT PRODUCTION

FIG 16.27



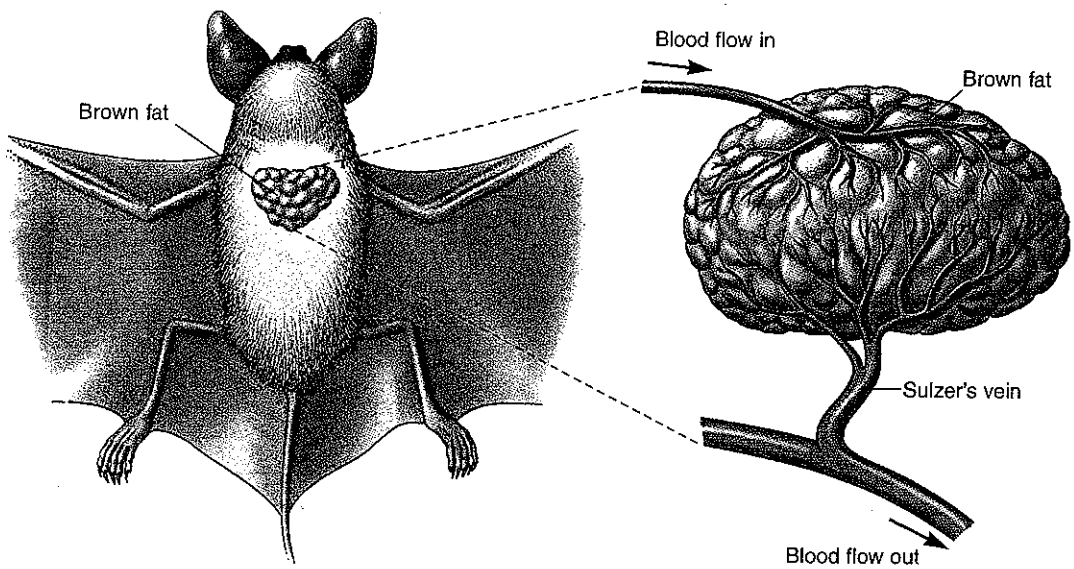
'HEATER' TISSUE IN SWORDFISH

MODIFIED MUSCLE CELLS THAT HAVE LOST CONTRACTILE MACHINERY

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

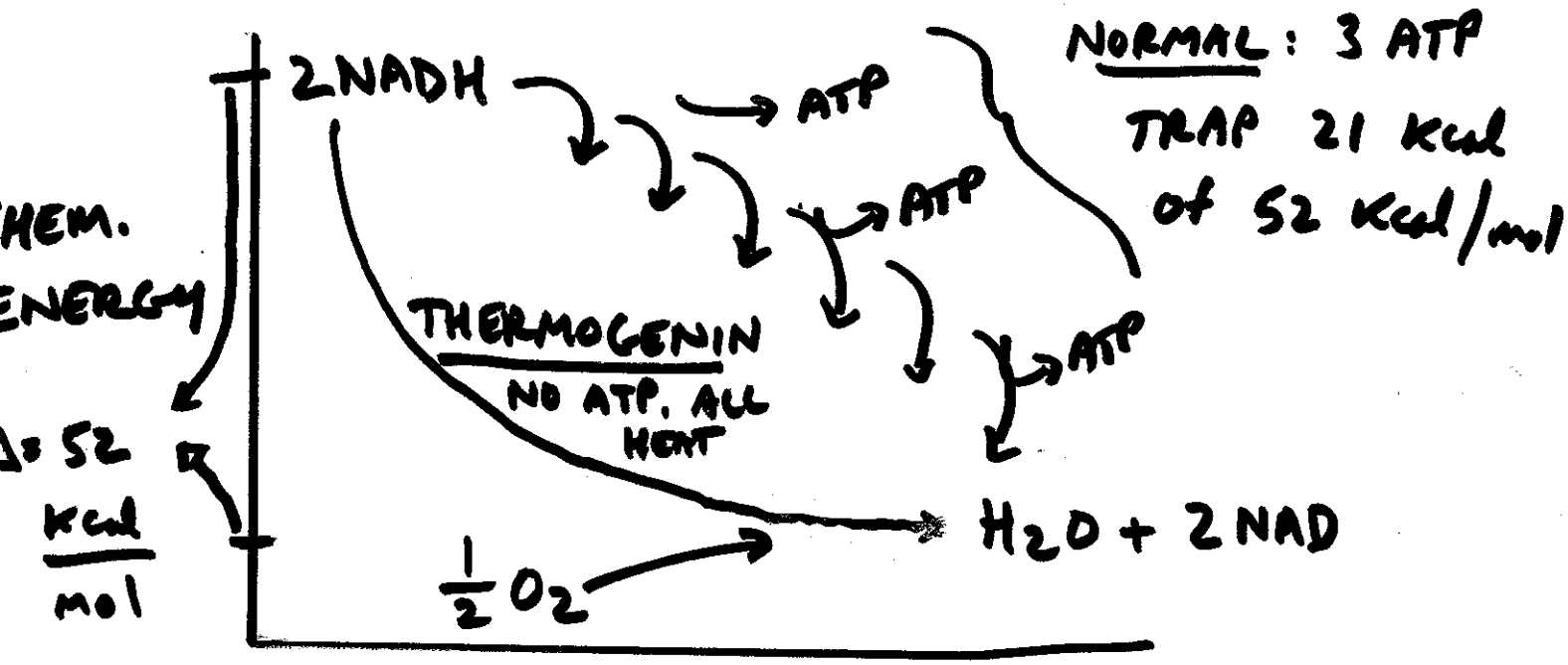
METABOLIC HEAT PRODUCTION

Fig 16.27



BROWN FAT
- VASCULARIZED
- DENSE MITOCHONDRIA
- MODIFIED MITOCHONDRIAL FUNCTION

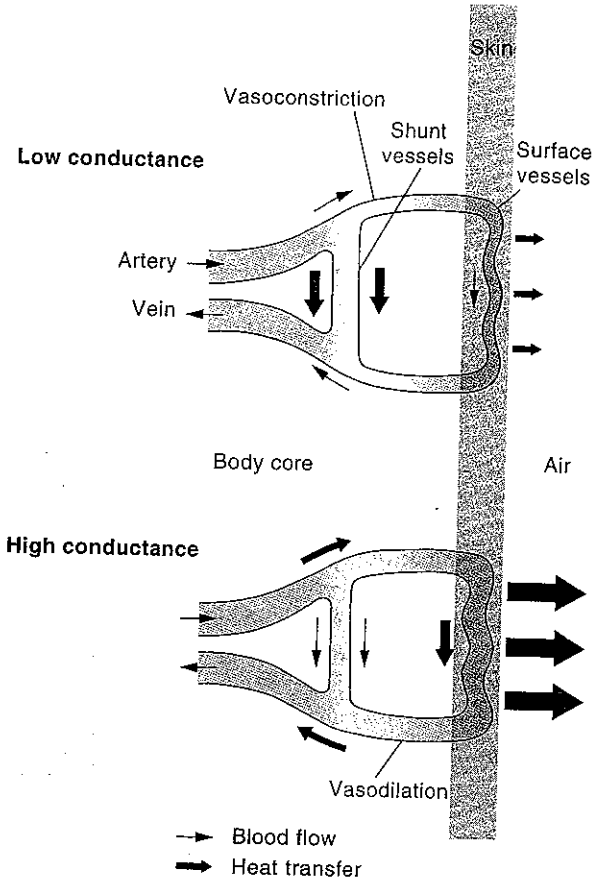
} RATE OF CATABOLISM



PROGRESSION ALONG E.T.C.

HEAT CONDUCTION

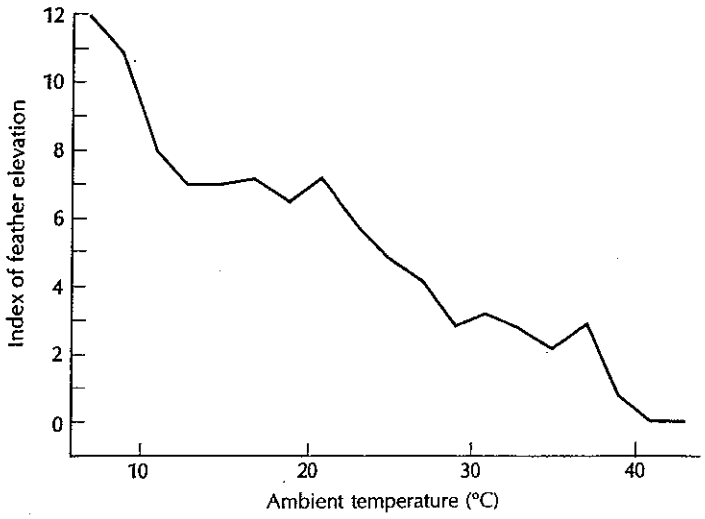
FIG 16-14



CONDUCTANCE $\propto \frac{1}{\text{INSULATION}}$

AUTONOMIC RESPONSE ALTERS CONDUCTANCE VIA CAPILLARY DILATION/CONSTRICTION

HEAT CONVECTION

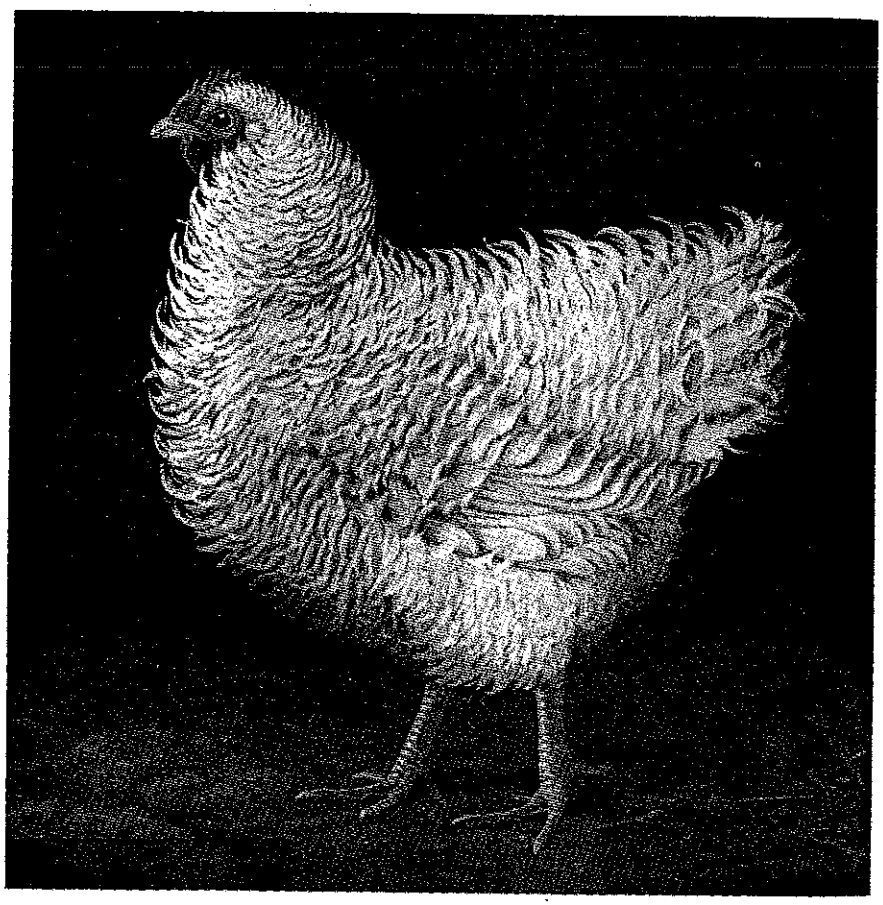


PILOERECTION

ALTERS ΔH

DUE TO CONV.

AND COND.

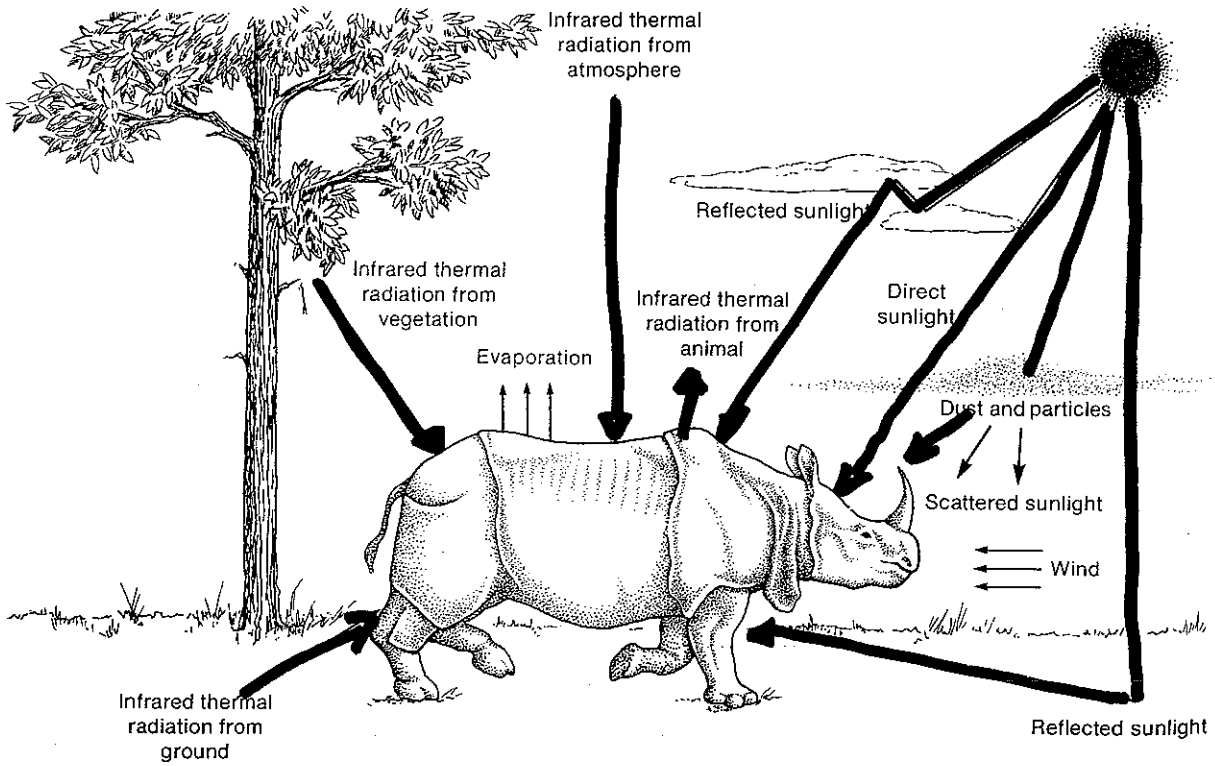


'FRIZZLED CHICKENS'

- Bred for feather structure.
- k ↑
- BMR ↑ in response.

RADIATION OF HEAT

FIG 16.13



ΔH BOTH DIRECTIONS AT ONCE

EMISSIVITY AFFECTS BOTH EMISSION + ABSORPTION

TEMPERATURE AFFECTS EMISSION

EVAPORATIVE COOLING: SWEAT / PANT

- works only 1-way.
- relationship b/wn Thermoreg. + osmoreg.

A Exocrine glands

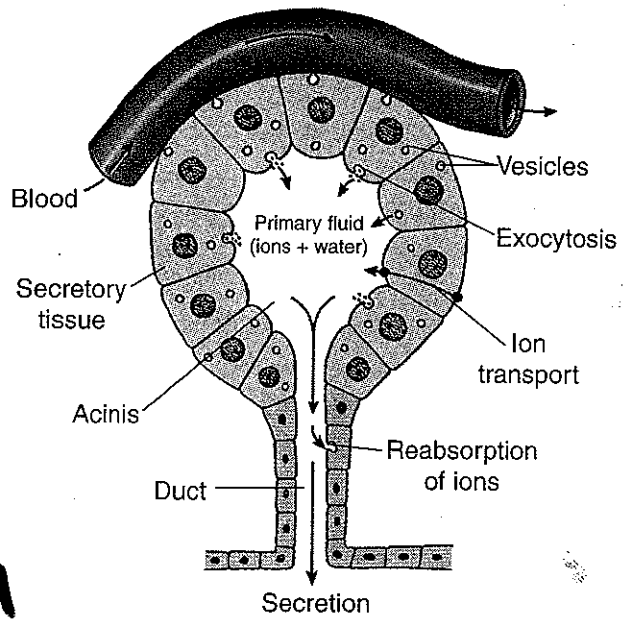


FIG 8.9

DIK DIK EXPT.

—o— NORMAL

—●— DEHYDRATED

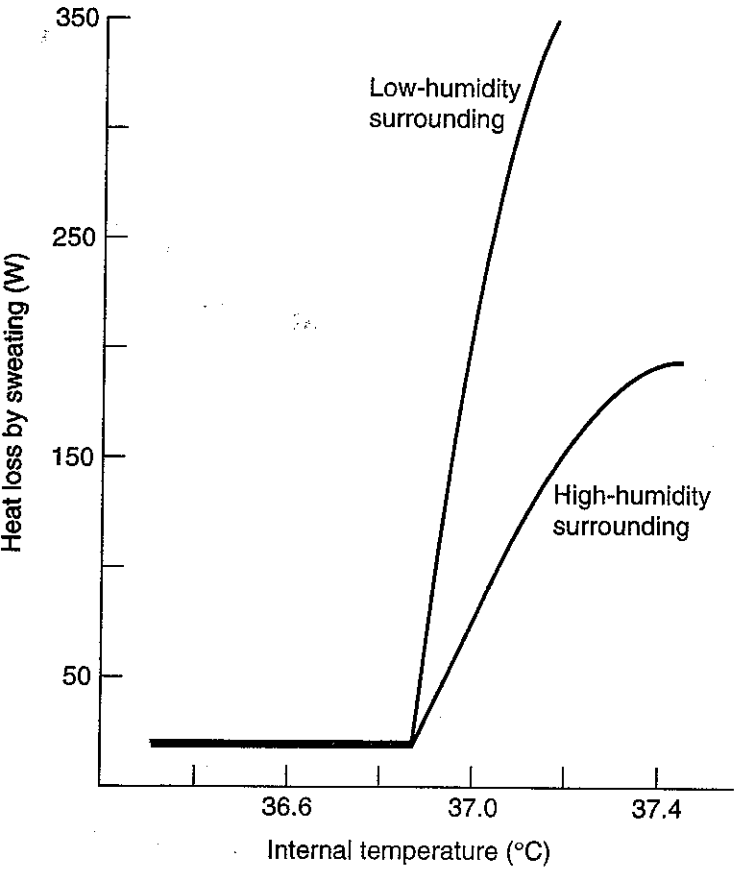
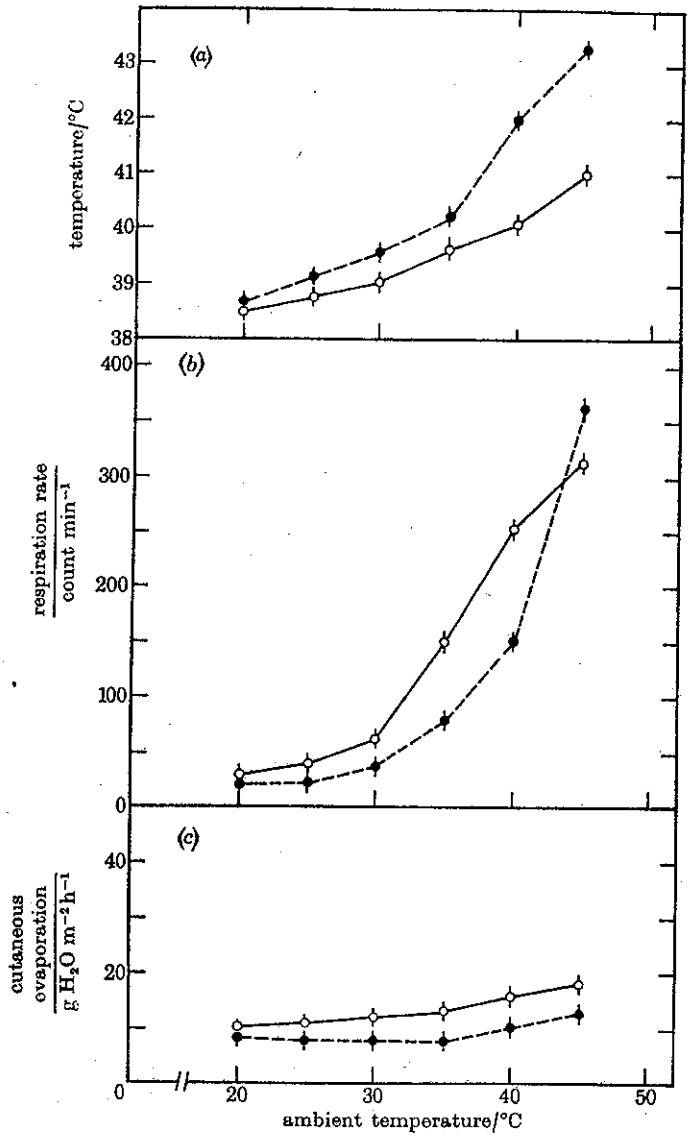
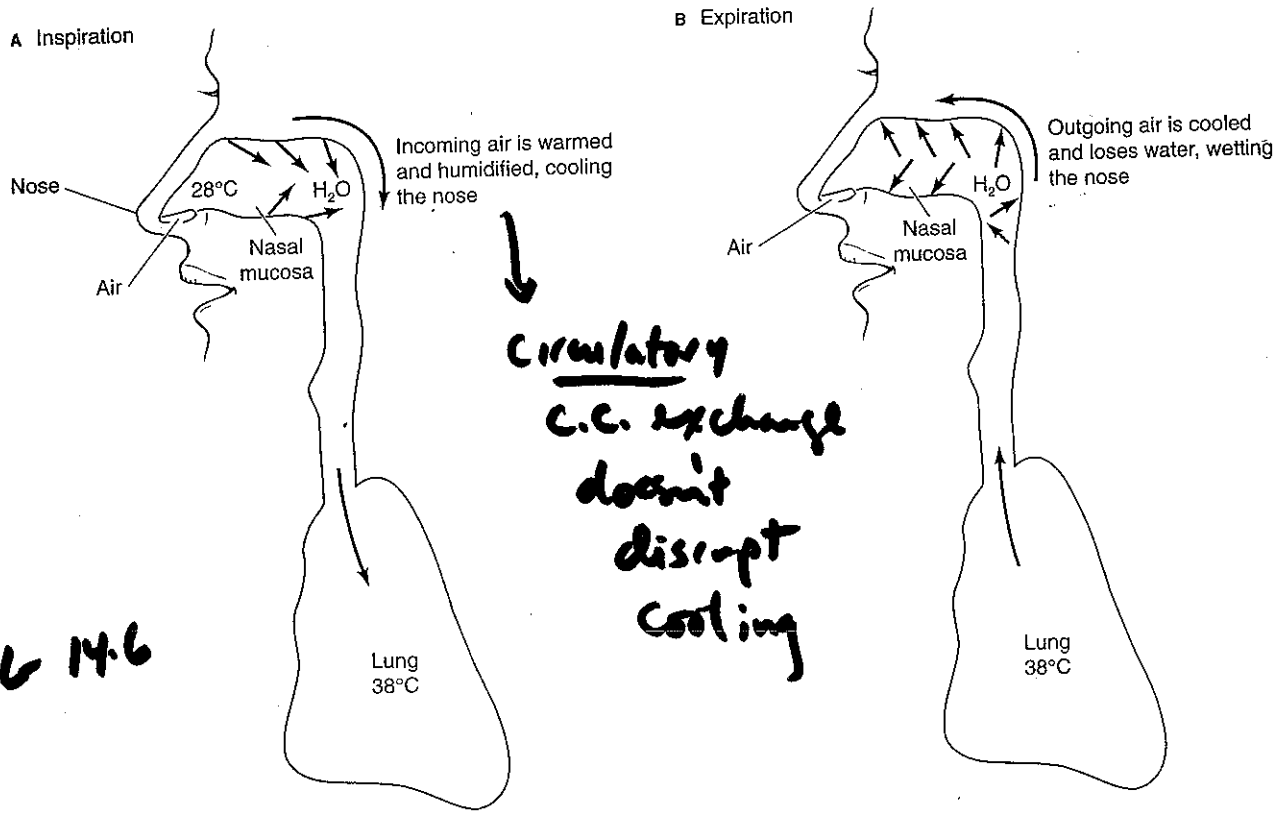


FIG 16.39



EVAPORATIVE COOLING: WATER CONSERVATION VIA TEMPORAL COUNTER-CURRENT MECHANISM



Circulatory
C.C. exchange doesn't disrupt cooling

FIG 14.6

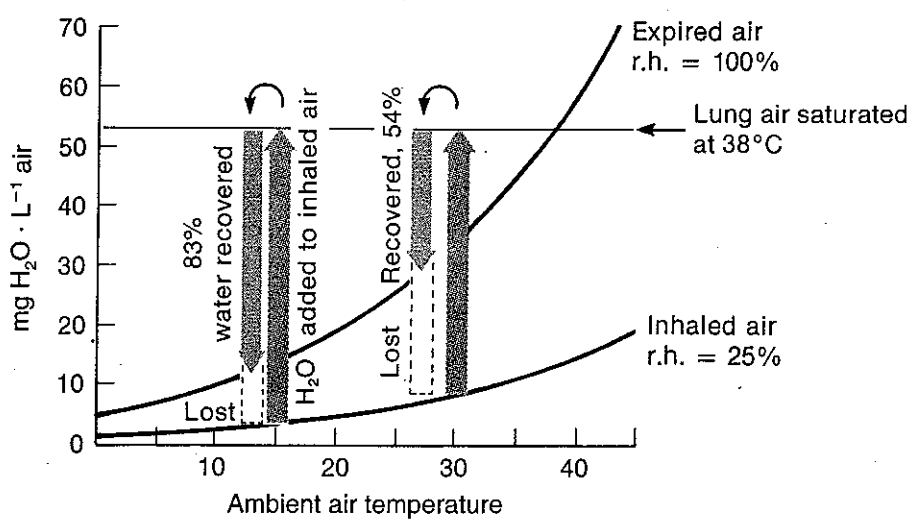


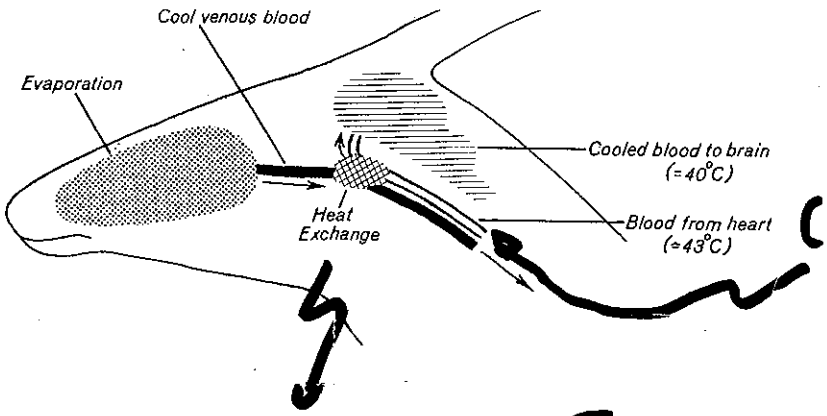
FIG 14.5

EXAMPLE WITH KANGAROO RAT AT TWO T_A'S.

30°C
15°C
} 25% REL. HUM.

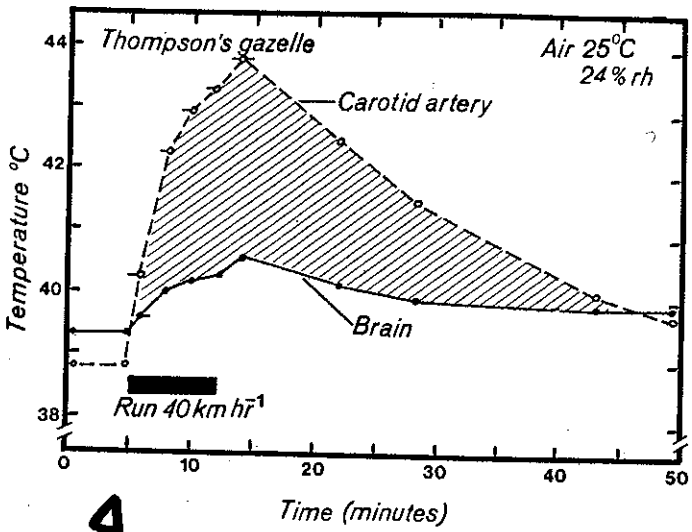
EXPLOITING COOL NASAL PASSAGE: COUNTER-CURRENT HEAT EXCHANGE

Thomson's Gazelle



(CAROTID ARTERY)

CAROTID RETE

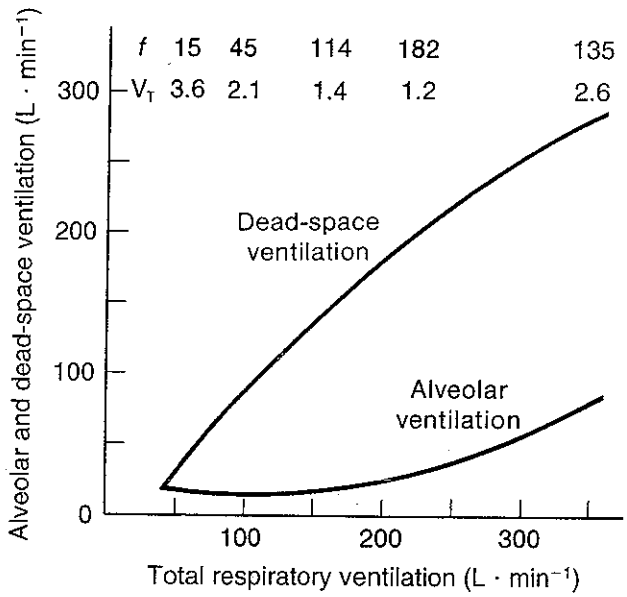


= 77°F

25 mph for 15 minutes

INTERACTION BETWEEN EVAPORATIVE COOLING AND GAS EXCHANGE / pH

Fig 16.31



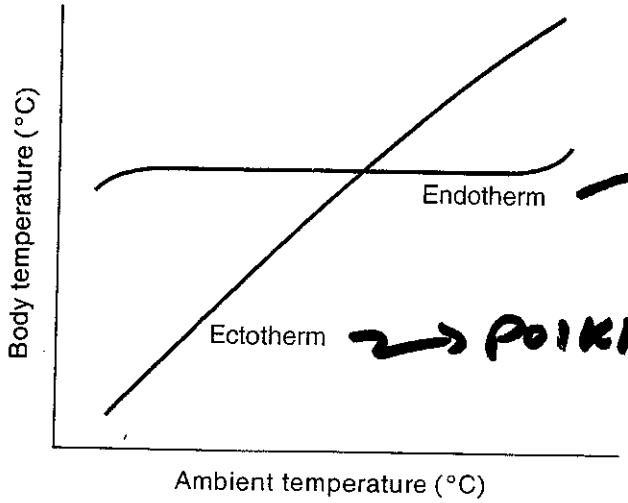
↑ resp. rate

↑ CO_2 clearance

↑ blood pH

FAINTING BIRDS

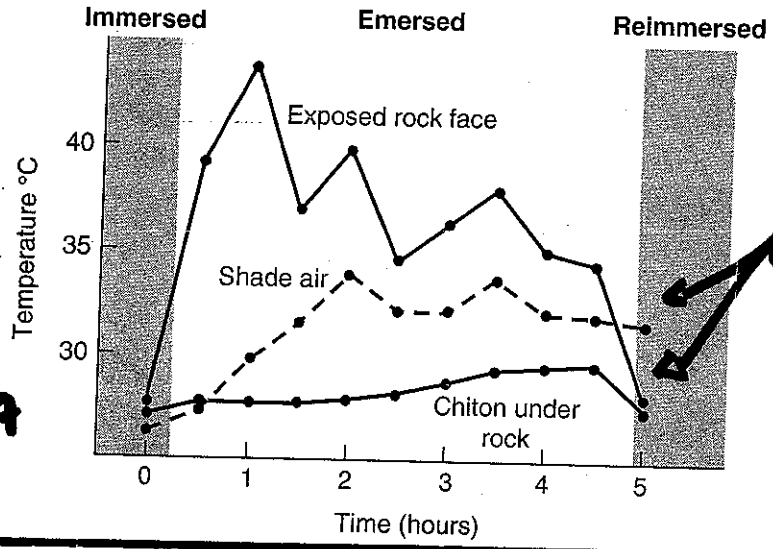
SOURCE OF HEAT / TYPE OF TEMP. REGULATION



→ HOMEOTHERM!

→ POIKILOTHERM!

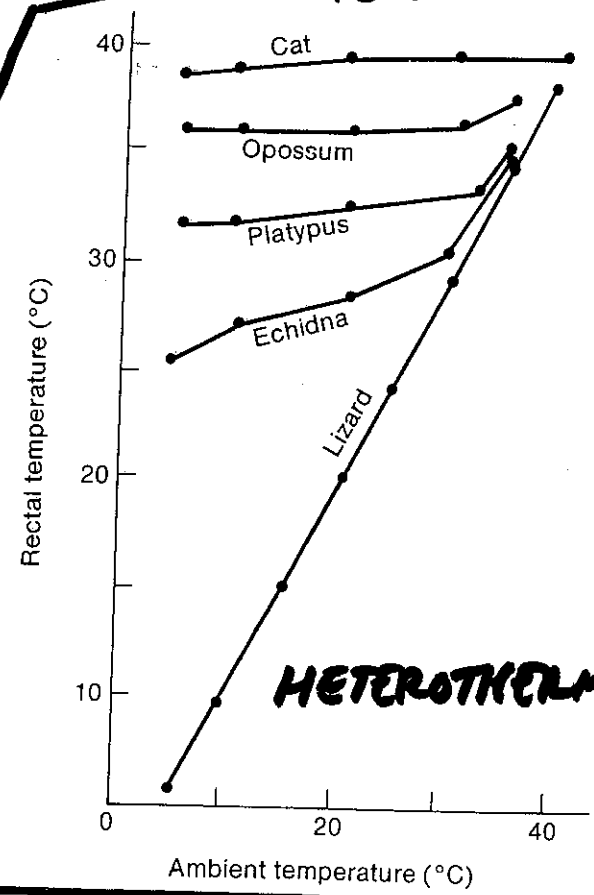
16.6



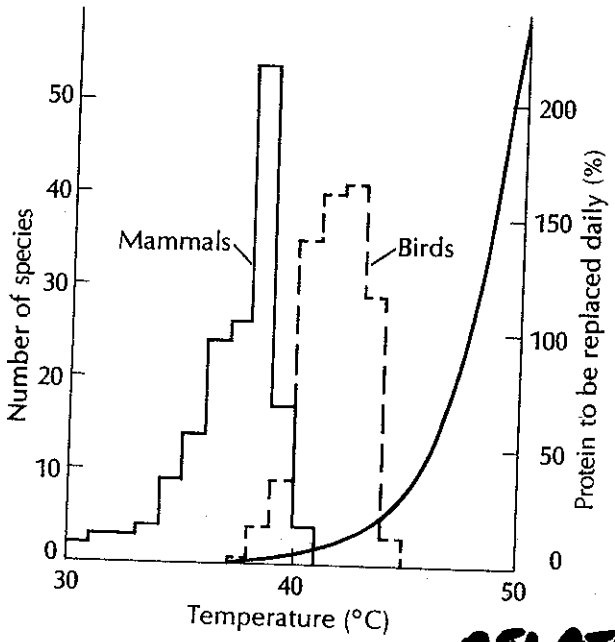
16.7

AN ECTOTHERM, BUT NOTE THAT T_B CAN BE HELD CONSTANT.

16.30



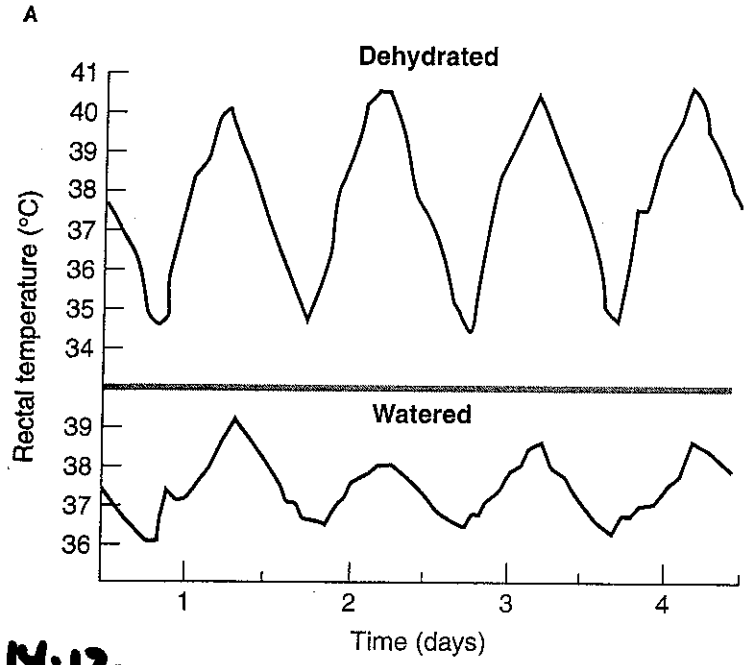
HETEROTHERMY

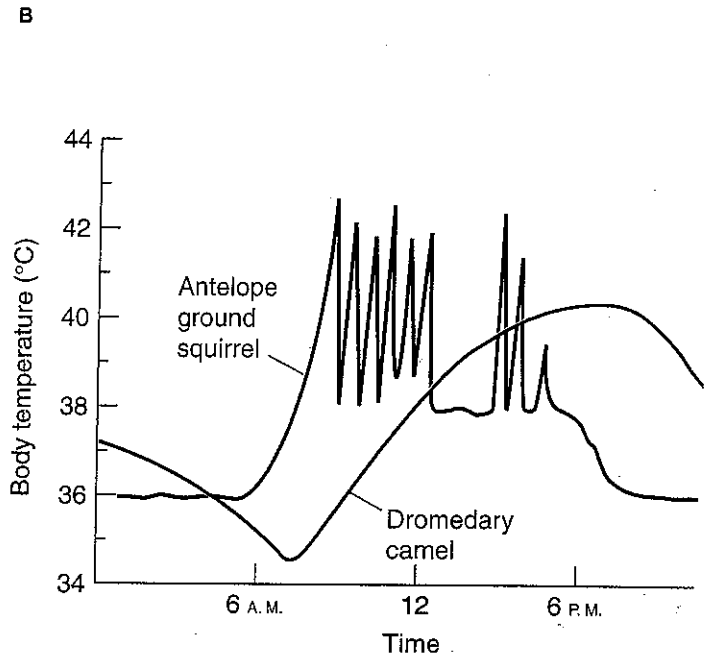


RELATION OF T_B TO DENATURING

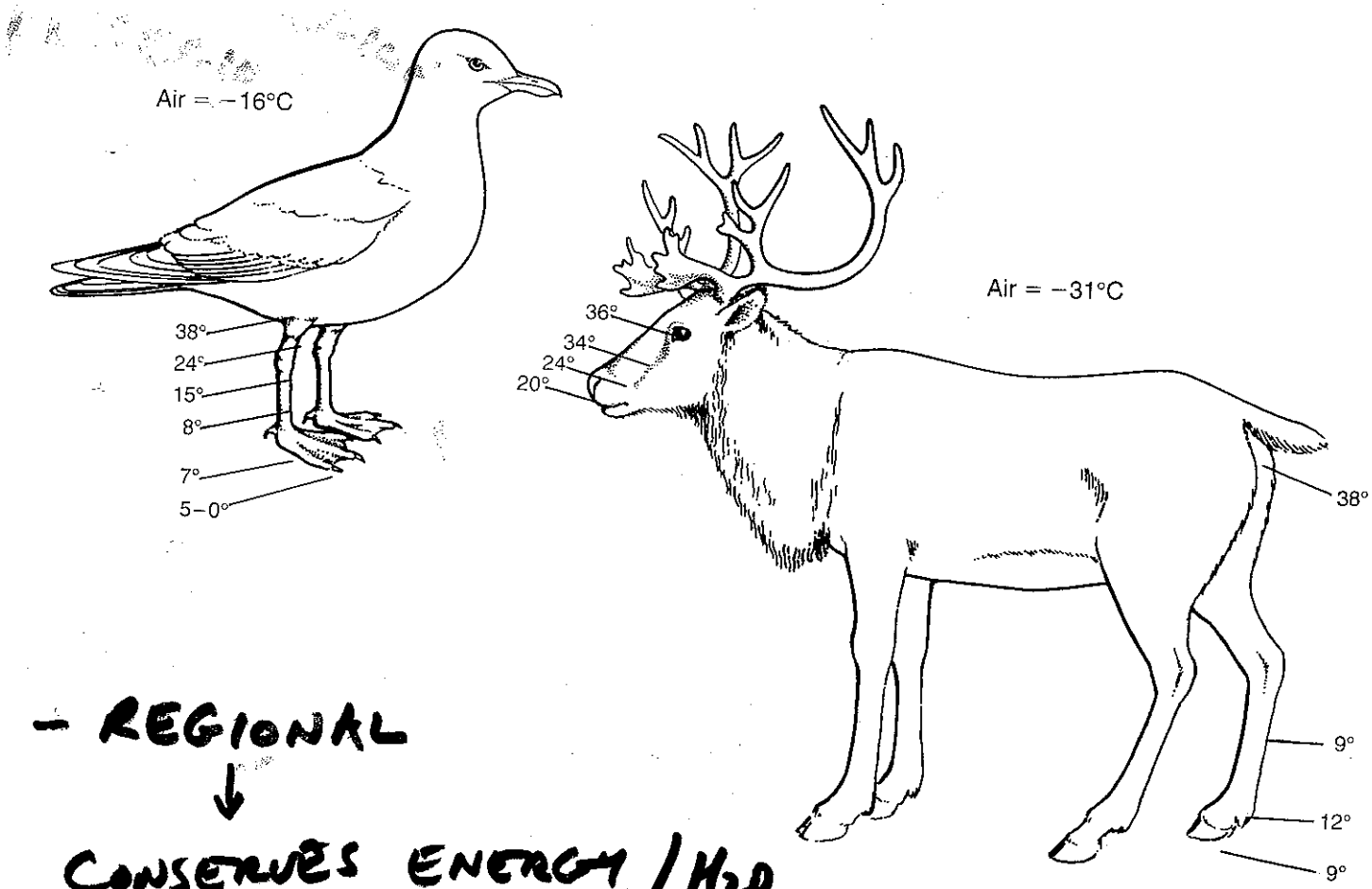
HETEROTHERMY

- TEMPORAL → CONSERVES H_2O + ENERGY





14.12



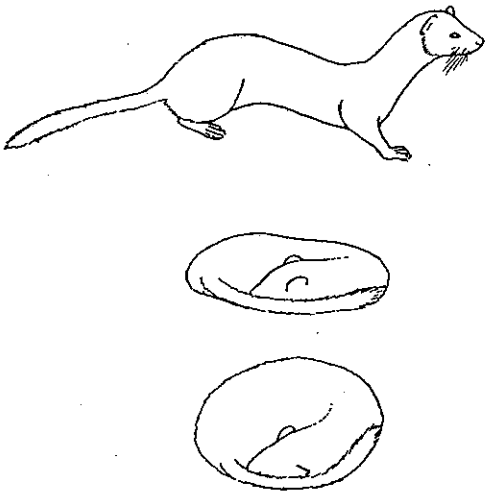
- REGIONAL
↓
CONSERVES ENERGY / H_2O
PROTECTS CORE

WARM BLOODED / COLD BLOODED TRADE-OFF

BODY SIZE → S/V

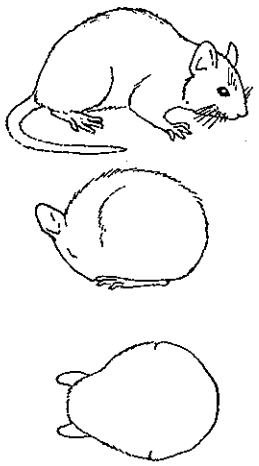
WEASEL

Mustela frenata



WOOD RAT

Neotoma lepida

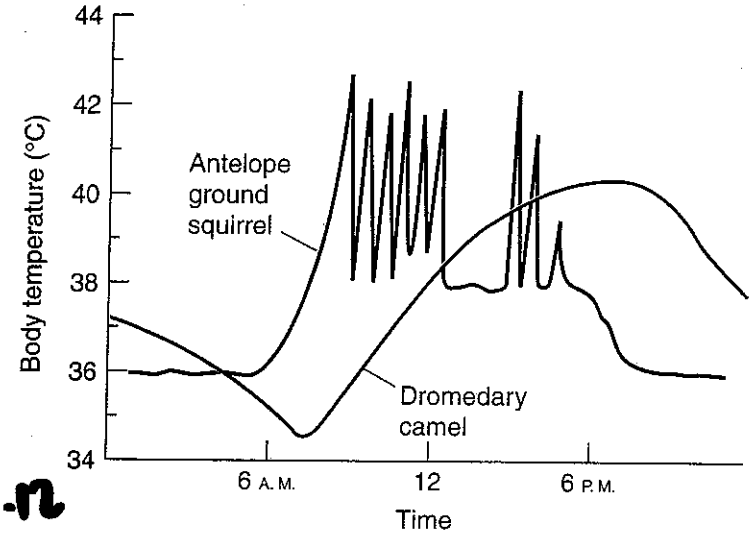


SPHERICAL ANIMALS

- NOT SUCH A STUPID ASSUMPTION
- TWO WAYS TO ↓ S/V BEHAVIORALLY

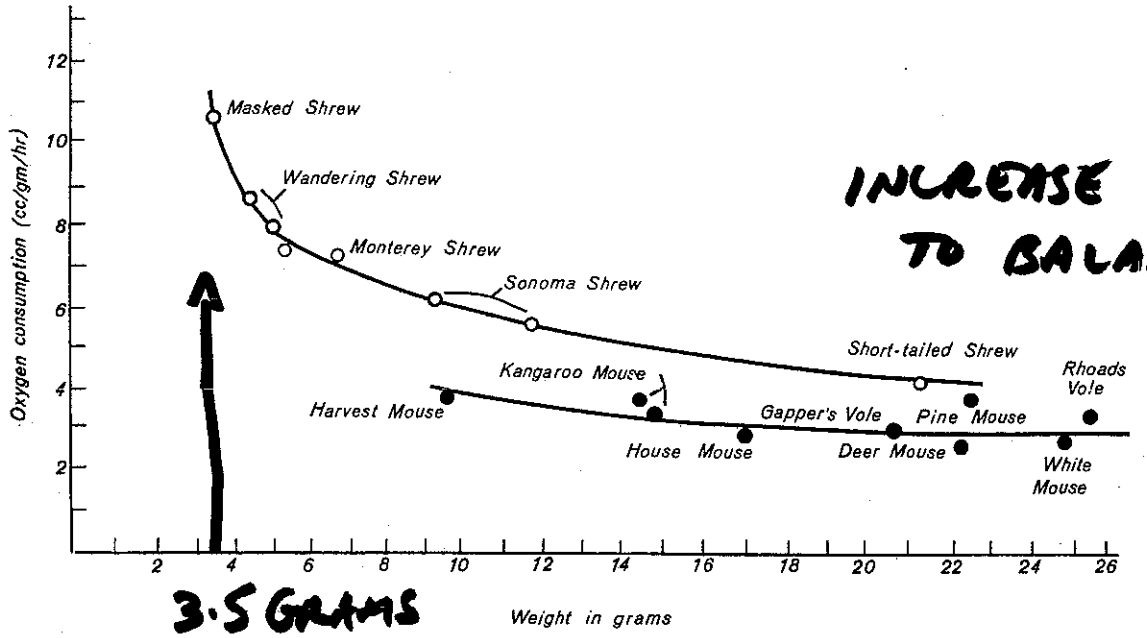
BODY SIZE AS LIMIT ON ENDOTHERMIC HOMEOTHERMY

ACTIVITY PATTERNS



4-12

INCREASE IN M.R. TO BALANCE

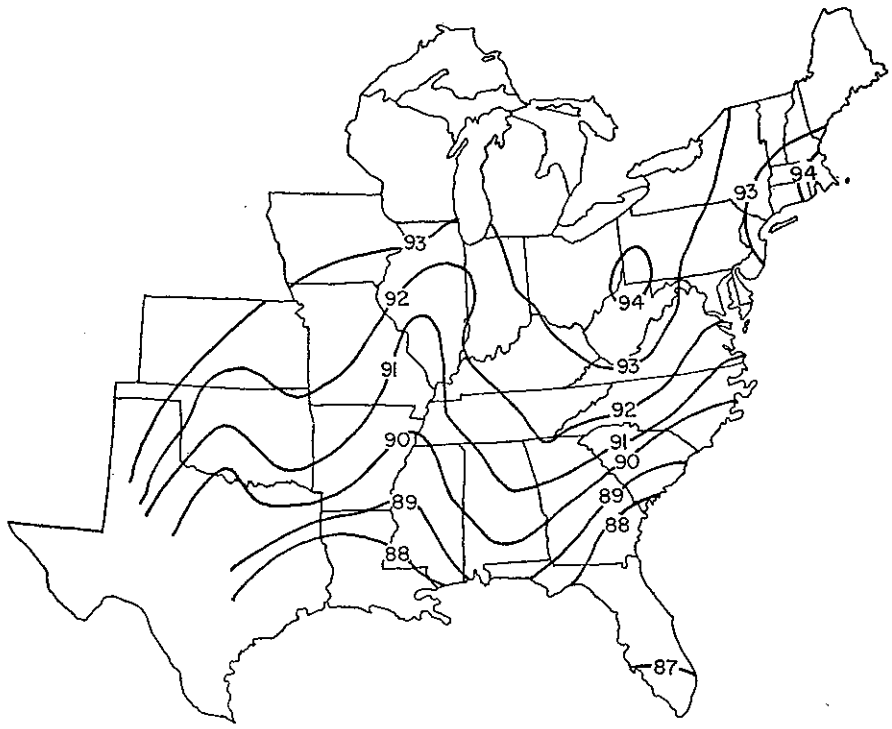


3.5 GRAMS

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

BERGMANN'S RULE

WING LENGTH (≈ BODY SIZE) IN DOWNY WOODPECKERS



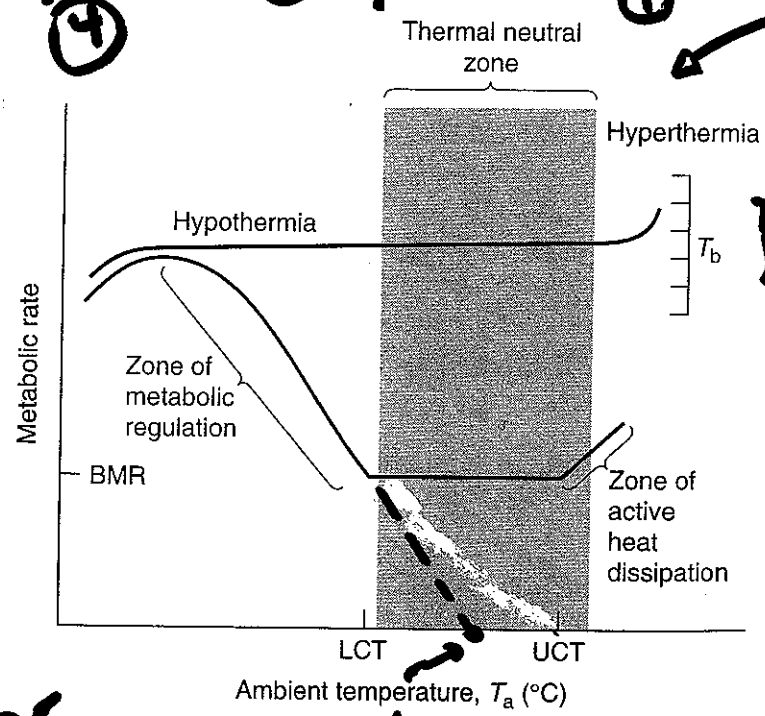
WB/CB TRADE OFF: ENERGY = FOOD AVAILABILITY

POSITIVE FEEDBACK

ACTIVE HEAT PRODUCTION + CONS.

PASSIVE MECHANISMS (Δ CONDUCTANCE) (Δ CONVECTION)

ACTIVE HEAT LOSS



37-43°C

16.25

T_{SET}: NO CORRECTION NEEDED

UPPER CURVE = BODY TEMP

LOWER CURVE = MET. RATE

BMR of Endotherm > BMR of Ectotherm given equal size

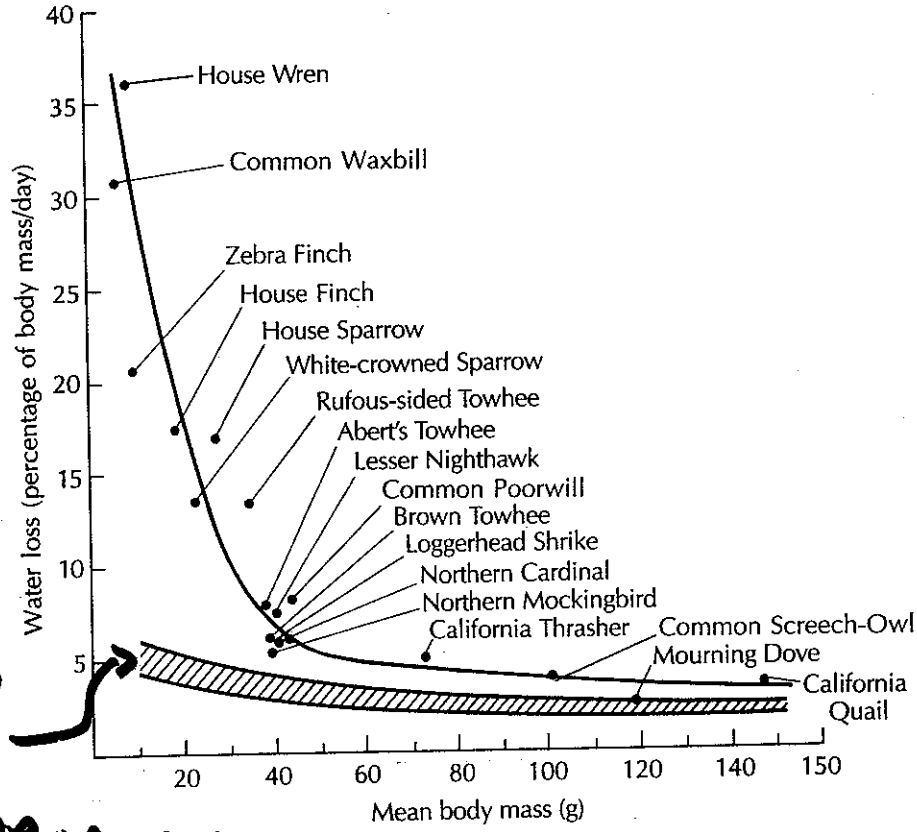
BMR Δ can be 17x. Depends on $T_b - T_a$

WB/CB TRADE OFF : AVAILABILITY OF WATER

1) DIRECT LOSS OF H_2O IN HOMEOTHERMS BY EVAP. COOLING

2) INDIRECT EFFECT. BMR ↑ IN ENDOTHERMS.
HIGH BMR → ↑ RESPIRATION RATE
↑ RESP. H_2O LOSS

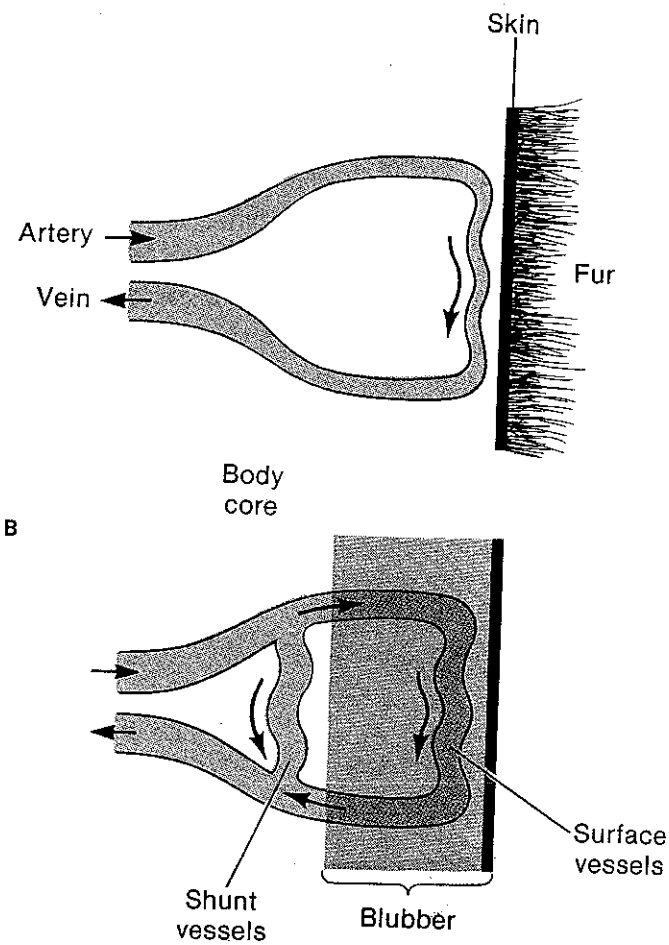
THIS INTERACTS WITH BODY SIZE EFFECT SO THAT SMALL SIZE LIMITS BEING W.B. PARTICULARLY IF H_2O IS LIMITED



RESP. H_2O LOSS VS. BODY SIZE IN BIRDS

PARTIAL OFFSET BY METABOLIC WATER PRODUCTION

WB/CB TRADE-OFF: AQUATIC VS. TERRESTRIAL ENVIRONMENT



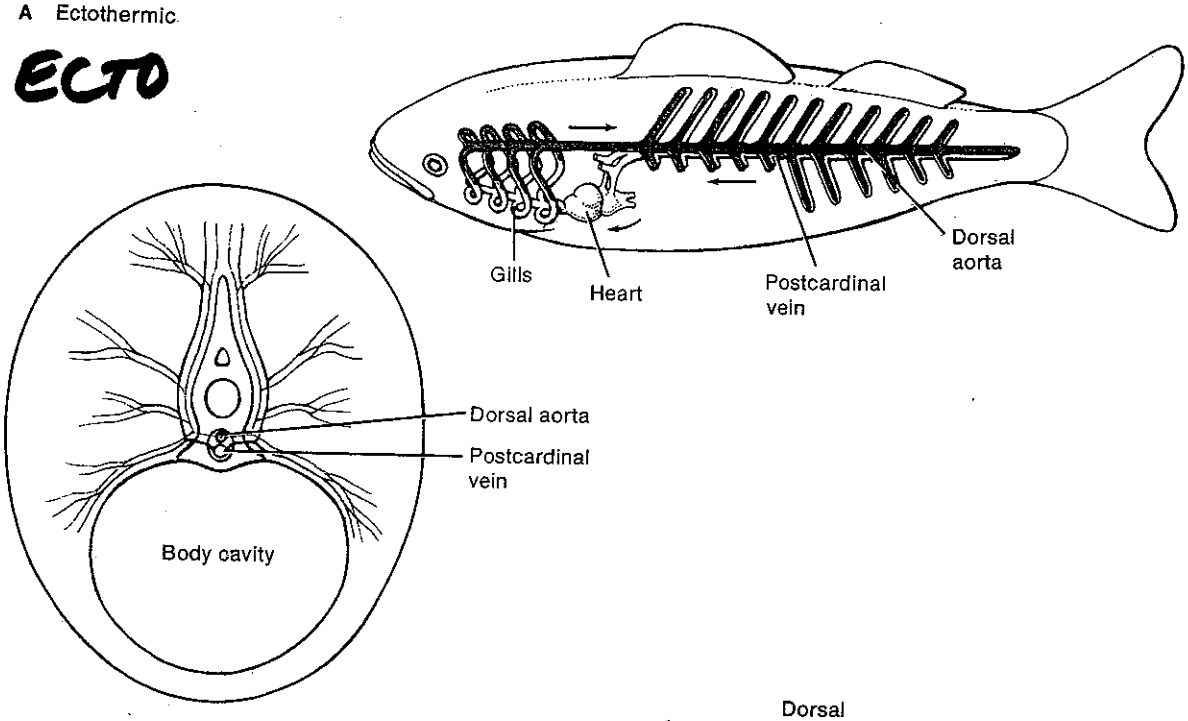
AQUATIC MAMMALS
- BLUBBER

16-15

HETEROTHERMIC FISH – SOLVING THE O_2/HEAT CAPACITY PROBLEM OF WATER

A Ectothermic

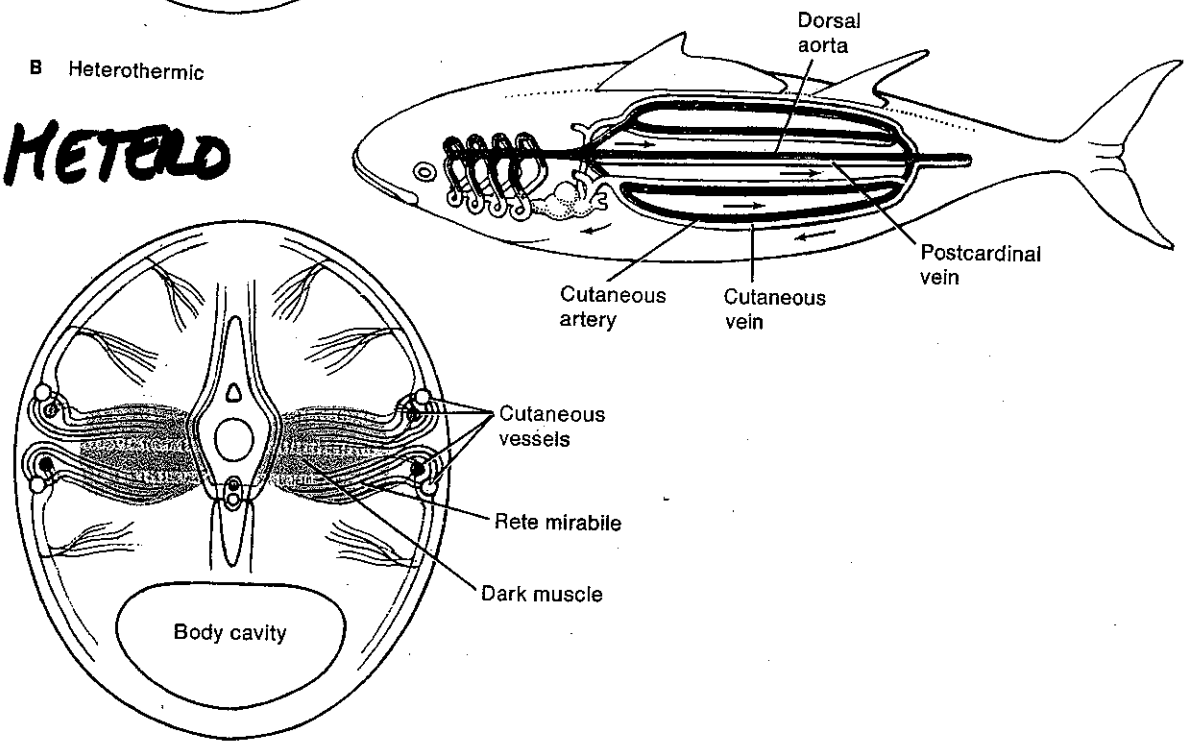
ECTO



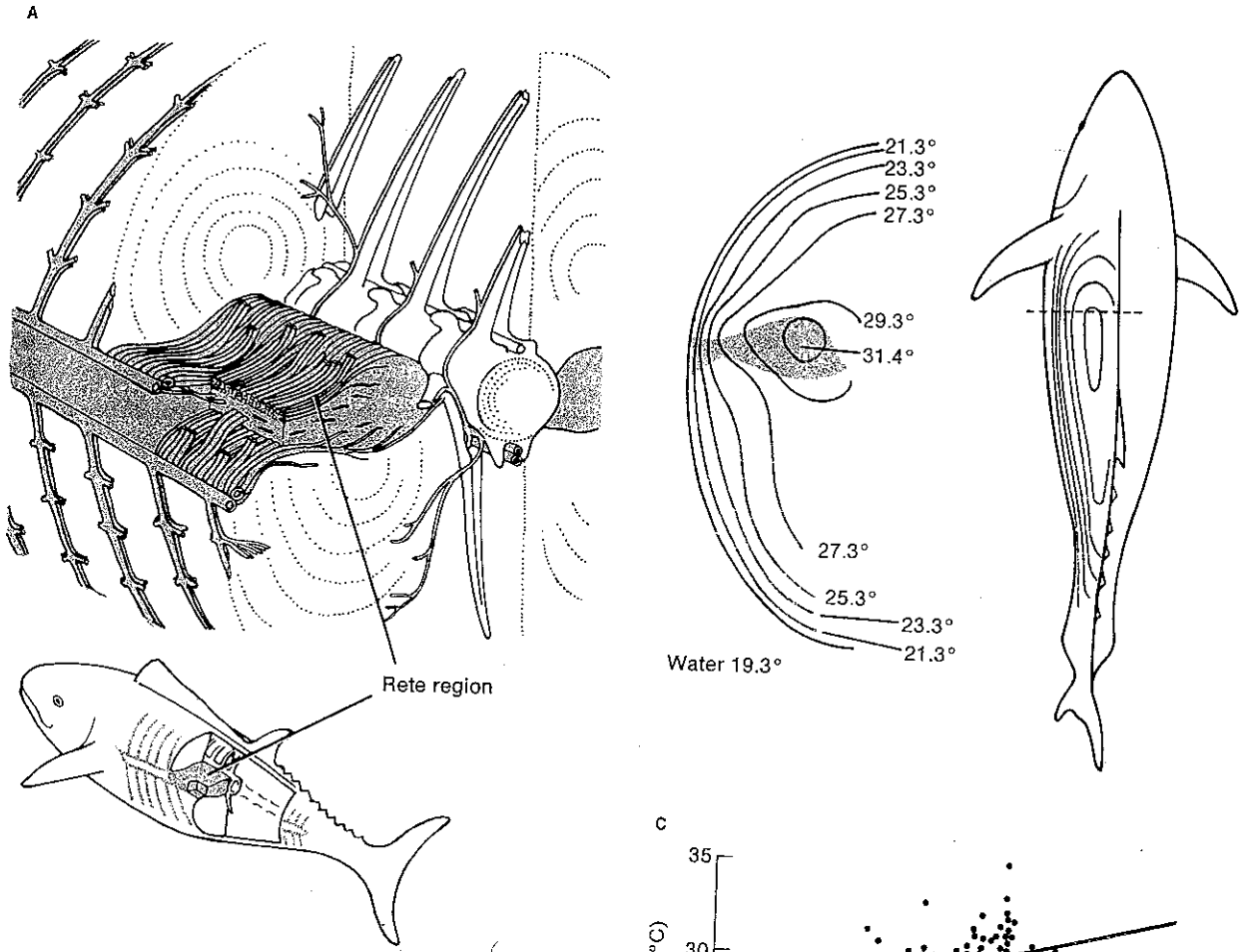
6-23

B Heterothermic

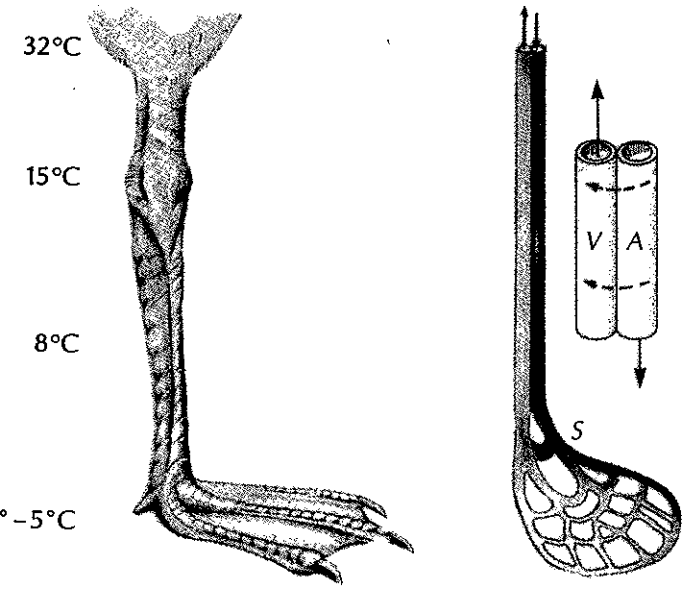
HETERO

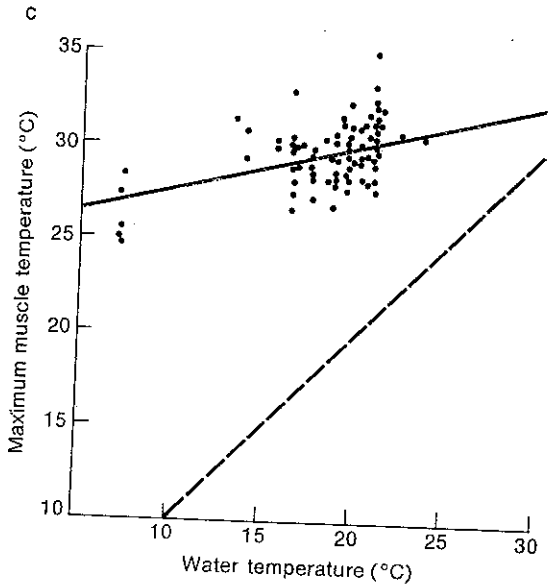


HETEROTHERMIC FISH: BLUEFIN TUNA
HEAT EXCHANGE BY RETE MIRABILE



1624

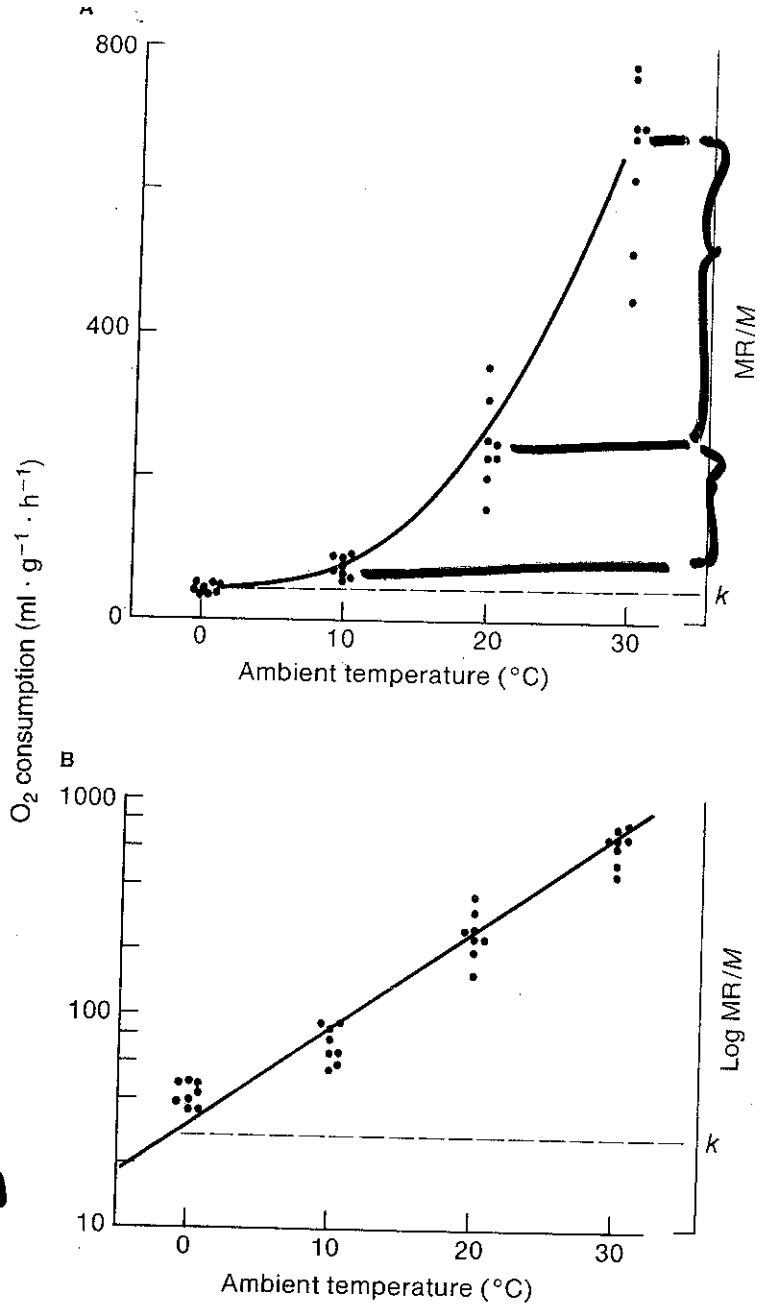




BIRD REGIONAL HETEROTH.
ALMOST SAME MECHANISM

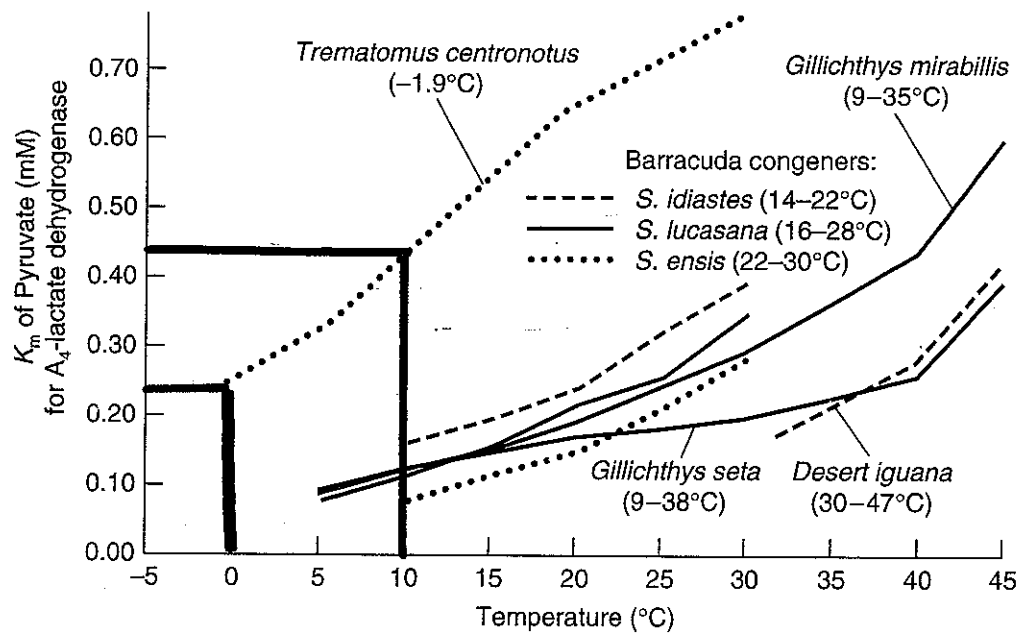
Effect of Temp on rxn rates + M.R.

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



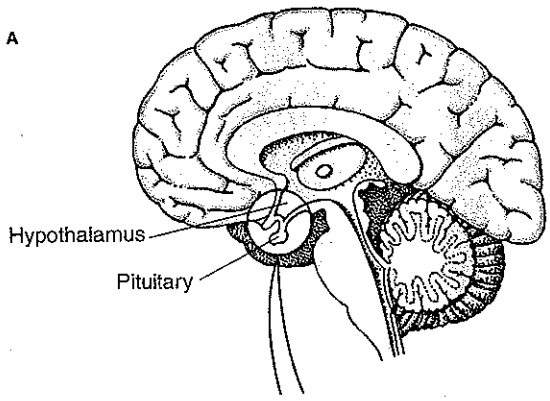
16-9

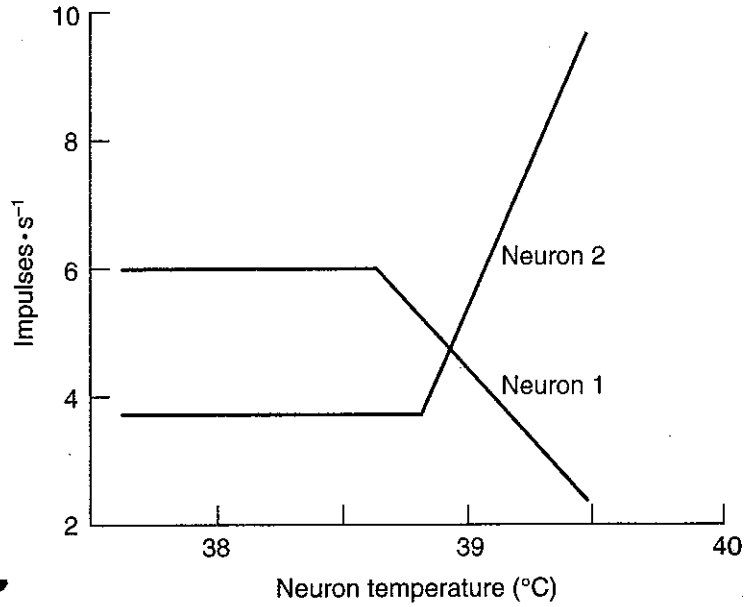
16-19



Q_{10} typically 2 to 3

HYPOTHALAMIC CONTROL OF T_B AND HEAT FLUXES

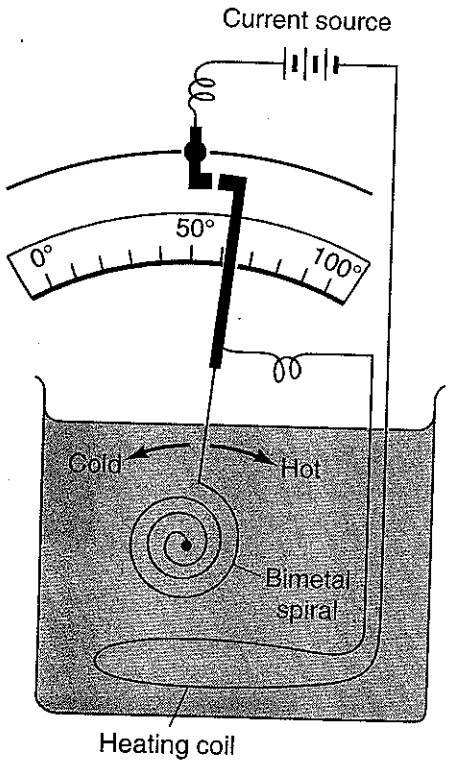




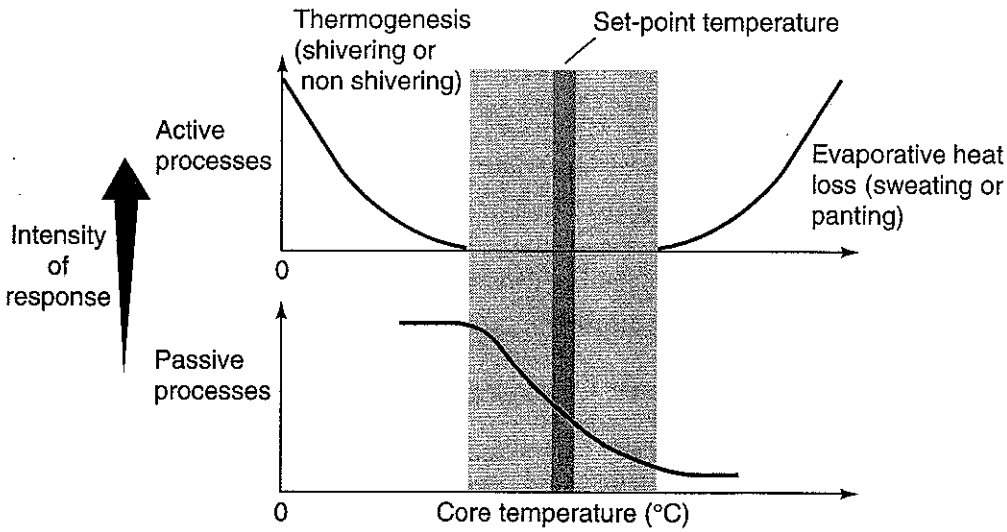
① SET POINT

② INTEGRATION + SENSATION — CENTRAL / PERIPHERAL

③ NEG. FDBK



④ EFFECTOR MECHANISMS



⑤ PROPORTIONAL CONTROL