Temperature and Performance

<figure for lizards and environment, plants and environment>

biophysics is largely from [Gates, 1980]

$M + Q_a = \Re + C + \lambda E + G + X$

energy in:

M rate of production of metabolic energy

Q_a the amount of radiation absorbed by the surface

energy out:

$\Re$ radiation emitted by the surface of the organism $\Re = \varepsilon\sigma[T_s+273]^4$

ε=emissivity (how grey is the grey body), σ= Stefan-Botlzmann const $5.673X10^{-8}$ $Wm^{-2}K^{-4}$

C energy transferred by convection $C = h_c[T_{surface}-T_{air}]$; $C = k_1\frac{V^n}{D^m}[T_s-T_a]$

h_c=convection coef=$k_1\frac{V^n}{D^m}$∝roughness*$\frac{\text{velocity fluid}^n}{\text{diameter object}^m}$

λE energy exchanged by evaporation or condensation $\lambda E = \lambda(T_{surface})E(T_s,T_a,h,r^{-1})$

λ=latent heat of vaporization, h=relative humidity, r is the resistance of pathway

G energy exchanged by conduction with substrate $G=kA\frac{T_{surface}-T_{substrate}}{d}$

k=conductivity, A=area, d=thickness of (skin)

X energy put into or taken out of storage in the organism what the organism does

In terms of energy out, different organisms differ in the losses

<figure with losses for plants and animals>

Note that most losses by lizards are due to $\Re$ radiation emitted & secondarily by convection

Note that most losses by plants are due to $\Re$ radiation emitted & secondarily by evaporation

Beginning with the fundamental source for energy, let us consider Radiation from the sun and radiative losses.

IN for lizards:

M rate of production of metabolic energy is trivial for ectotherms the major gains are from

Q_a absorptance by the animal

absorptance vs reflectance, absorptance=1-reflectance

function of color and spectral properties of the organism.

Could be a trade-off between color matching and heat collected.

Early in the morning as the animal heats up, it wants to be dark. As high noon approaches, the animals may want to be very little and thus is considerably lighter than the surface material.

<figure representative color matching, Uma, Callisaurus dracanoides>

Losses are largely due to $\Re$ radiation emitted which is emissivity which changes! What is a blackbody -- a body that is so black it absorbs all, most things reflect some radiation so $\varepsilon<1$. A small hole in a box is considered a black surface because radiation entering the aperture is trapped within and has a remote chance of getting out. The aperture appears black to observers. When the enclosure is maintained at a constant temperature a certain amount of radiation per second passes out through the aperture -- "blackbody radiation" -- that exhibits a special relationship to the temperature of the enclosure (enterior of a forest with a closed canopy approximates a black body). rate of emission is given by the Stefan-Boltzmann Law:

$$\Re = \varepsilon\sigma[T_s+273]^4$$

emissivity=absorptivity of the surface or a good absorber is a good emitter (vice versa).
radiation varies in wavelength.

What about the source of radiation
<spectral distribution of different kinds of sunlight>
must match up energy sources * absorptance (1-reflectance).

Could also gain or loose energy by conduction/convection

If it is energy gains it is largely by conduction

Nomenclature [Pough, 1982 #199]

ectothermy (vs endothermy): body temperature regulation depends primarily on absorption of heat energy from the environment. (**poikilotherm** -- large variations in temperature, also used is **eurythermal** or **stenothermal**, c.f., euryhaline)

heliothermy: thermoregulation obtained by basking under the sun

thigmothermy: thermoregulation achieved by contact with a warm surface.

Preferred temperature as selected in a laboratory thermal gradient.

Activity body temperature as observed in the wild

Thermal effects on reptile physiology
<figure for lots of metabolic traits, from Huey>
consequences for a thermal conformer vs thermoregulator

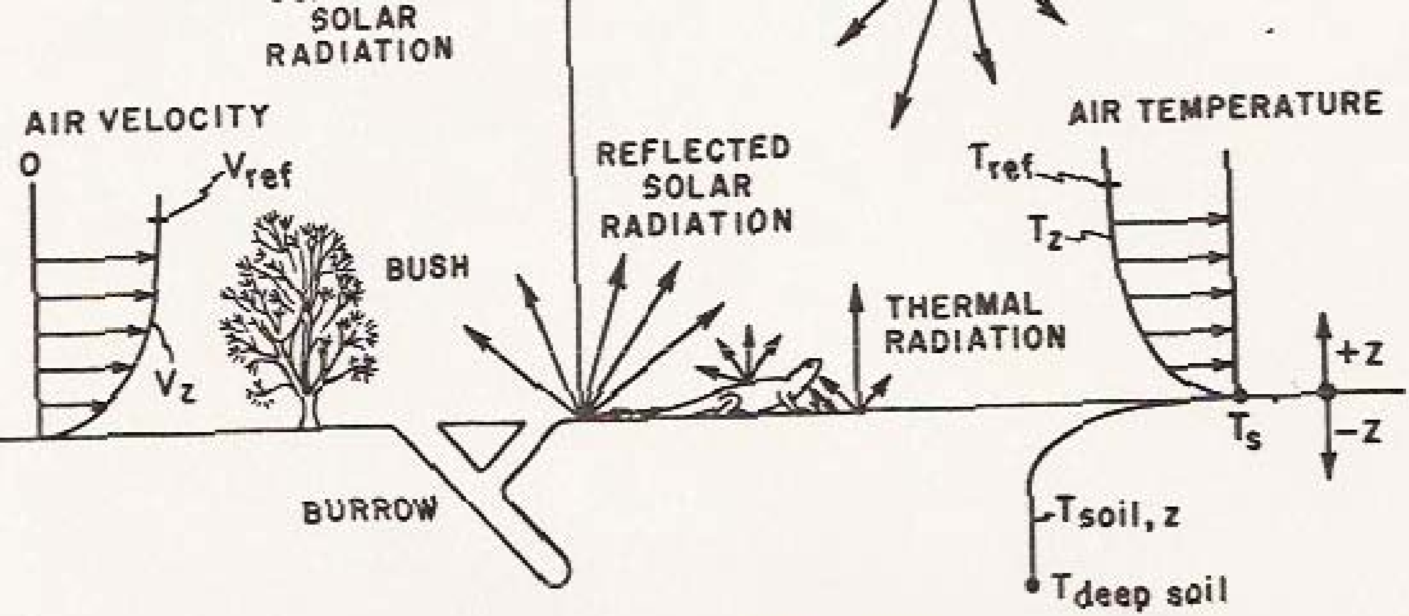
Parameters of the performance curve
optimal temperature, thermal performance breadth, tolerance range
CT_{max}=critical thermal maximum, CT_{min}=critical thermal minimum

Thermal conformer: Variation in body temperature that parallels variation in ambient temperature

versus

Thermoregulator: Maintenance of body temperature within a specified and usually narrow range when ambient temperatures extend above and below that range.
<show the classic thermal conformers vs thermoregulators>

Beyond performance, then there are lethal limits and sub-lethal limits.



[illegible] for the soil surface and a lizard.