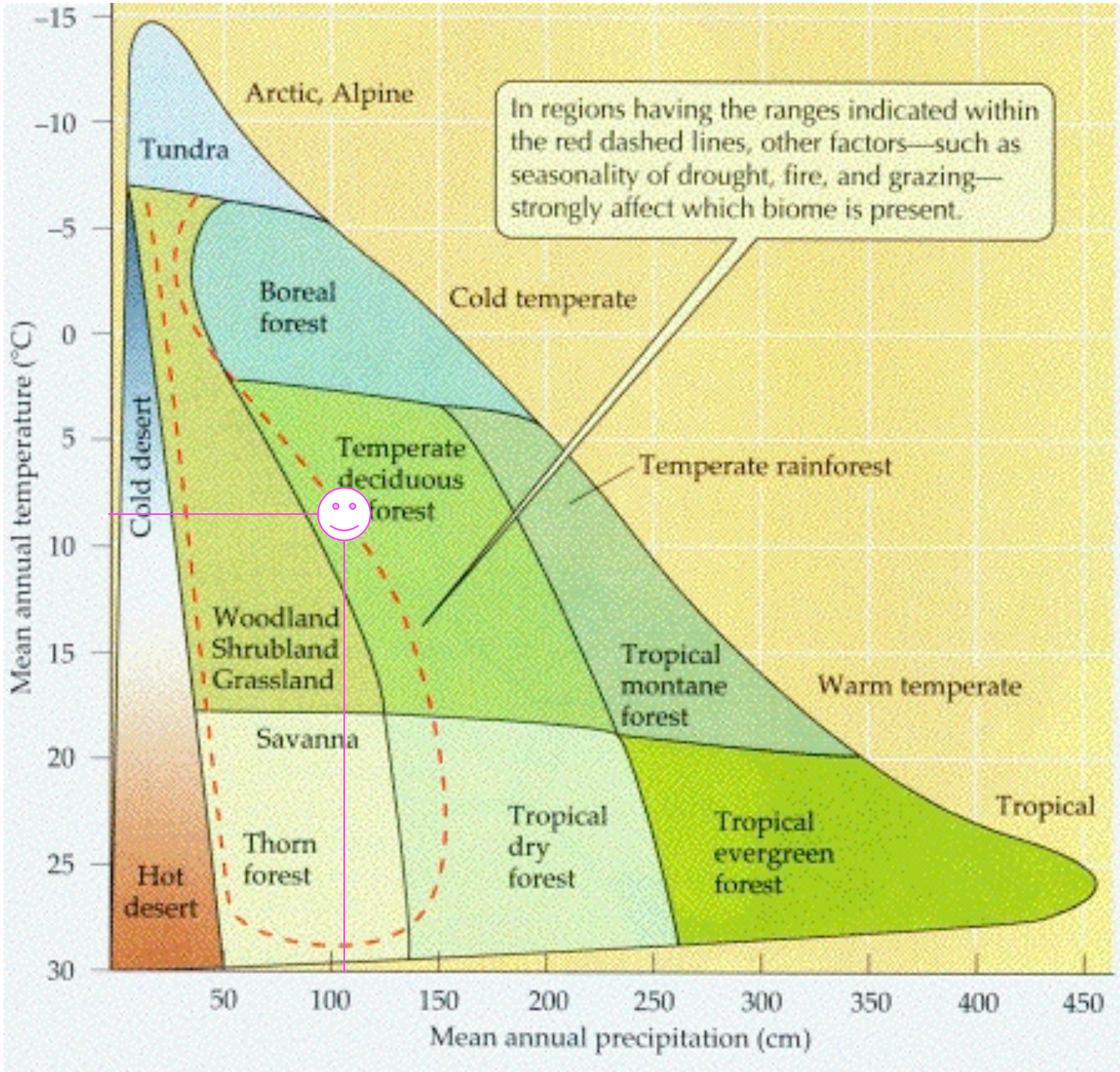


Arctic, Alpine
Tundra
In regions having the ranges indicated within the red dashed lines, other factors—such as seasonality of drought, fire, and grazing—strongly affect which biome is present.
Boreal forest
Cold temperate
Cold desert
Temperate deciduous forest
Temperate rainforest
Woodland Shrubland Grassland
Tropical montane forest
Warm temperate
Savanna
Tropical
Thorn forest
Tropical dry forest
Tropical evergreen forest
Hot desert
Mean annual temperature (°C)
Mean annual precipitation (cm)
–15
–10
–5
0
5
10
15
20
25
30
50
100
150
200
250
300
350
400
450

Robert H. Whittaker

Vegetation gradients

Environmental tolerance determines distribution

Great Smoky Mountains

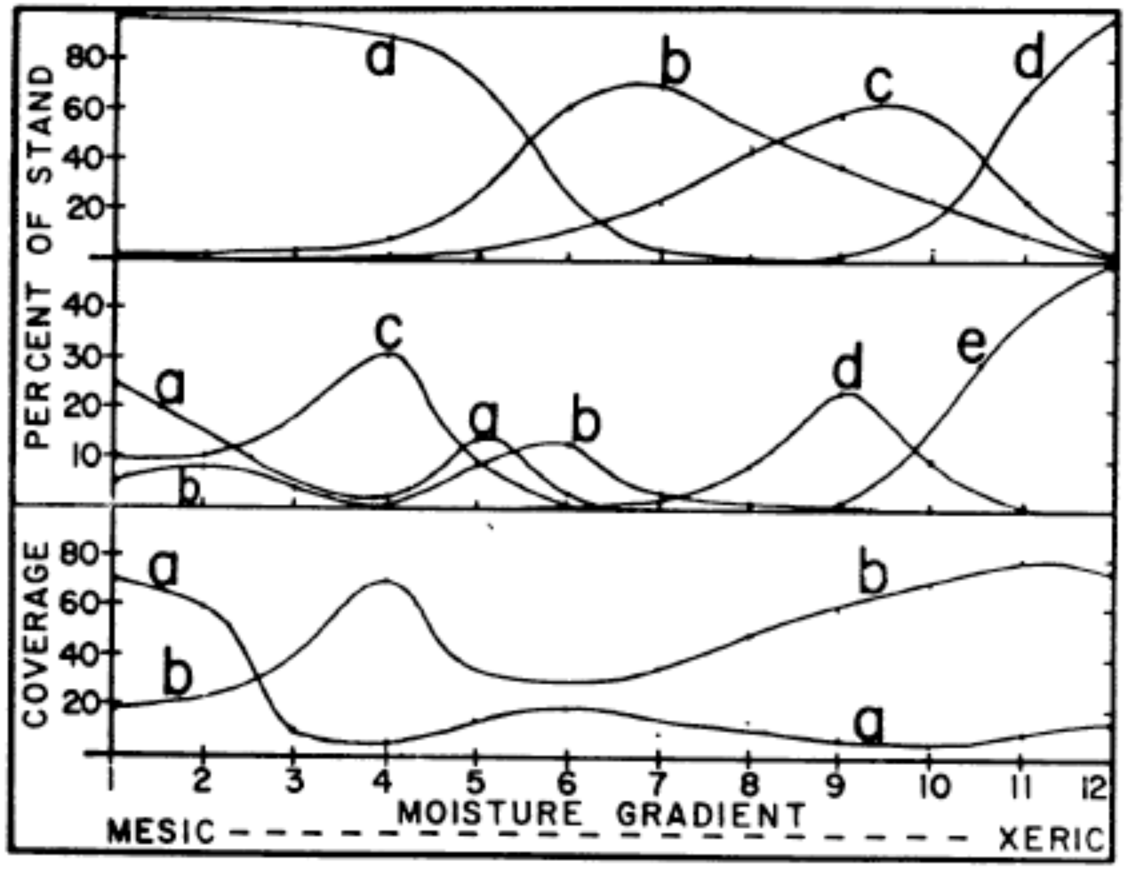
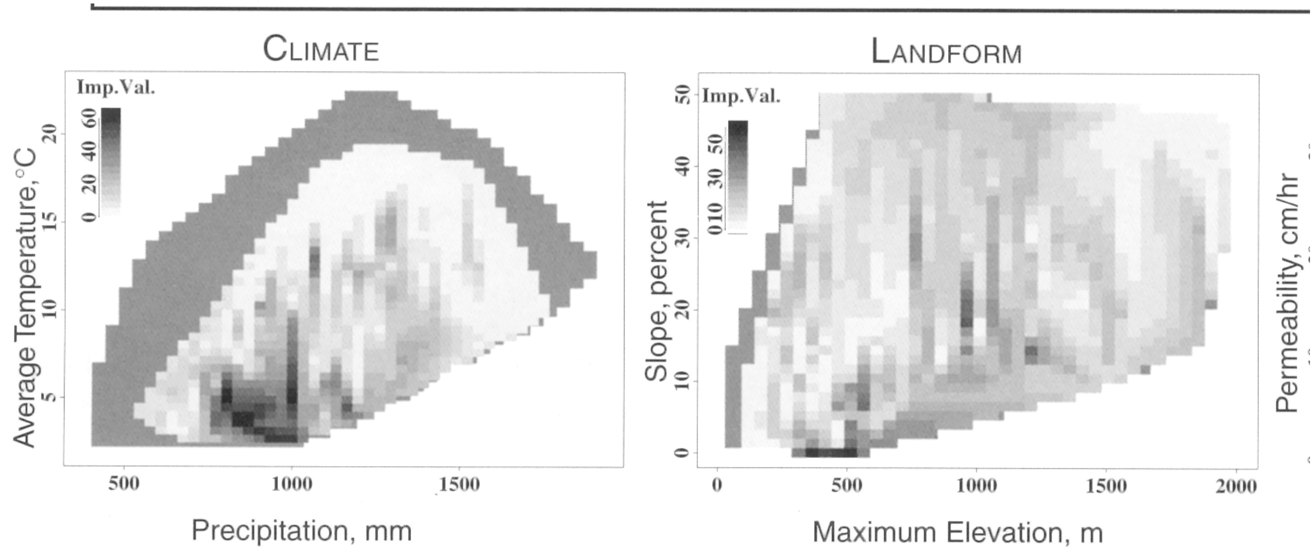
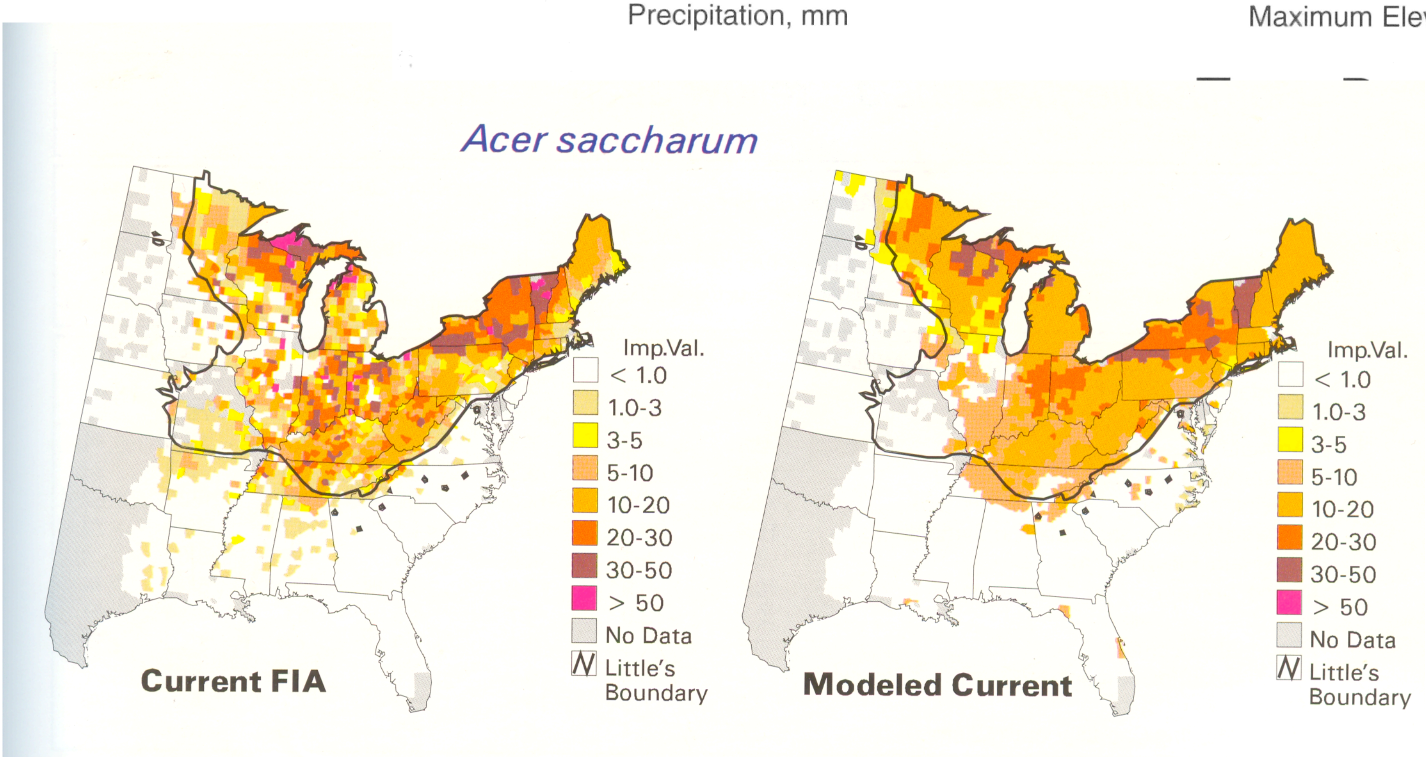


FIG. 4. Transect of the moisture gradient, 3500-4500 ft. Top—curves for tree classes; a, mesic; b, submesic; c, subxeric; d, xeric. Note expansion of mesic stands, compared with Figs. 2 and 3. Middle—curves for tree species: a, *Tilia heterophylla*; b, *Halesia monticola* (both the preceding are bimodal, with populations on each side of the mode of Tsuga); c, *Tsuga canadensis*; d, *Quercus alba*; e, *Pinus pungens*. Bottom—curves for undergrowth coverages: a, herbs; b, shrubs.

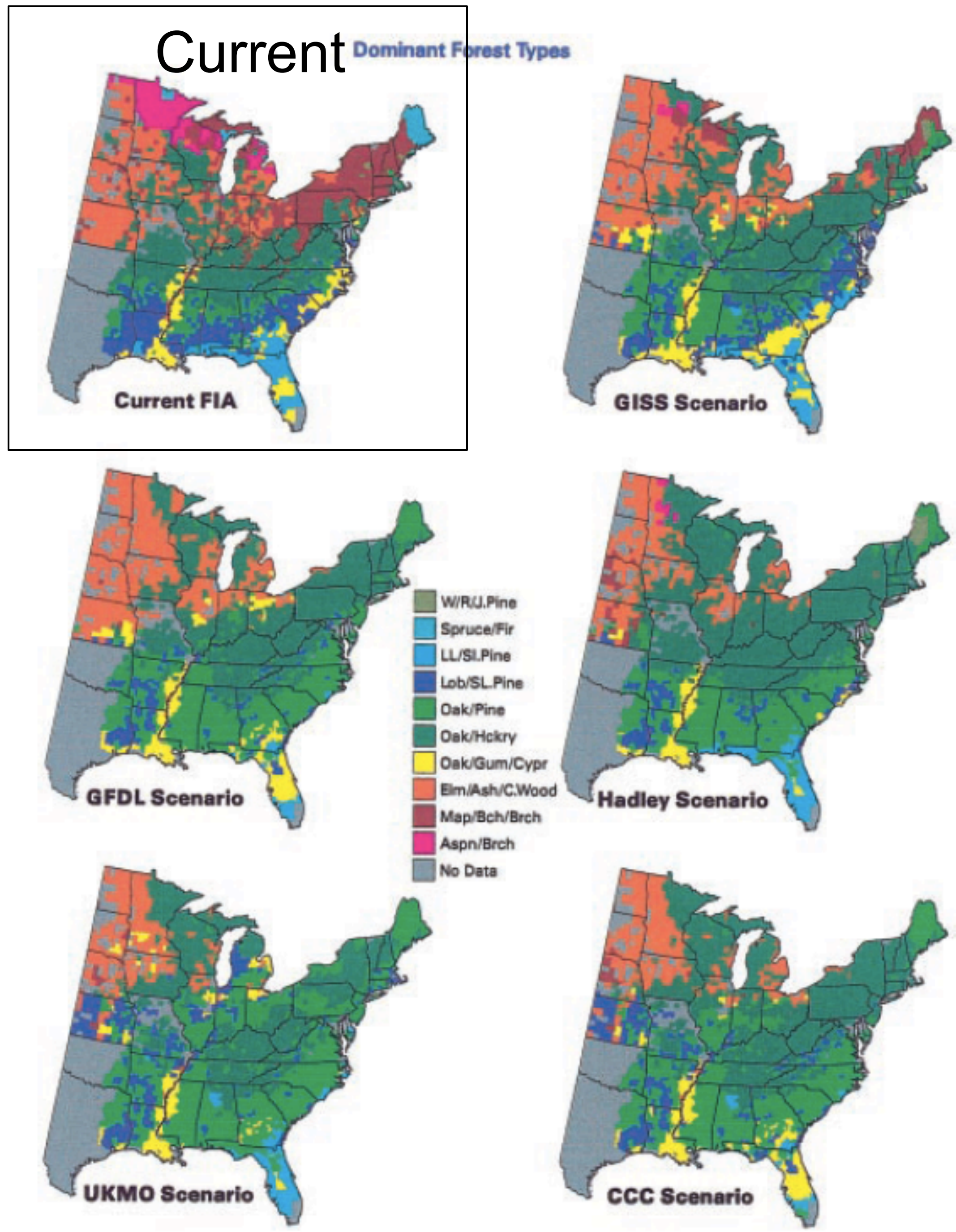
Iverson and Prasad 1998, Distributions of 80 sp. of trees





Iverson and Prasad 2001

Potential forest change under alternative climate change scenarios based on species specific tolerance and environmental optima.



Crozier 2003

Range change in Atalopedes campestris

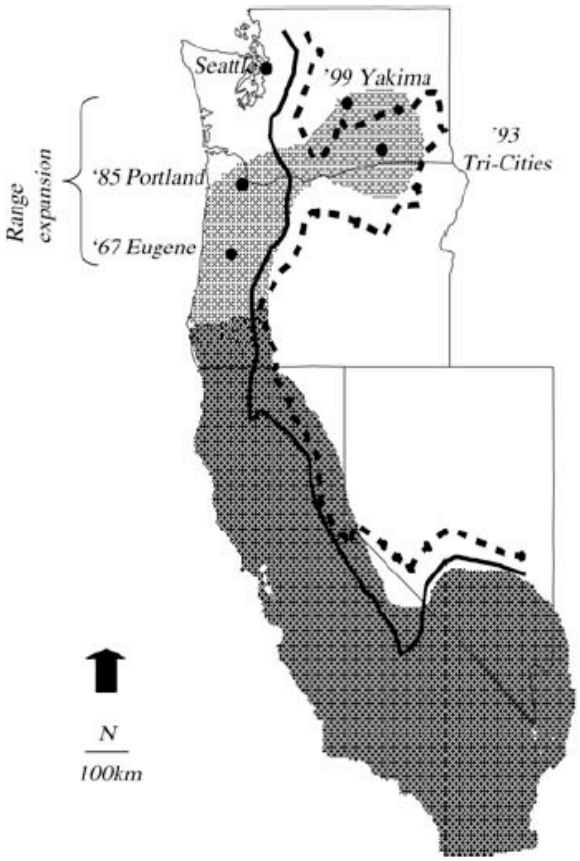


Fig. 1 Overwintering range of *Atalopedes campestris* (*shaded*) in Washington, Oregon, California, and Nevada from Opler (1999), modified to include the western range expansion (*lighter shading*). Colonization dates of *A. campestris* by four cities in Oregon and Washington show the chronology of the range expansion. Contour lines represent the January average minimum –4°C isotherm from 1950–1959 (*solid*) and 1990–1998 (*dotted*) (NCDC 2000)

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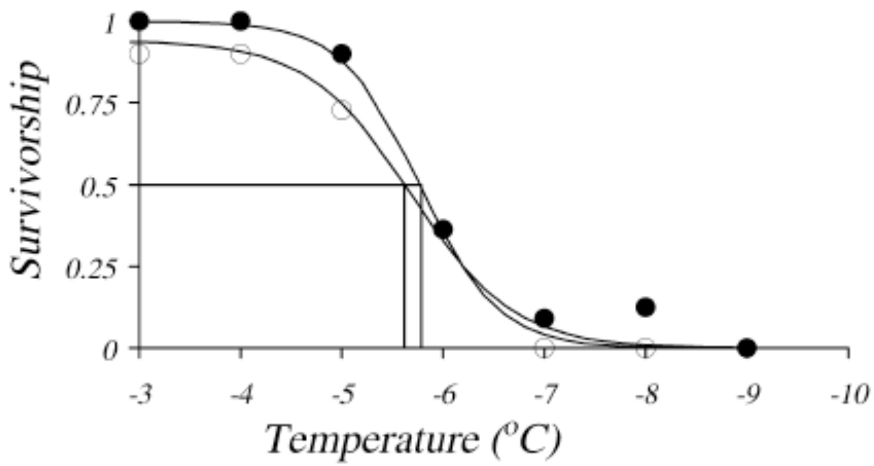
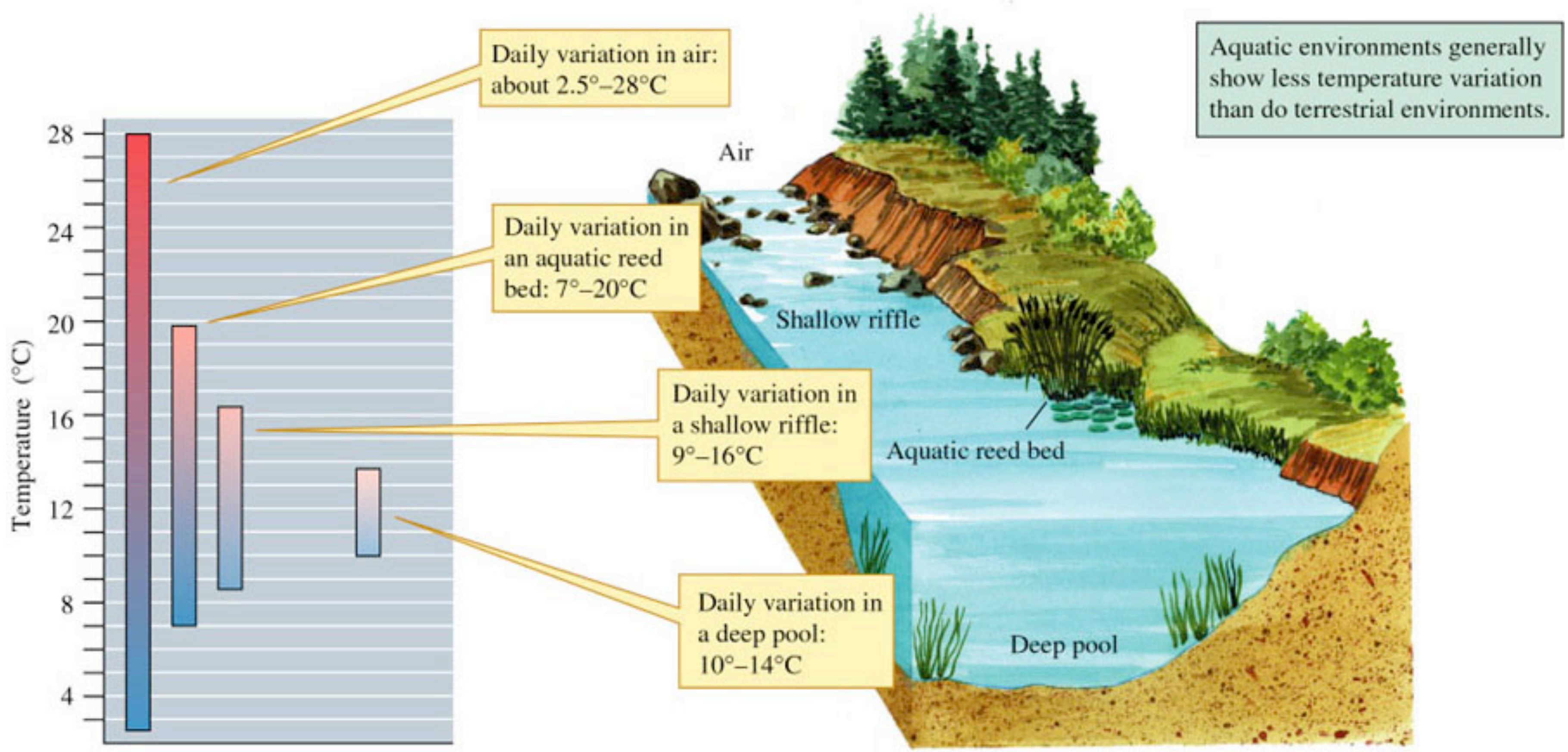


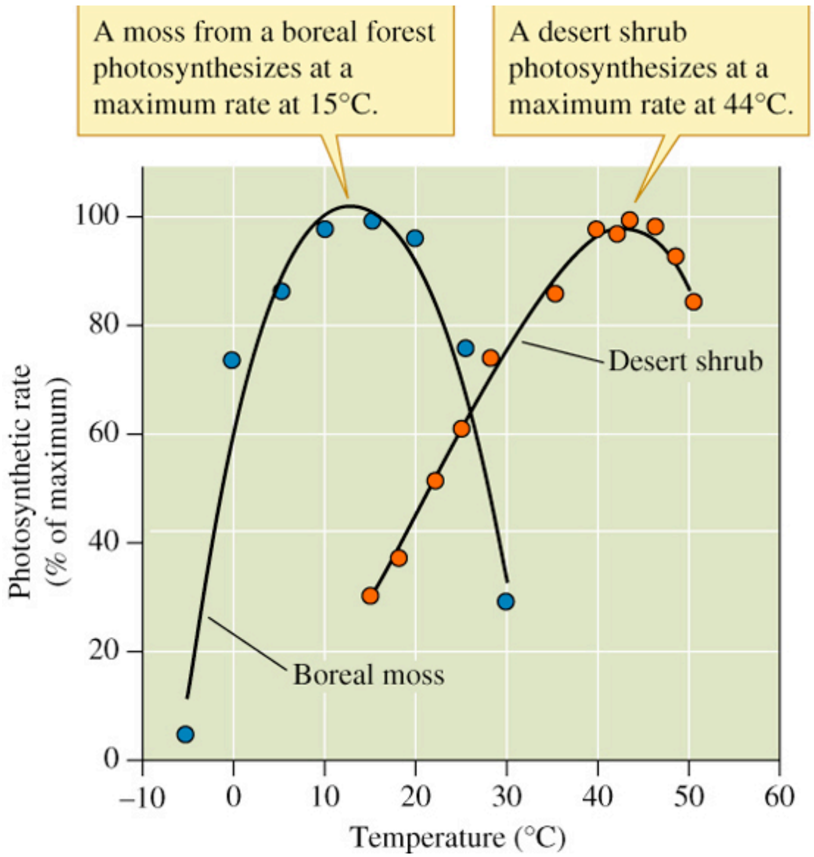
Fig. 3 Lethal temperature for 50% of the sample (LT_{50}) fc Californian (*open circles*) and Washingtonian (*closed circles*) thir instar larvae with a hyperbolic tangent curve fit. Estimated LT_{50} i –5.6°C (Calif.), and –5.8°C (Wash.) (*drop-down lines*). Th difference between populations is not significant (P>0.05)

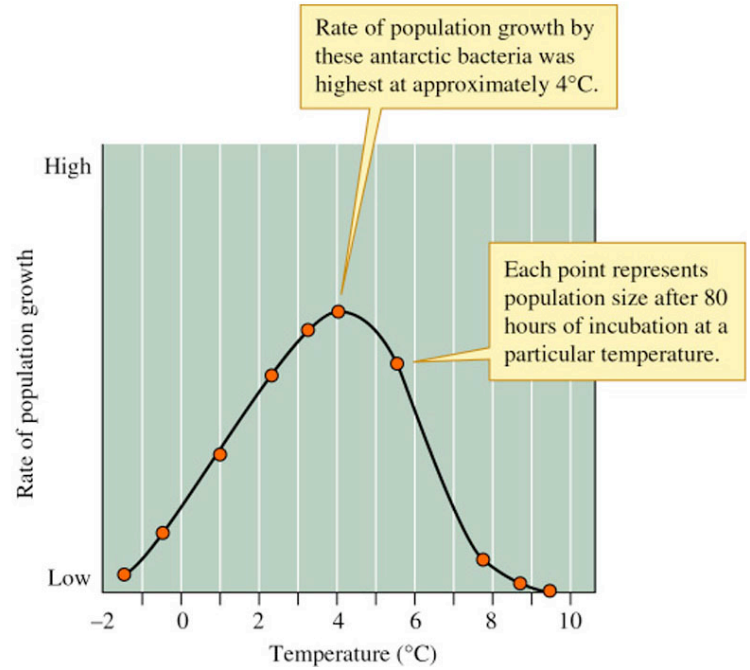
What is microclimate?

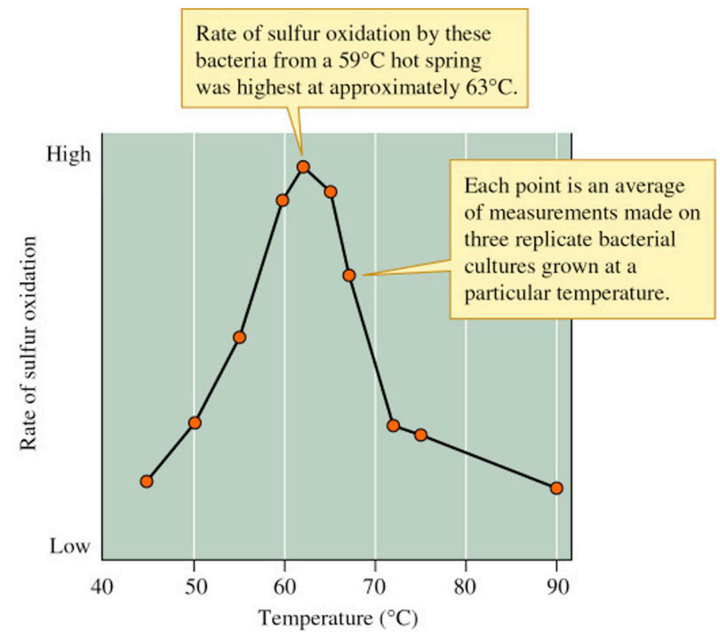
Stream microclimates



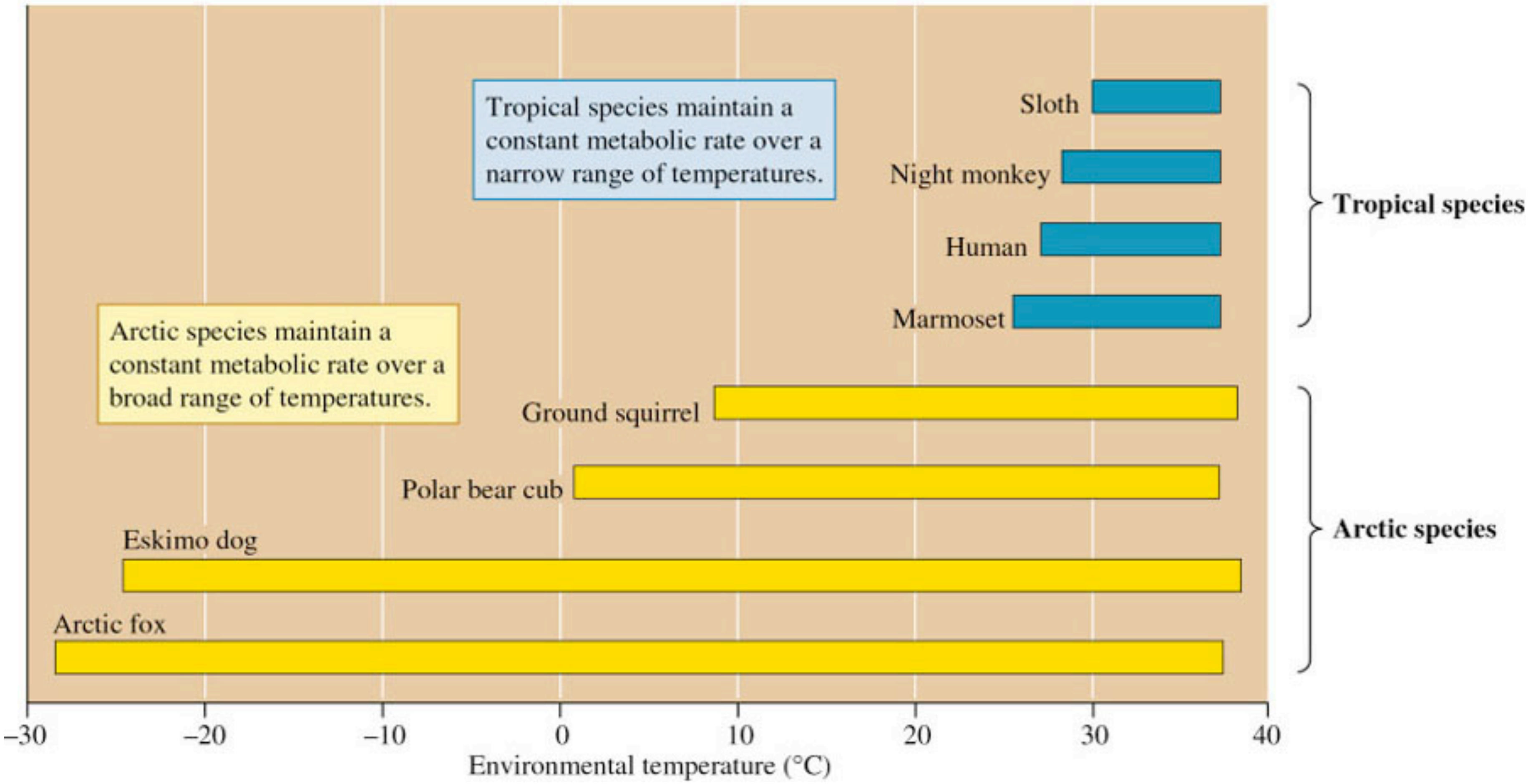
Temperature optima in ectotherms







Evolution of thermal tolerance homeotherms



What is this range of temperatures called?

Heat balance equation

$$H_S = H_m \pm H_{cd} \pm H_{cv} \pm H_r - H_e$$

H_S = Total heat stored in an organism

H_m = Gained via metabolism

H_{cd} = Gained / lost via conduction

H_{cv} = Gained / lost via convection

H_r = Gained / lost via electromagnetic radiation

H_e = Lost via evaporation

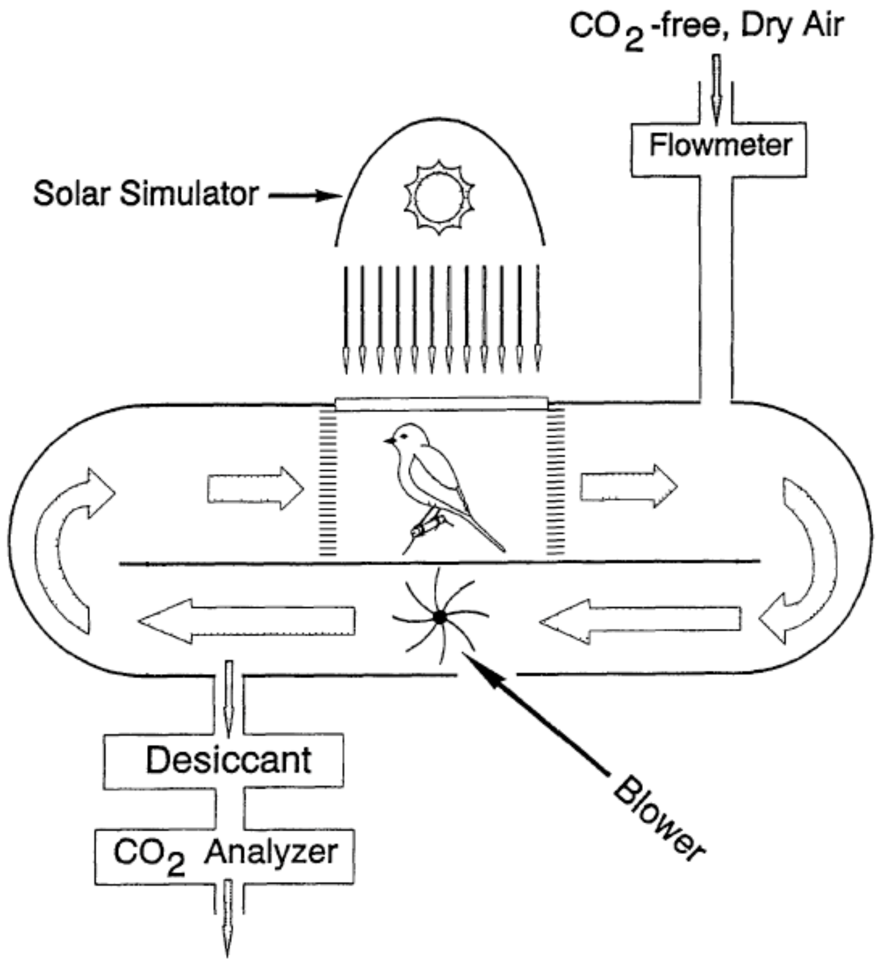


FIG. 1. Wind tunnel metabolic chamber used to vary the radiative and convective environment and measure Verdin metabolic responses.

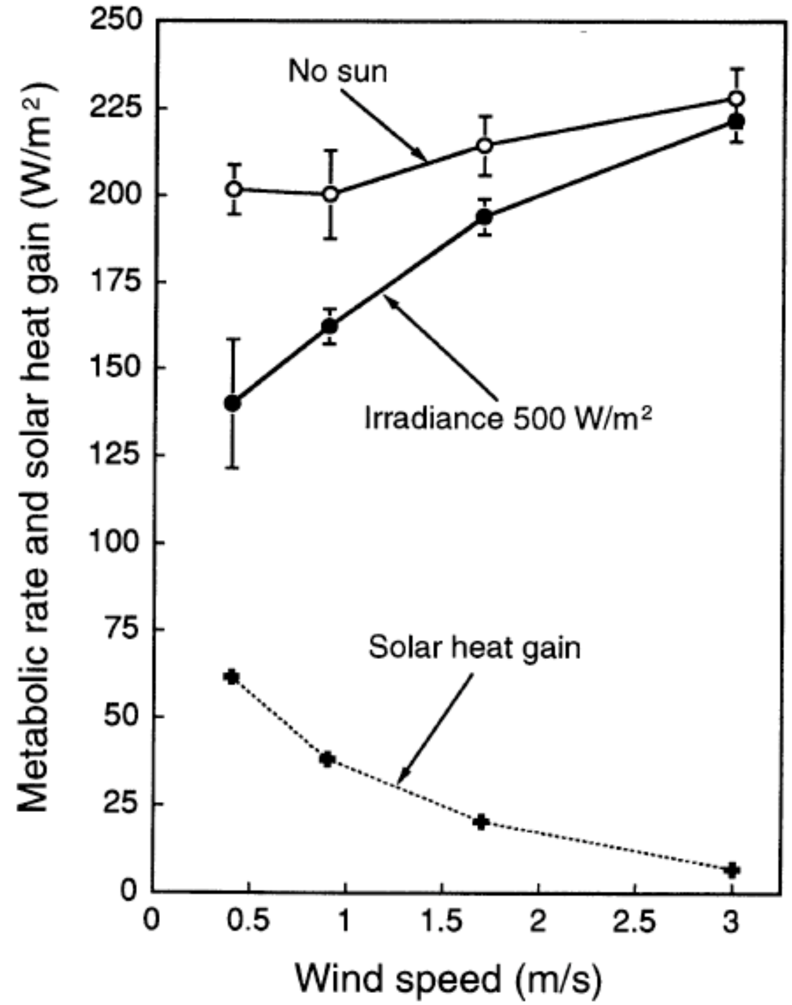
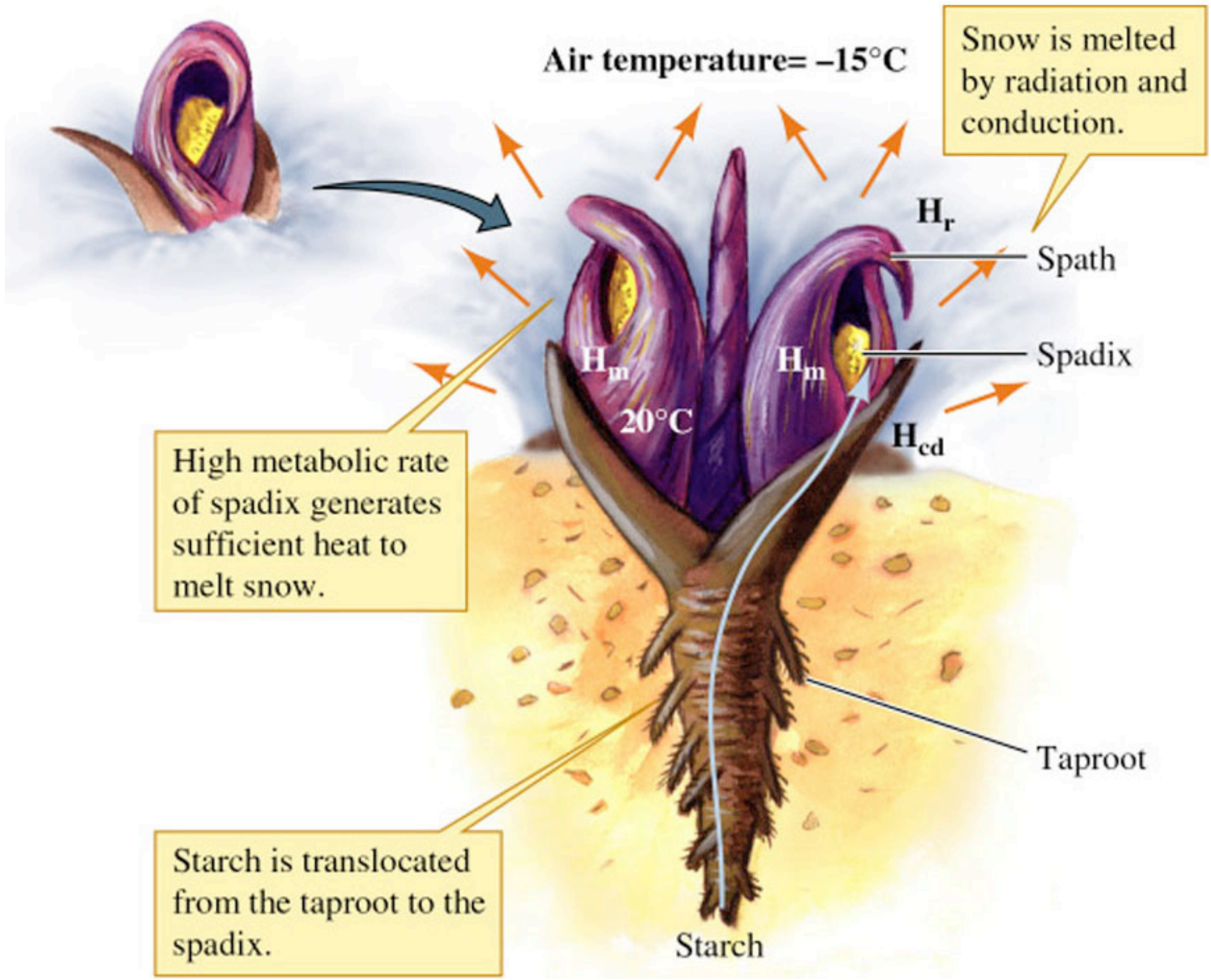


FIG. 4. Metabolic rates of Verdins as a function of wind speed in the presence and absence of simulated solar radiation at an air temperature of 15°C. Values are means and 95% confidence intervals with n = 7 at 0.4 m/s and n = 8 at all other wind speeds.

Metabolic thermoregulation in verdins (*Aureparus flaviceps)*
Wolf and Walsberg, 1996

Not all plants are ectotherms: *Symplocarpus foetidus*



Thermoregulation by environmental manipulation
Fungus-growing termites (*Macrotermes bellicosus)*

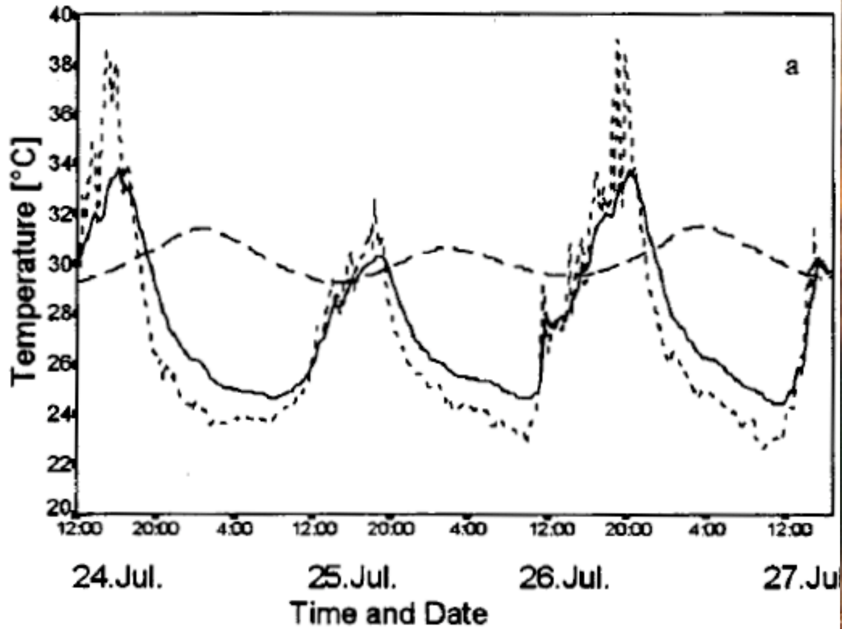
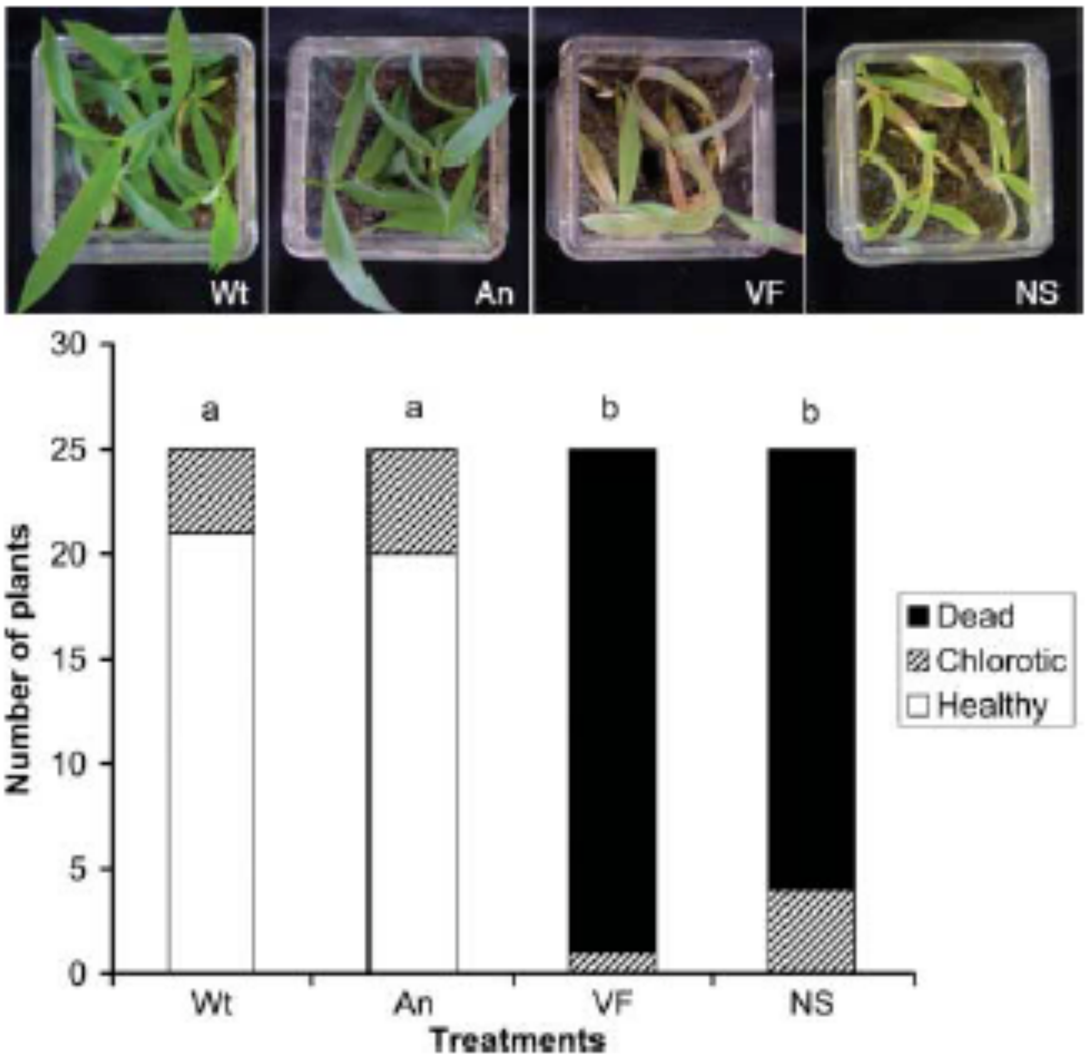


Figure 3. Continuous temperature measurements over the course of four days in and at a typical mound of the shrub savanna (S5-c; a) and gallery forest (R5-c; b). Temperature of the air: – – –; air channel: ——; fungus garden: — — —.

Korb and Linsenmair, 1998

Thermal tolerance - a virus in a fungus in a plant



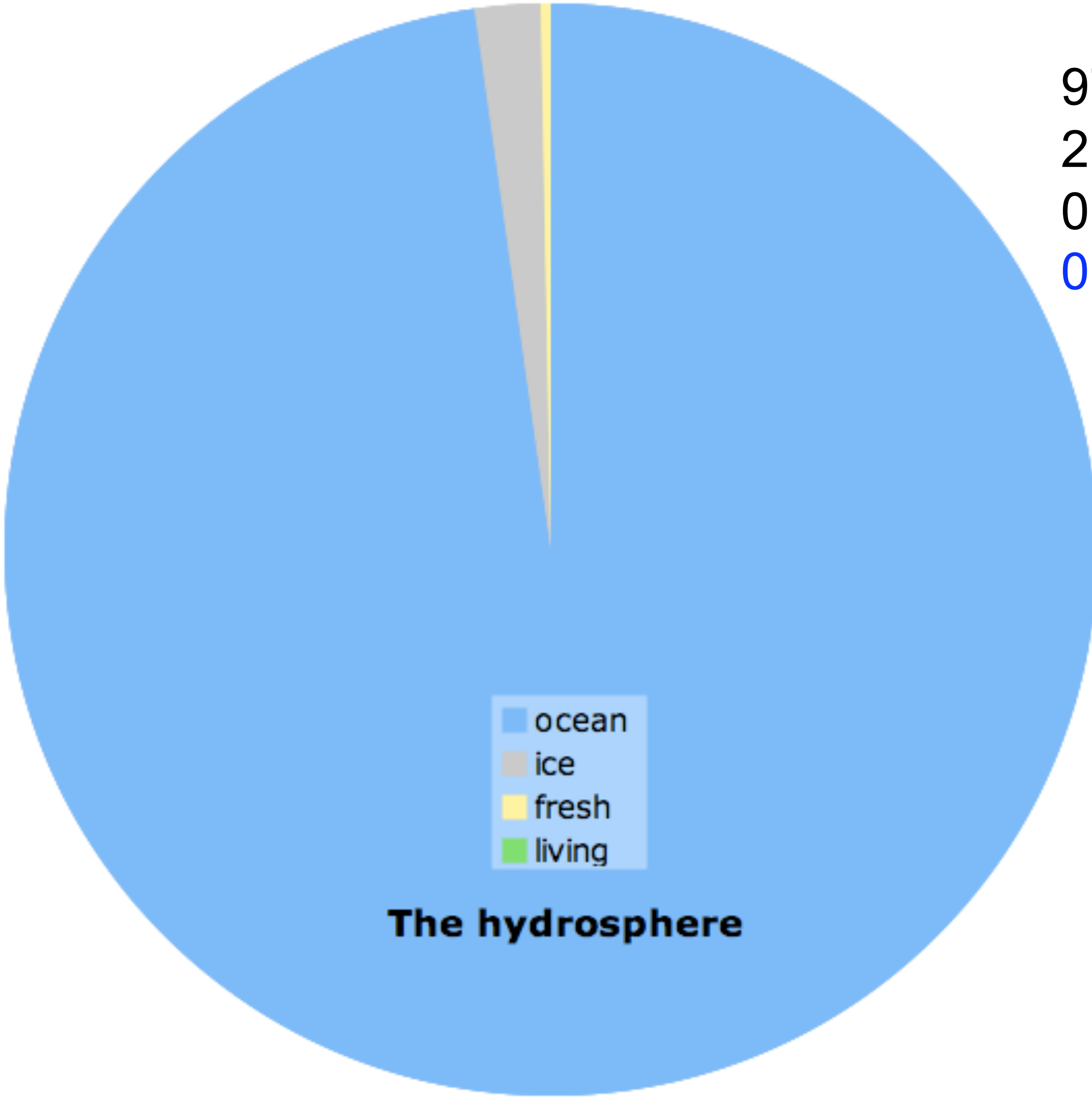
Dichanthelium

(a tropical grass)

Soil heated to 65 C
10 hrs per day

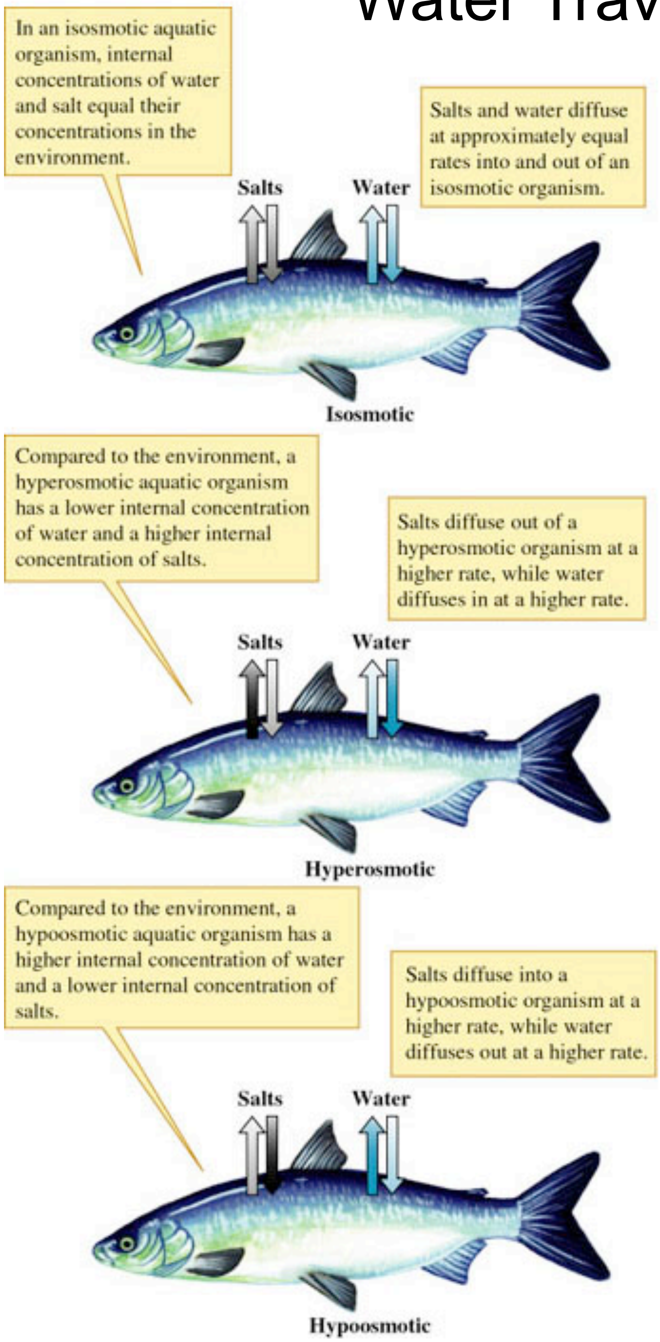
That is HOT!

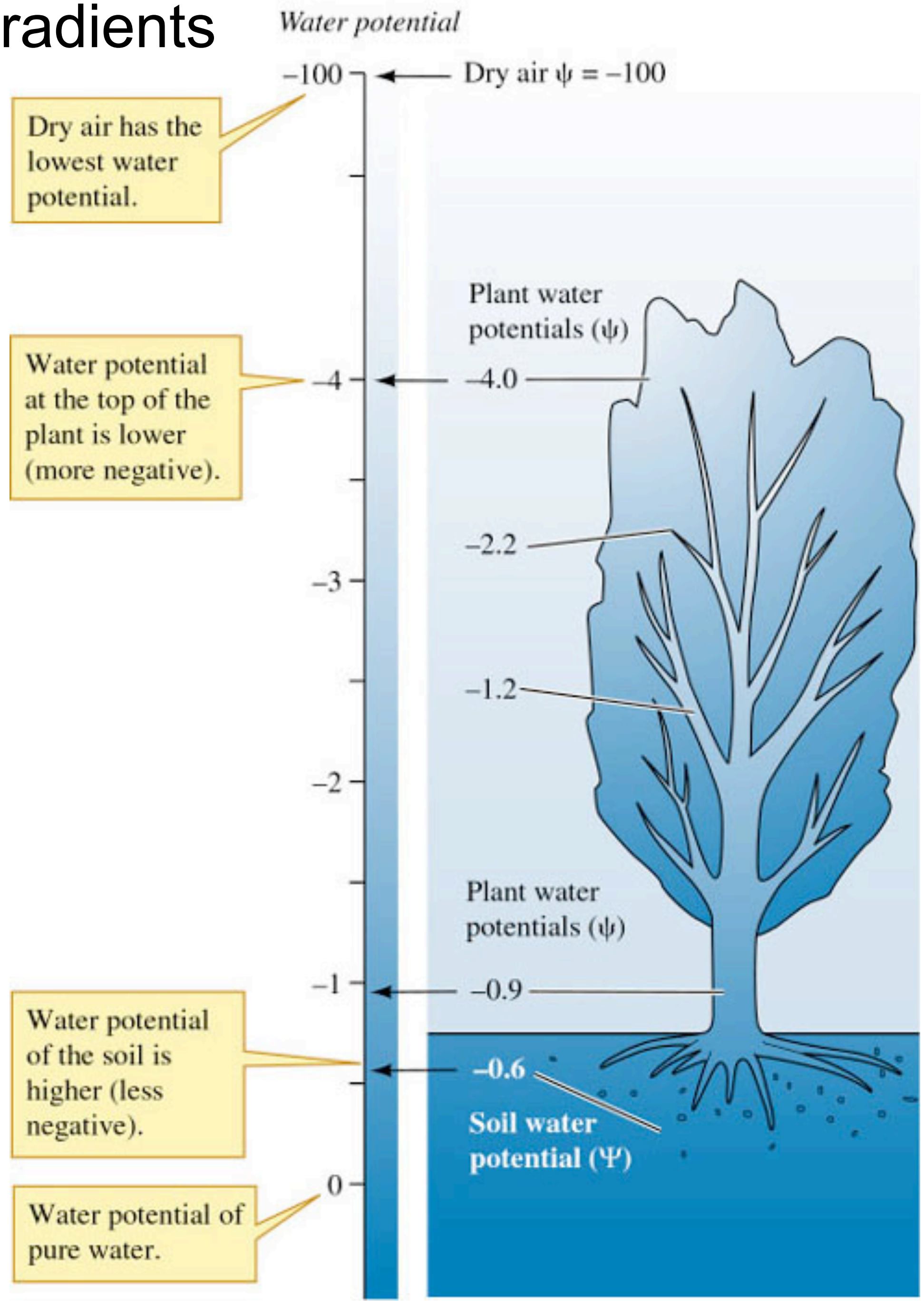
Marquez et al. 2007 *Science*



97.7% Oceans
2% Ice
0.02% Fresh
0.00002% Living

Water Travels on Gradients





Water movement from soil to plant

$\Psi_{plant} = \Psi_{solute} + \Psi_{matric} + \Psi_{pressure}$

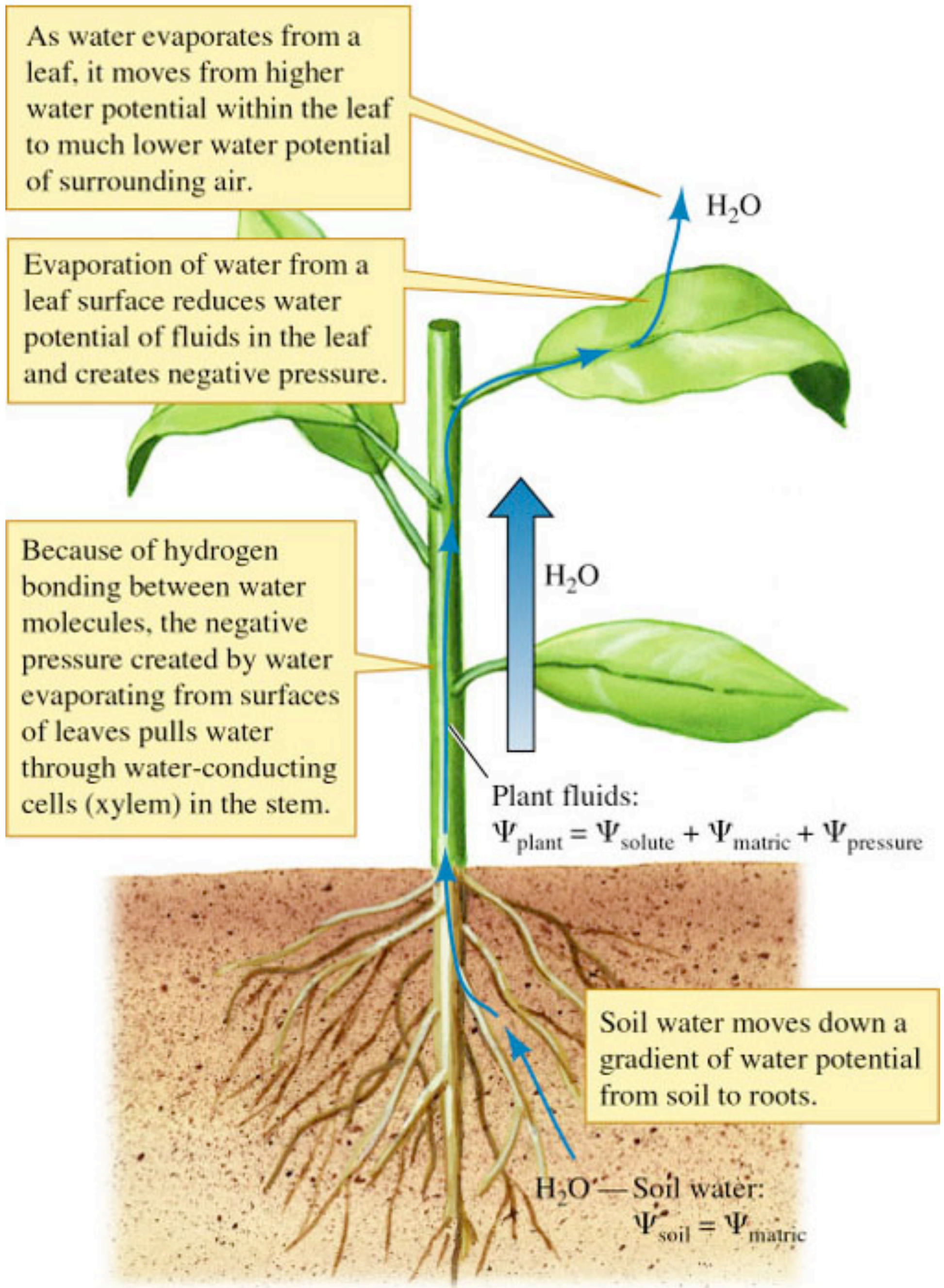
$\Psi_{soil} \approx \Psi_{matric}$

Water potentials are NEGATIVE and water flows from less negative to more negative potential.

Ψ_{matric} represents water's tendency to adhere to surfaces.

$\Psi_{pressure}$ is the reduction in water potential due to negative pressure created by water evaporating from leaves.

As long as $\Psi_{plant} < \Psi_{soil}$, water flows from the soil to the plant.



In plants, water flows in a continuous stream from root to leaf

Plant	Animal
$W_{ip} = W_r + W_a - W_t - W_s$	$W_{ia} = W_d + W_f + W_a - W_e - W_s$
W_{ip}= Internal water	W_{ia}= Internal water
W_r =Root uptake	W_d = Drinking
W_a = Absorbed (air)	W_f = Food (as source)
W_t = Transpiration	W_a = Absorbed (air)
W_s = Secretions	W_e = Evaporation
	W_s = Secretion / Excretion

Water budgets in plants and animals.