

Water Regulation and Adaptation Chap. 6

- I. Water potential
 - A. components
 - B. water flow
- II. Water balance
 - A. water loss
 - B. water gain
- III. Regulation & Adaptations – plants & animals
 - A. Terrestrial
 - B. Aquatic
 - 1. Isoosmotic
 - 2. Hypoosmotic
 - 3. Hyperosmotic

Which way does water flow?

Questions

1. How do you get water to the top of a 300 ft. tall redwood tree?
2. Why is soil under some trees more wet in the morning than the previous afternoon? Hint: it comes from the roots, not from rainfall.
3. Why are salmon so spectacular physiologically? (what makes going from fresh to salt water and back again so remarkable?)

Global Warming effects – change in precipitation



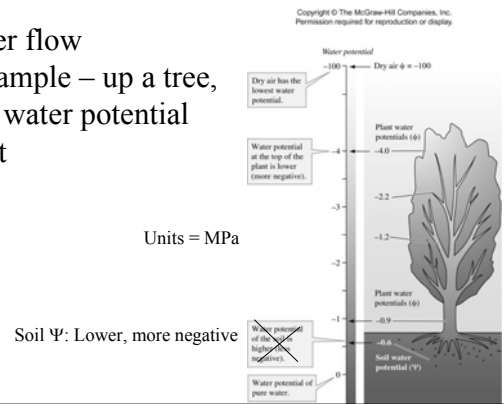
I. Water potential (Ψ)

A. The components

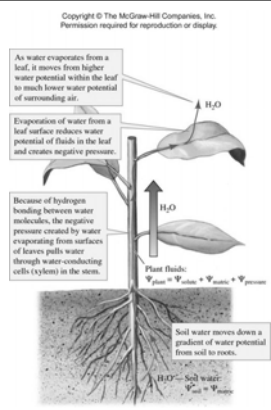
$$\Psi = \Psi_p + \Psi_s + \Psi_m + \Psi_g$$

B. Water flow

Example – up a tree,
down a water potential
gradient



Tension-cohesion mechanism



Effect of water content on soil water Ψ

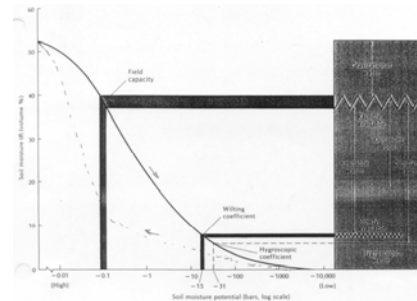


FIGURE 5.21 Potential moisture curve of a loam soil as related to different terms used to describe water in soils. The wavy lines in the diagram to the right suggest that measurements such as field capacity are not very quantitative. The gradual change in potential with soil moisture change discourages the concept of different "forms" of water in soils. At the same time, such terms as potential and available assist in the qualitative description of moisture utilization in soils.

Effect of water content on soil Ψ : different soil types

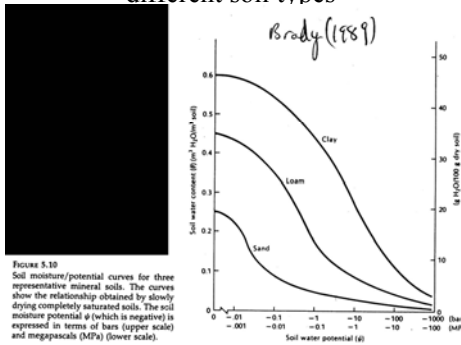


FIGURE 5.10 Soil moisture/potential curves for three representative mineral soils. The curves show the relationship obtained by slowly drying completely saturated soils. The soil moisture potential Ψ (which is negative) is expressed in terms of bars (upper scale) and megapascals (MPa) (lower scale).

Effect of Relative Humidity on Air Ψ

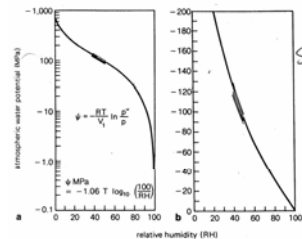
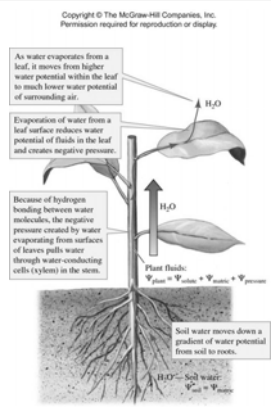


FIGURE 4-10 The relationship of atmospheric water potential (20°C) to relative humidity, plotted on a logarithmic scale (a) and on a linear scale (b). The four thin lines are for different temperatures: 0° (bottom line), 10°, 20°, and 30°C (upper line). The curves were calculated with the equations shown, which are equations 2.4 and 2.5 on page 42.

S&R Fig.4-10

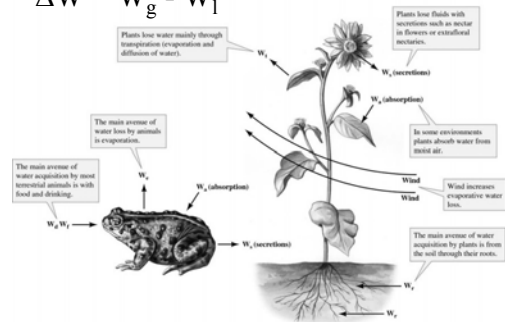
Hydraulic lift



II. Water balance

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$$\Delta W = W_g - W_l$$



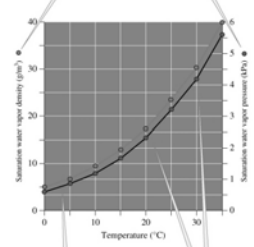
A. Water loss - Terrestrial organisms

1. Evaporation

Vapor pressure deficit (VPD)

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Water vapor in air can be measured either as grams of vapor per cubic meter of air... or by the pressure exerted by the water vapor in air.



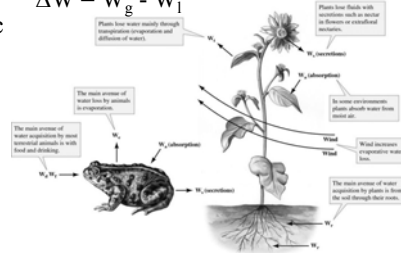
As low temperatures, air is saturated by low quantities of water vapor and water vapor pressure is low. As temperature increases, the amount of water air holds at saturation and saturation water vapor pressure increases.

B. Water gain

- Drinking/root uptake
- Uptake via body surface
- Water in food
- Oxidation (metabolic water)

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$$\Delta W = W_g - W_l$$



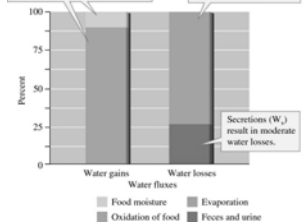
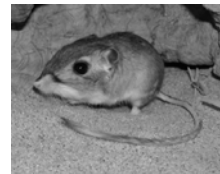
III. Regulation & Adaptations

A. Terrestrial – high potential for water loss

1. Intake – metabolic water

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The kangaroo rat can go without drinking (no W_d) and obtain all the water it needs from its food (W_f). Most water loss is through evaporation (W_e).

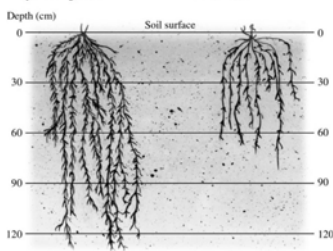


<http://www.calmzoo.org/stories/storyReader5229>

1. Intake

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On dry sites, the foeh grows a dense network of deeply penetrating roots. On moist sites, the foeh grows a sparse network of shallow roots.



Prosopis (mesquite)

Fig. 5.12

2. Storage

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3. Loss

Physiological

MARINE AIR-BREATHING VERTEBRATES 349

	Sea water consumed		Urine produced		Water balance gain or loss (ml)
	Volume (ml)	Cl ⁻ concentration (mmol liter ⁻¹)	Volume (ml)	Cl ⁻ concentration (mmol liter ⁻¹)	
Human	1000	535	1350	400	-350
Whale	1000	535	650	820	+350

Table 8.18 Effect on the water balance of ingesting 1 liter of sea water in a human and in a whale.

Schmidt-Neilson 1995

3. Loss

Behavioral – reduce surface area

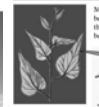


phenology

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In a shaded portion of a greenhouse, the leaves of the rain forest plant are sunlit and fully exposed to incoming light.

Wilting



Minutes after being moved into the sun, the leaves begin to wilt.

2 minutes in sun

4 minutes in sun

6 minutes in sun

After 8 minutes, wilting reduces the surface area exposed to the sun by 20% and decreases rate of transpiration by 50%–60%.

3. Loss

Linked behavior/morphology

- vapor-limited evaporation
- membrane-limited evaporation

Earthworm	400
Frog	300
Salamander	600
Garden snails, active	870
Garden snail, inactive	39
Man (not sweating)	48
Rat	46
Iguana lizard	10
Mealworm	6

Table 8.8 Evaporation of water from the body surface of various animals at room temperature. The data indicate orders of magnitude; exact figures vary with experimental conditions. All data refer to micrograms of water evaporated per hour from 1 cm² body surface at a vapor pressure difference of 1 mm Hg (0.13 kPa). [Schmidt-Nielsen 1969]

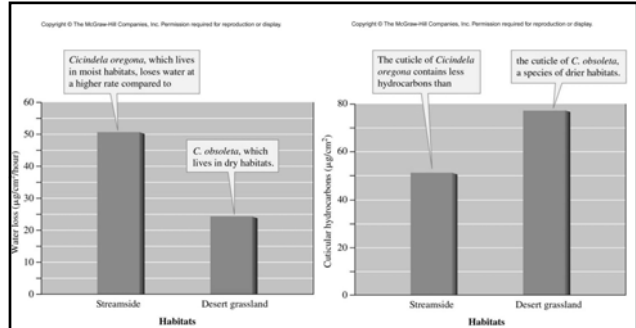


Fig. 5.16

Fig. 5.17

Tiger beetles – cuticle thickness in different habitats

3. Loss

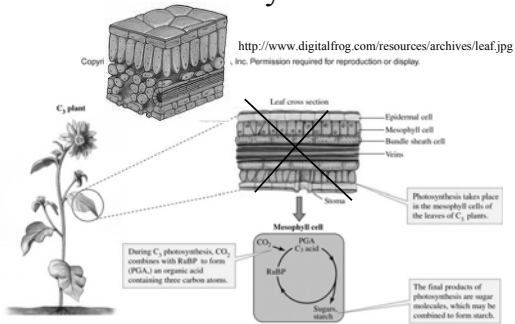
Linked behavior/morphology

- vapor-limited evaporation
- membrane-limited evaporation - **Sclerophylls**

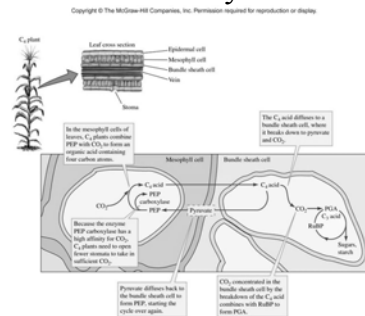
4. Linked Temperature And Water Adaptations

C3, C4, and CAM photosynthesis

C3 Photosynthesis



C4 Photosynthesis



C4 Distribution

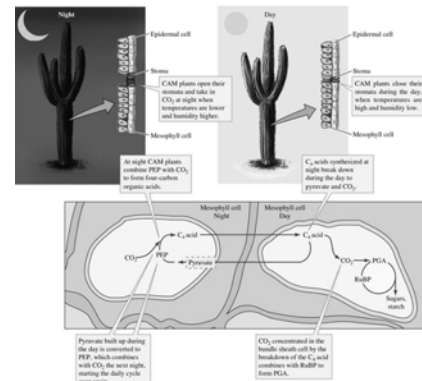
9 Temperature influences plant distribution. C_3 and C_4 grasses, as measured by relative grounding an elevational gradient in the Hawaii Volcanoes ark. (After Rundel 1980:355.)



7-10 The numbers shown here indicate the percentages of the total number of grass species having the C_4 pathway in each of 32 local areas in North America. The highest percentages are found in those regions with the highest temperatures during the growing season.

CAM Photosynthesis

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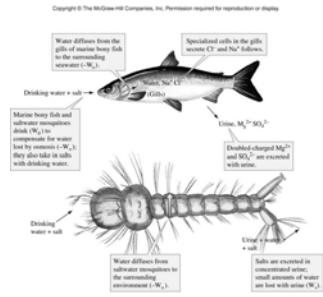


B. Aquatic – 5 Questions

1. Terms: Iso-osmotic (isomotic), hypo-osmotic (hyposmotic), hyperosmotic.
2. To what situations do these refer?
3. What do animals (fish, invertebrates) need to do in marine environments to maintain their water and salt balances?
4. What do animals (fish, inverts.) need to do in freshwater environments to maintain their water and salt balances?
5. What about anadromous fish such as salmon? How must their physiology change when migrating from fresh to salt water and vice versa?

Isosmotic

Saltwater – hypo-osmotic



Freshwater – hyperosmotic

