Water Regulation and Adaptation
Chap. 6

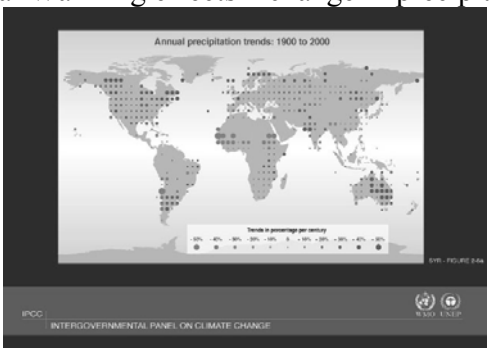
I. Water potential
  A. components
  B. water flow
II. Water balance
  A. water loss
  B. water gain
III. Regulation & Adaptations – plants & animals
  A. Terrestrial
  B. Aquatic
    1. Isoosmotic
    2. Hypoosmotic
    3. Hyperosmotic

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

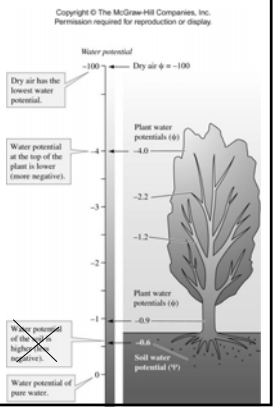
$\Psi = \Psi p + \Psi s + \Psi m + \Psi g$

B. Water flow

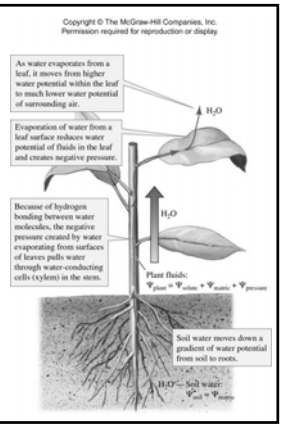
Example – up a tree, down a water potential gradient

Units = MPa

Soil Ψ: Lower, more negative



Tension-cohesion mechanism



Effect of water content on soil Ψ

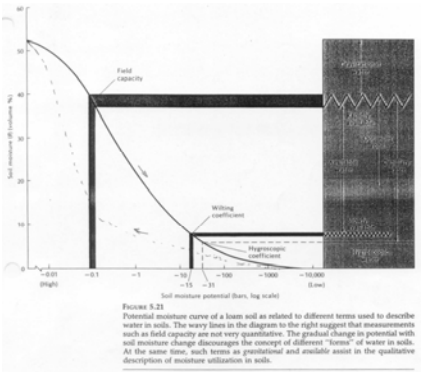


FIGURE 5.21
Potential moisture curve of a loam soil as related to different terms used to describe water in soils. The wavy lines in the diagram to the right suggest that measurements such as field capacity are not very quantitative. The gradual change in potential with soil moisture change discourages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

Effect of water content on soil Ψ: different soil types

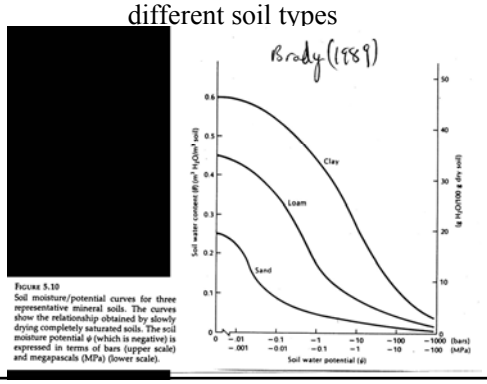


FIGURE 5.10
Soil moisture/potential curves for three representative mineral soils. The curves show the relationship obtained by slowly drying completely saturated soils. The soil moisture potential ψ (which is negative) is expressed in terms of bars (upper scale) and megapascals (MPa) (lower scale).

Effect of Relative Humidity on Air Ψ

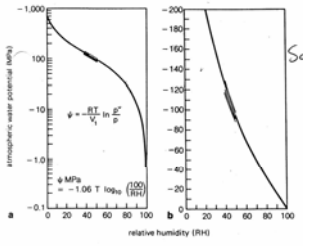
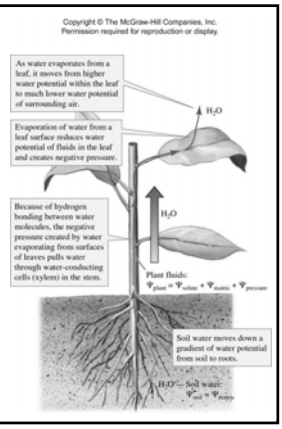


Figure 4-10 The relationship of atmospheric water potential (20°C) to relative humidity, plotted on a logarithmic scale (**a**) and on a linear scale (**b**). The four thin lines are for different temperatures: 0° (bottom line), 10°, 20°, and 30°C (upper line). The curves were calculated with the equations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

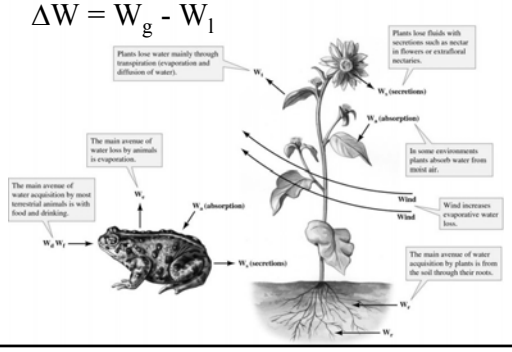
S&R Fig.4-10

Hydraulic lift



II. Water balance

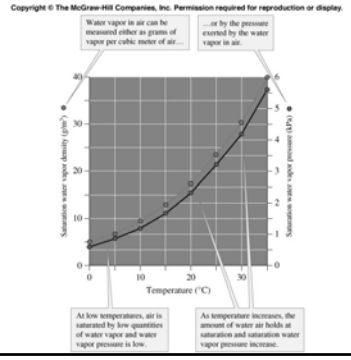
$\Delta W = W_g - W_l$



A. Water loss - Terrestrial organisms

1. Evaporation

Vapor pressure deficit (VPD)



B. Water gain

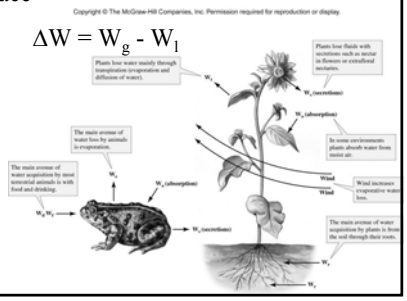
Drinking/root uptake

Uptake via body surface

Water in food

Oxidation (metabolic water)

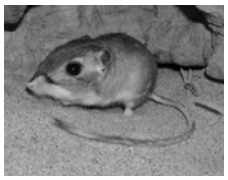
$\Delta W = W_g - W_l$



III. Regulation & Adaptations

A. Terrestrial – high potential for water loss

1. Intake – metabolic water



http://www.calmzoo.org/stories/storyReader$229

1. Intake

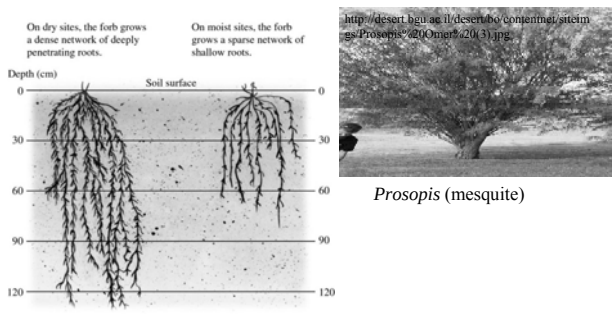
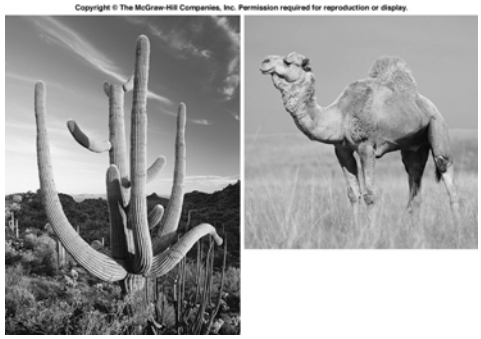


Fig. 5.12

http://desert.bgu.ac.il/desert/bo/contentnet/siteimgs/Prosopis%20Omer%20(3).jpg

Prosopis (mesquite)

2. Storage



3. Loss

Physiological

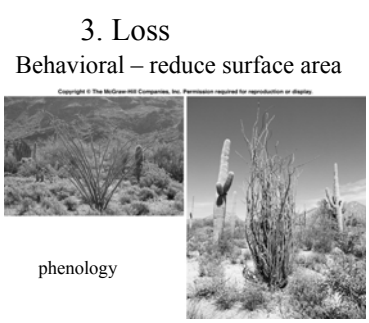
	Sea water consumed: Volume (ml)	Sea water consumed: Cl concentration (mmol liter^{-1})		Urine produced: Volume (ml)	Urine produced: Cl concentration (mmol liter^{-1})		Water balance: gain or loss (ml)
Human	1000	535		1350	400		−350
Whale	1000	535		650	820		+350

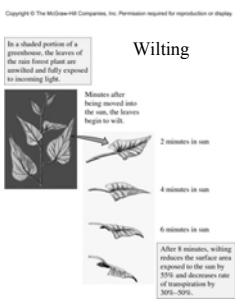
Table 8.18 Effect on the water balance of ingesting 1 liter of sea water in a human and in a whale.

Schmidt-Neilson 1995

3. Loss

Behavioral – reduce surface area





Wilting

phenology

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]

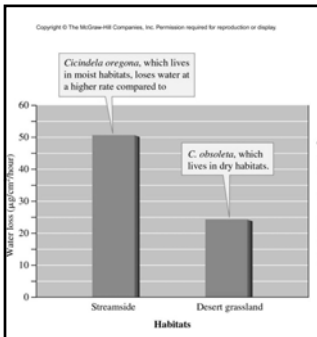


Fig. 5.16

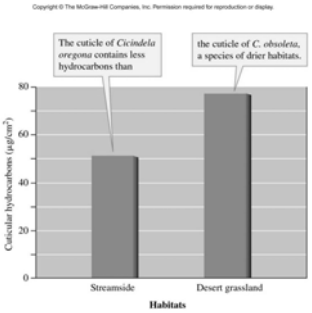


Fig. 5.17

Tiger beetles – cuticle thickness in different habitats

3. Loss

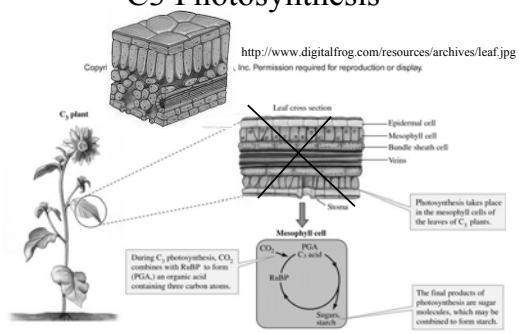
Linked behavior/morphology

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

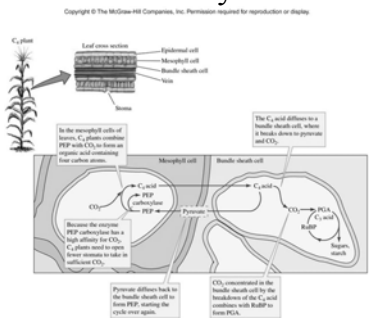
4. Linked Temperature And Water Adaptations

C3, C4, and CAM photosynthesis

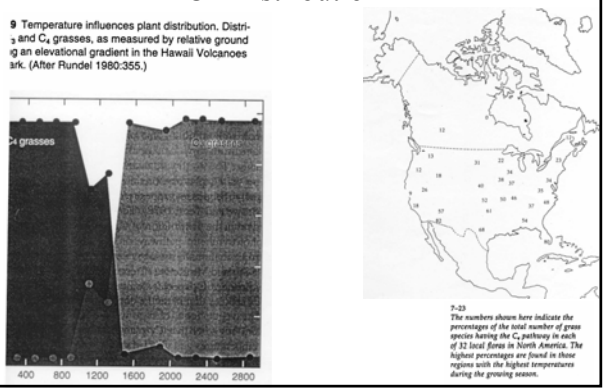
C3 Photosynthesis



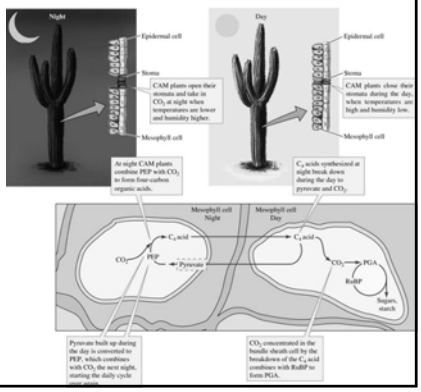
C4 Photosynthesis



C4 Distribution



CAM Photosynthesis

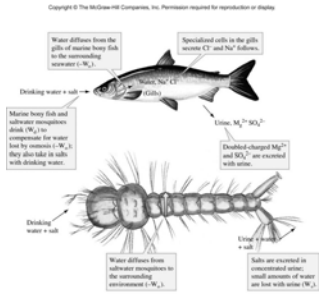


B. Aquatic – 5 Questions

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 <u>marine</u> environments to maintain their water and salt balances?
4. What do animals (fish, inverts.) need to do in <u>freshwater</u> 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