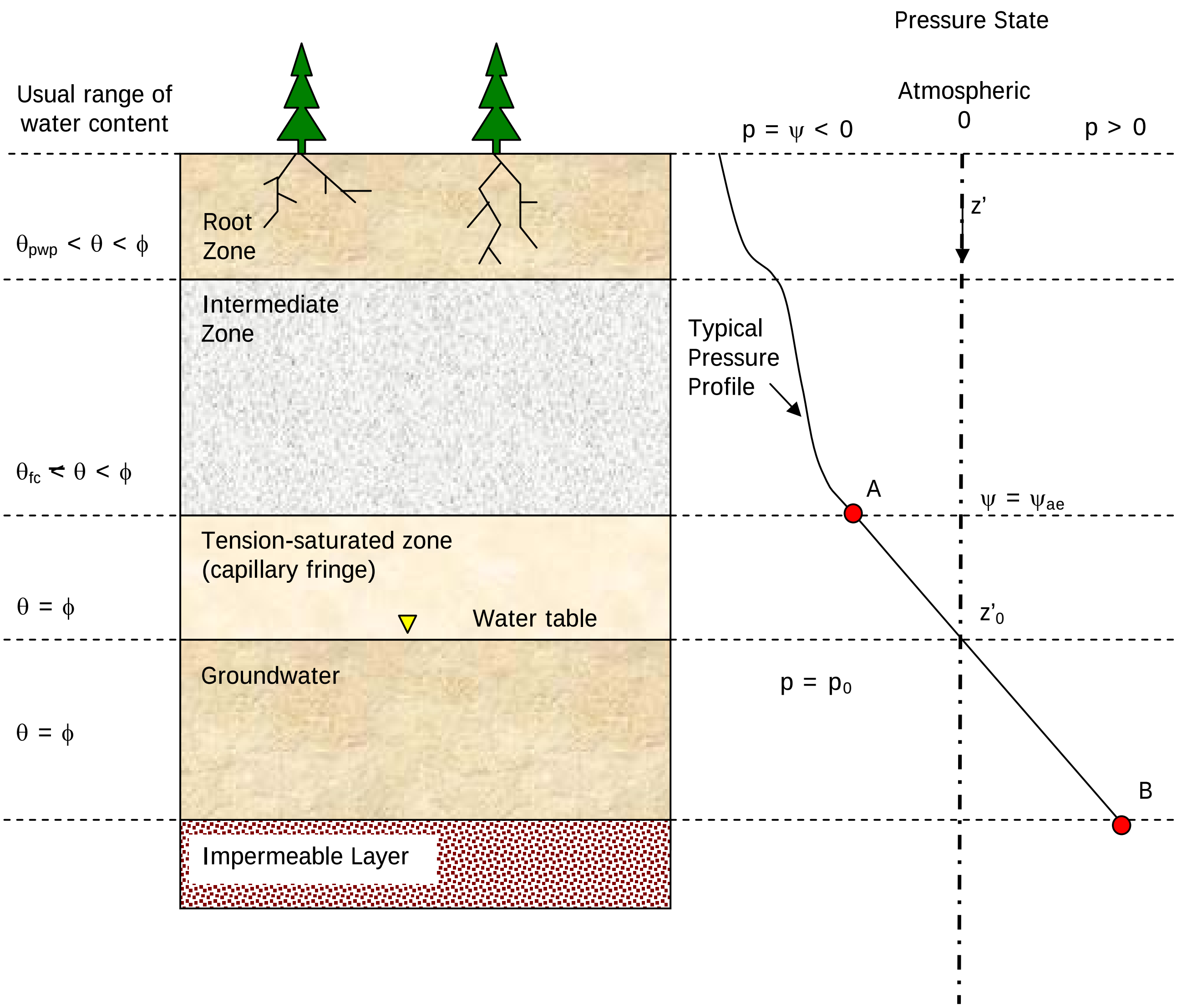
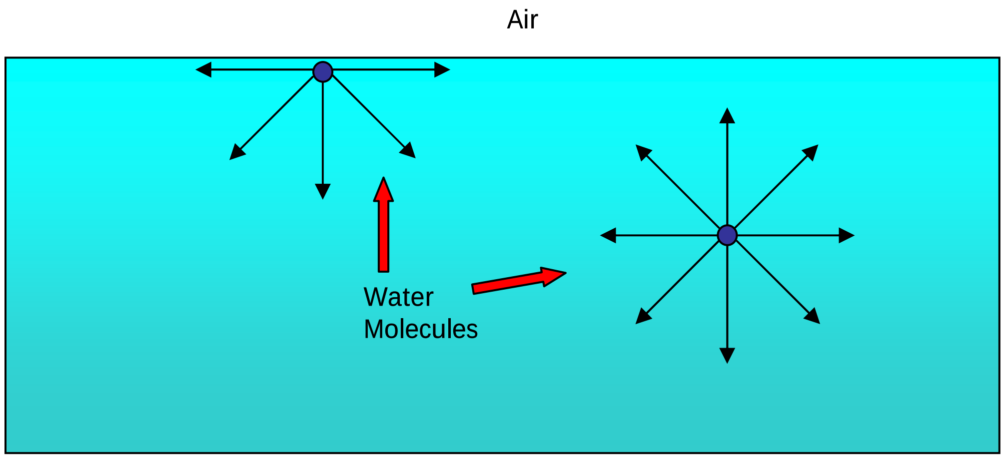
Lecture Packet #12: Soil Moisture

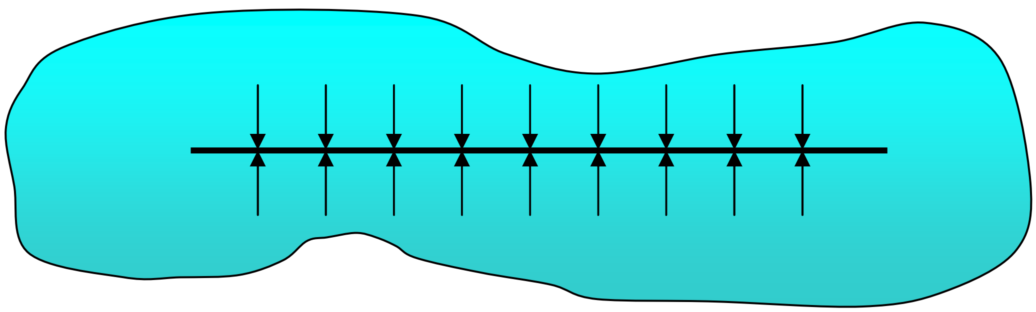


Terms and Interpretations	
Symbol	Definition
θ_{pwp}	Permanent wilting point water content
θ_{fc}	Field capacity water content
ϕ	Porosity
ψ_{ae}	Pressure at which air enters the system (top of the capillary fringe)
p_0	Atmospheric pressure; underground, the definition of water table
$\theta = \phi$	Saturation point

Unsaturated Flow: Movement of Soil Moisture

Water molecules attract each other so that at the surface there is a net downward pull on the molecule. The net effect is **surface tension**.





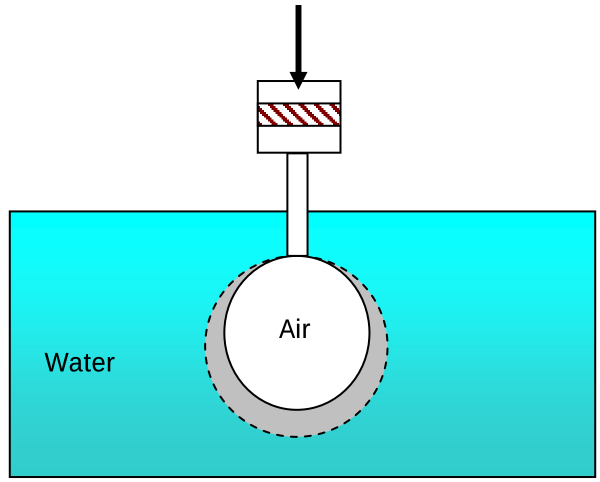
γ = 72.7 dyn/cm for water and air [F/L]
γ = 29 dyn/cm for benzene
γ = 430 dyn/cm for mercury

Energy/L^2 – the energy required to increase the area. Unlike a membrane, the surface tension doesn't change with expansion.

Surface tension depends on:

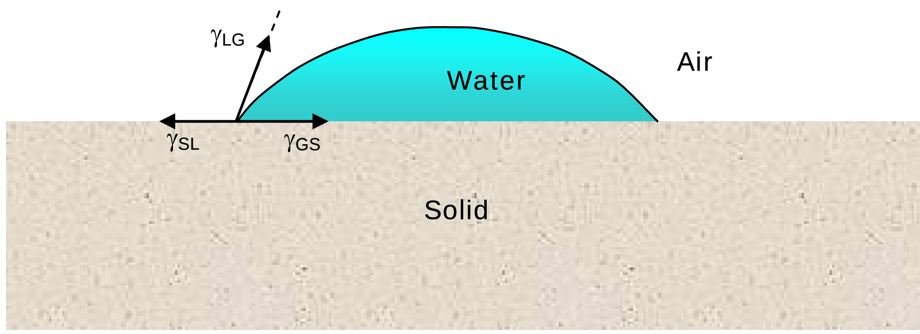
The substances
Any solutes
Temperature
Gas Pressure

Consider a bubble of air in water:



$\Delta P = 2\gamma/R$

Blowing air into the bubble decreases the pressure.

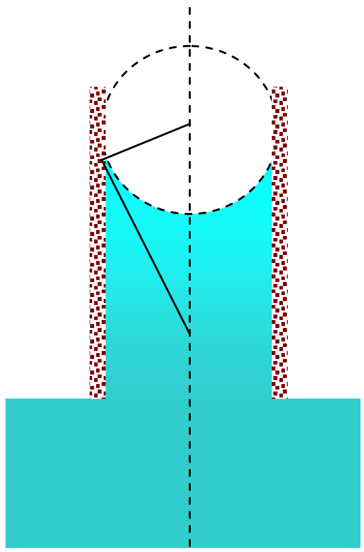


$$\gamma_{SL} = \gamma_{GS} + \gamma_{LS} Cos(\alpha)$$

$$Cos(\alpha) = \frac{\gamma_{SL} - \gamma_{GS}}{\gamma_{LG}}$$

GS = gas-solid
SL = solid-liquid
LG = liquid-gas

Capillary Rise



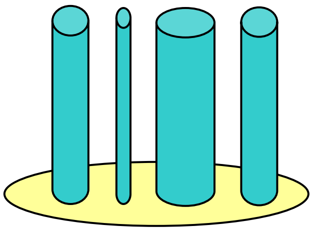
$$\Delta P = \frac{2\gamma Cos(\alpha)}{r}$$

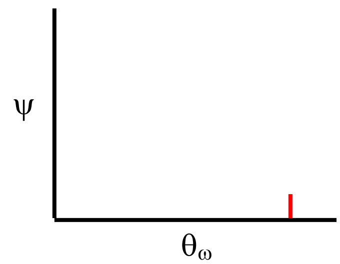
When the height of the meniscus is at steady-state, then the hydrostatic tension must balance the effect of surface tension.

$$hg\rho = \frac{2\gamma Cos(\alpha)}{r}$$

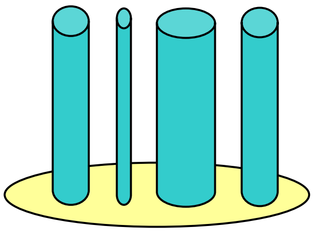
Retention Curves or Soil Moisture Characteristic Curves

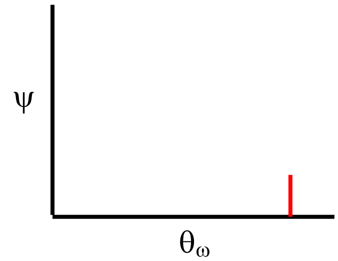
A bundle of capillaries (hydrophyllic) all of the same length with pressure adjusted at the bottom. The bundle contains a range of radii. Measure average water content as the suction is gradually increased at the bottom. Plot suction versus water content.

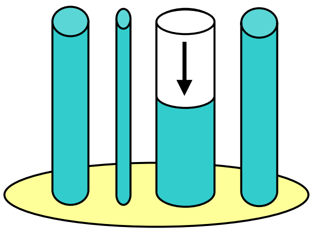


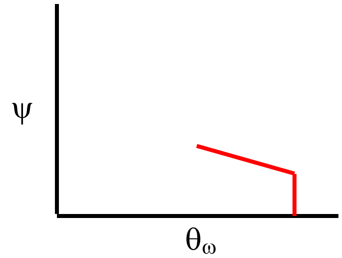


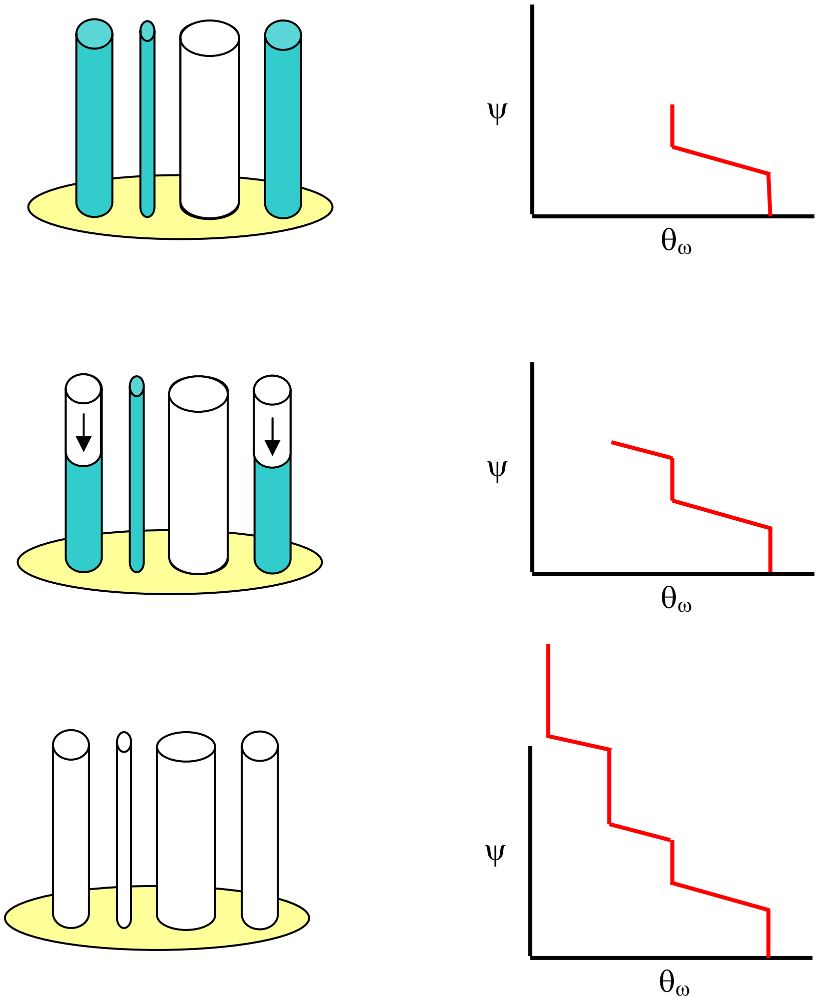
ψ = suction
θ_ω = water content



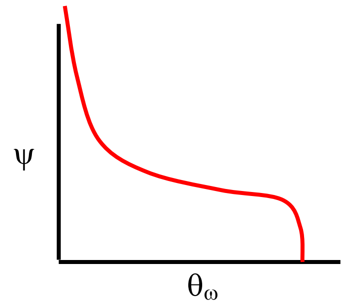







ψ
θω
ψ
θω
ψ
θω

Pore space in rocks and soil is much more complex geometrically but analogous phenomena give rise to characteristic retention curves for a given sample material.



The shape of the retention curve for a given porous material is influenced by:

1. Texture and Structure
    a. Particle-size distribution
    b. Pore-size distribution
    c. Particle shape
    d. Specific surface

2. History of wetting and drying – Hysteresis
    a. Non-wetting phase entrapment
    b. Swelling and shrinking
    c. Ink-bottle effect – Haines Jump