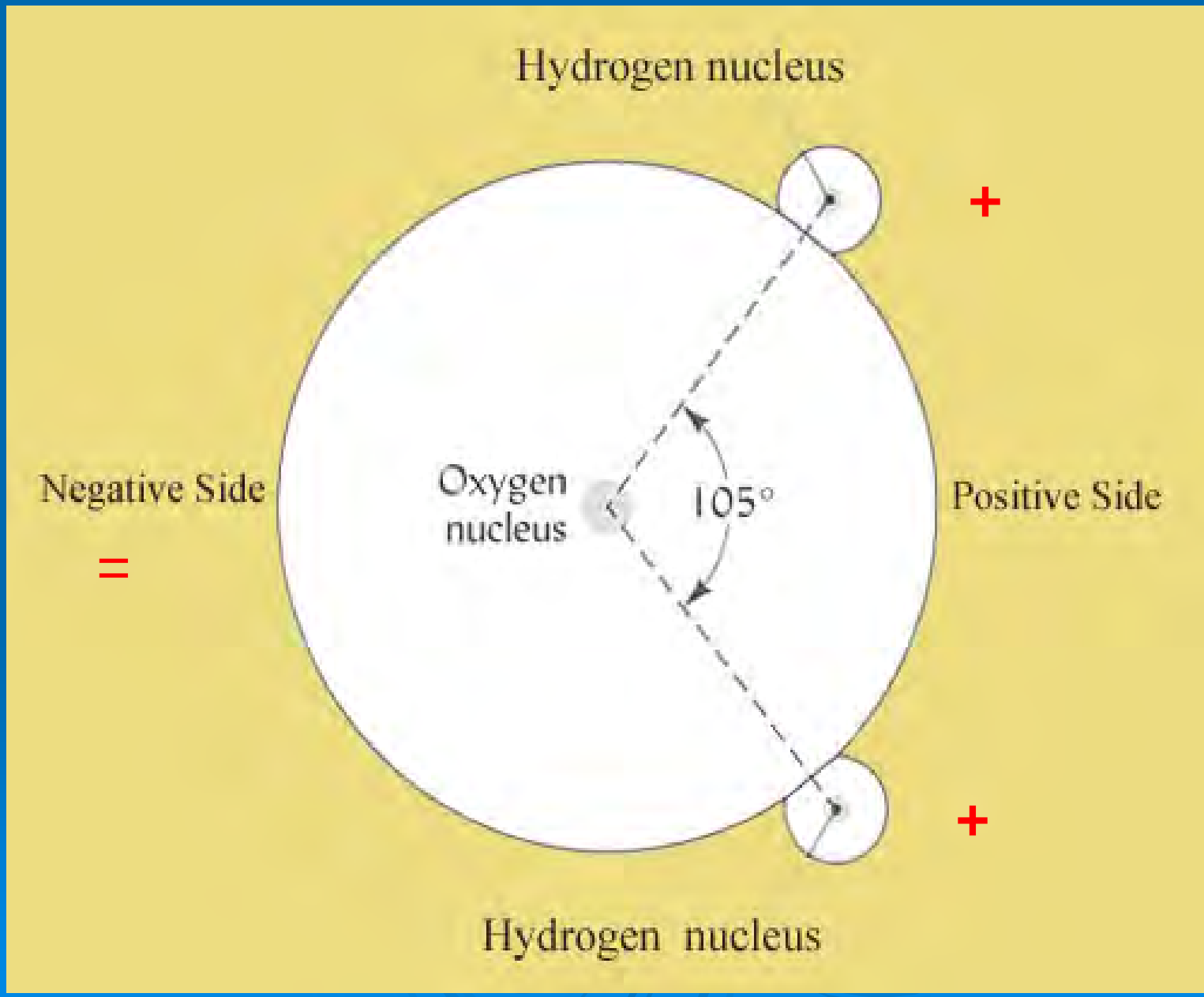
Understanding Soil Water

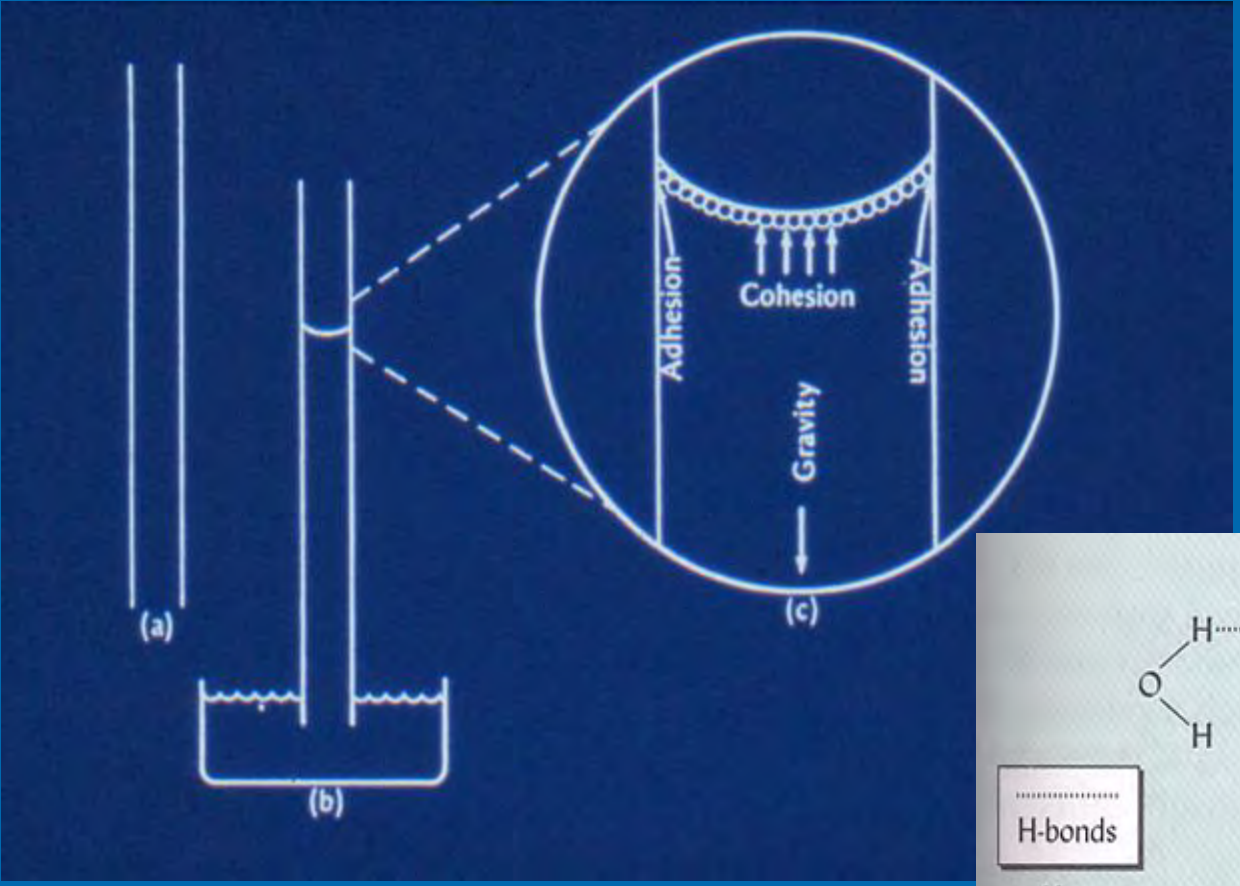
Objectives

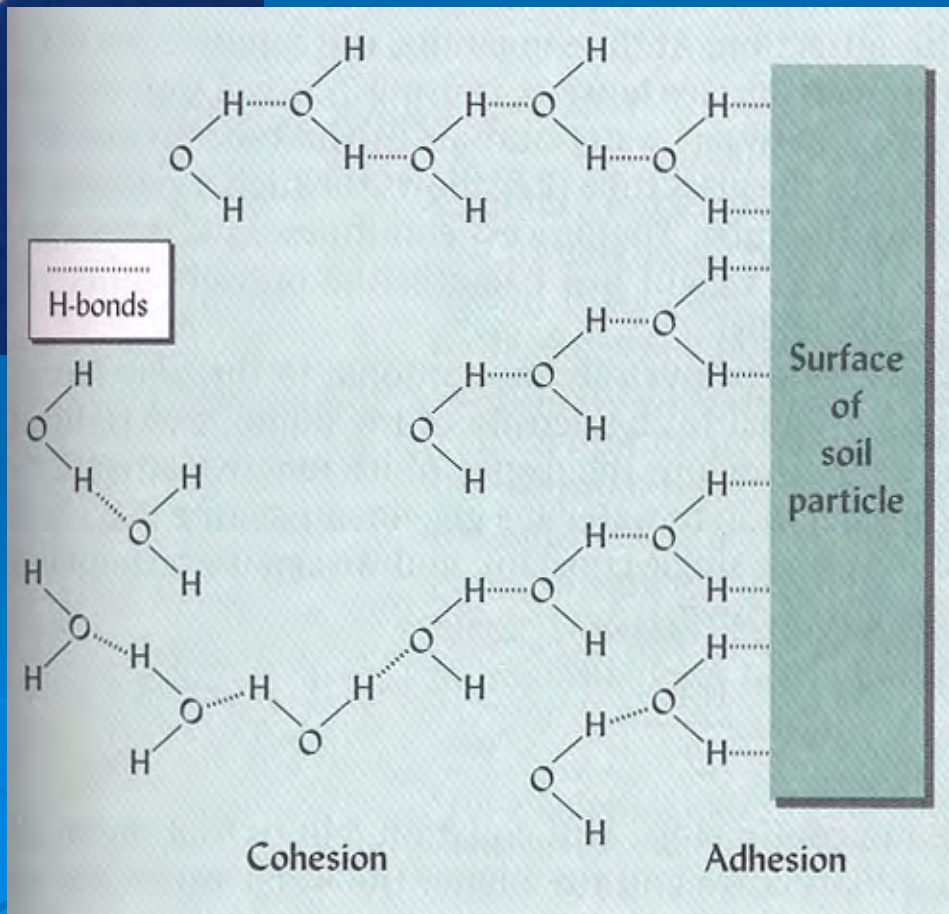
- Properties of water
- Energy concepts of water
- Classification of kinds of water
- Water retention in soils
- Significance of soil texture on water
- Water flow – Saturated vs. Unsaturated
- Soil water vs. Expected corn yields

Water Molecule

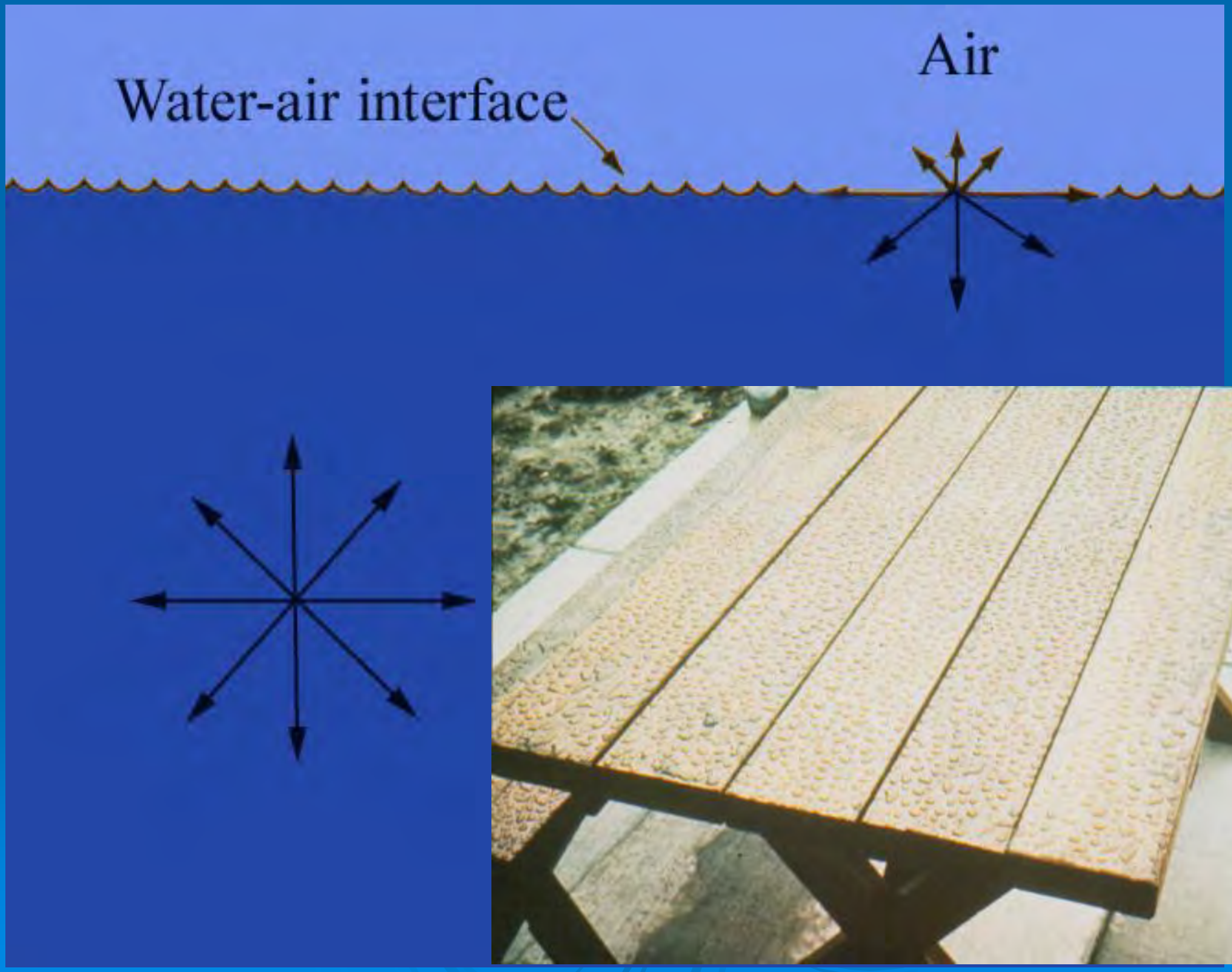


Cohesion vs. Adhesion

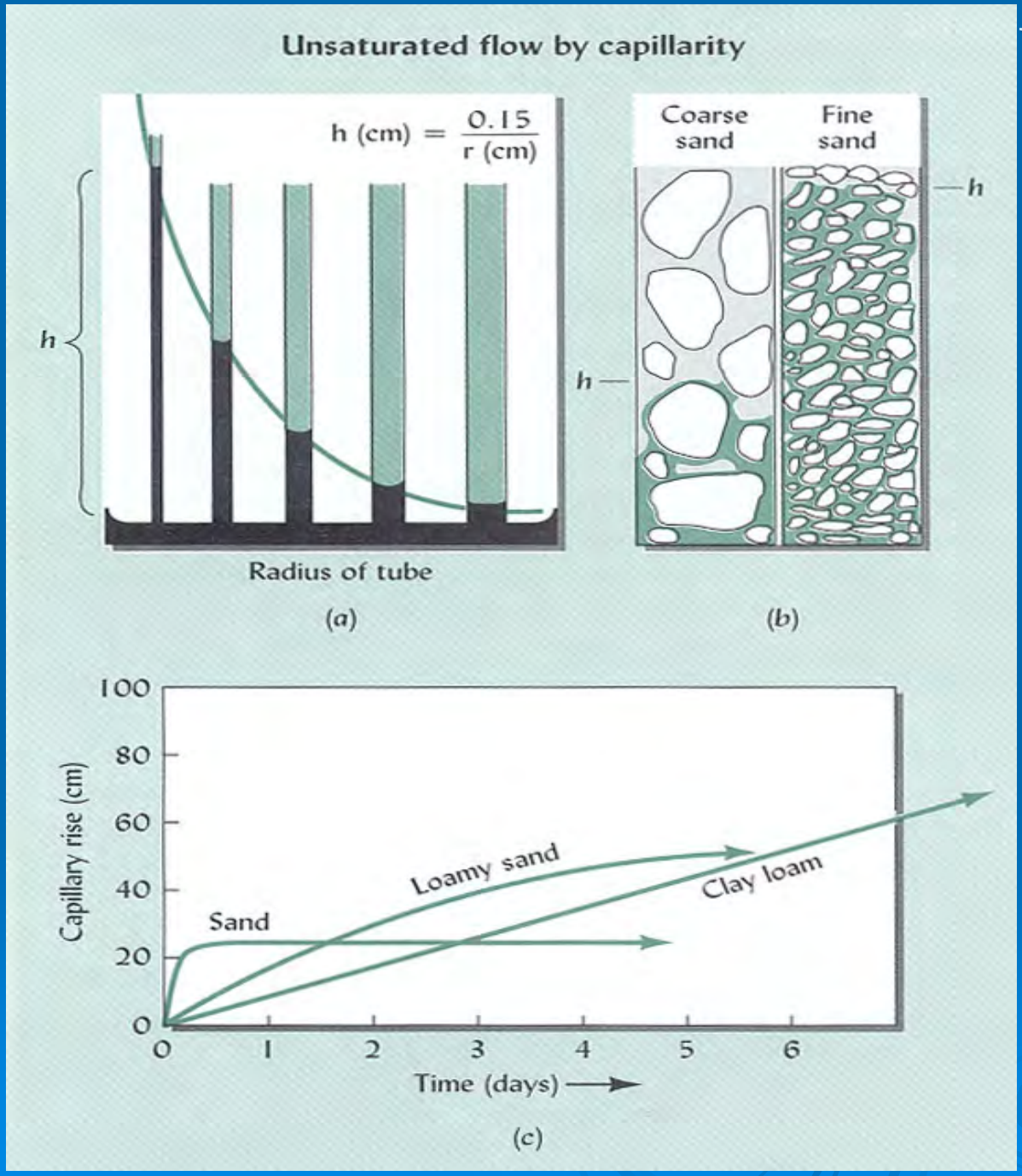




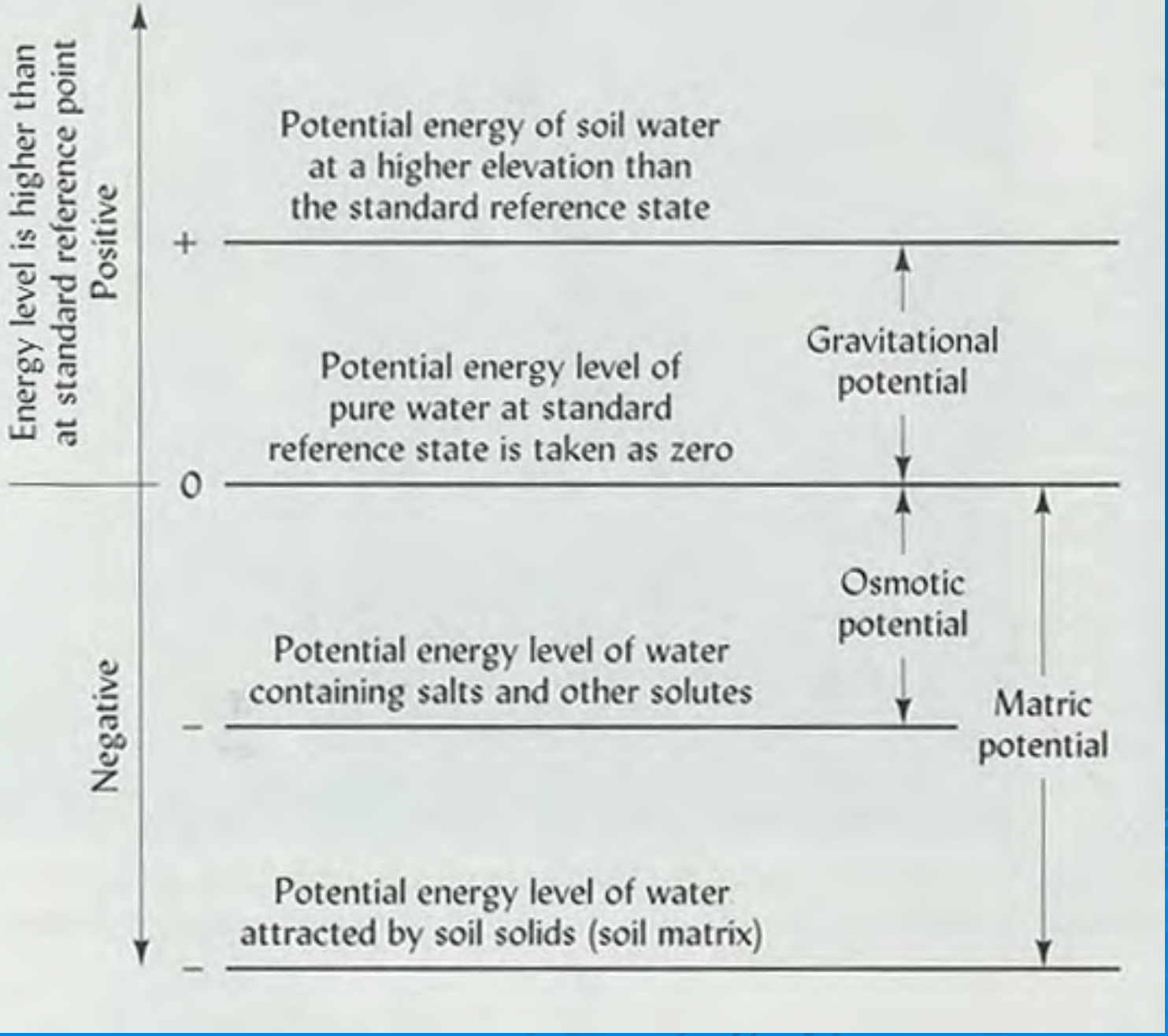
Surface Tension Diagram



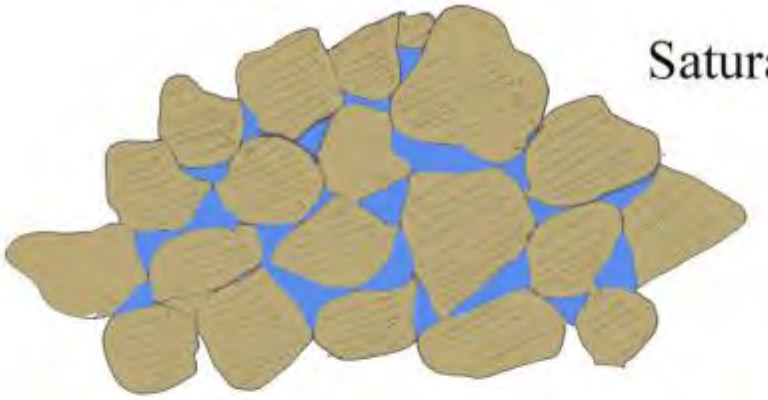
Unsaturated flow by capillary



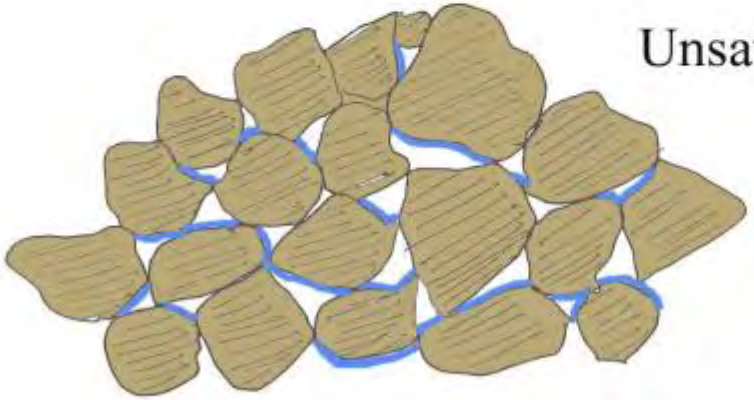
Energy


Energy level is higher than at standard reference point
Positive
Negative
Potential energy of soil water at a higher elevation than the standard reference state
+
Potential energy level of pure water at standard reference state is taken as zero
0
Potential energy level of water containing salts and other solutes
–
Potential energy level of water attracted by soil solids (soil matrix)
–
Gravitational potential
Osmotic potential
Matric potential

Saturated vs. Unsaturated

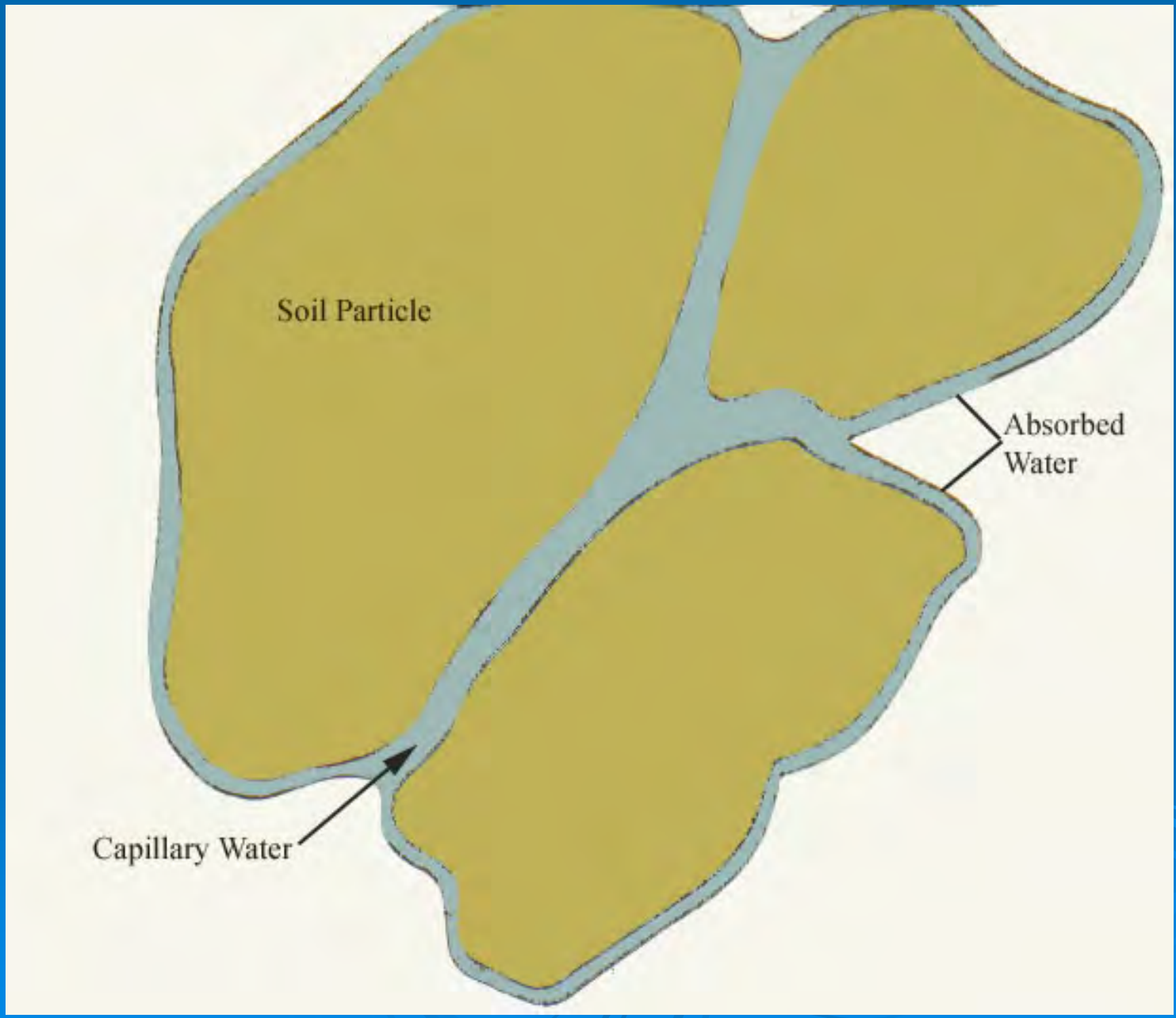


- **Flow:**
Rate is determined by pore size + pressure



- **Flow:**
Rate is determined by Water content + pressure (Very Slow)

Solid Particles with water film between particles



Field Capacity

- Volumetric Water Content at which large pores have drained and the soil surface starts to dry.
- THIS IS AT A SOIL WATER POTENTIAL RANGE OF
  -0.1 to -0.3 bars OR -10 to -30 k Pa.

- At Field Capacity:
  - the soil is holding the maximum amount of water useful to plants
  - the soil is near its lower plastic limit, which is the maximum water content for ease of tillage.
  - pore space contains enough air for most aerobic microbial activity.

Permanent Wilting Percentage

- Water content of a soil when plants can no longer extract water for use.
- THIS IS A SOIL WATER POTENTIAL OF
  -15 bars or -1,500 k Pa.

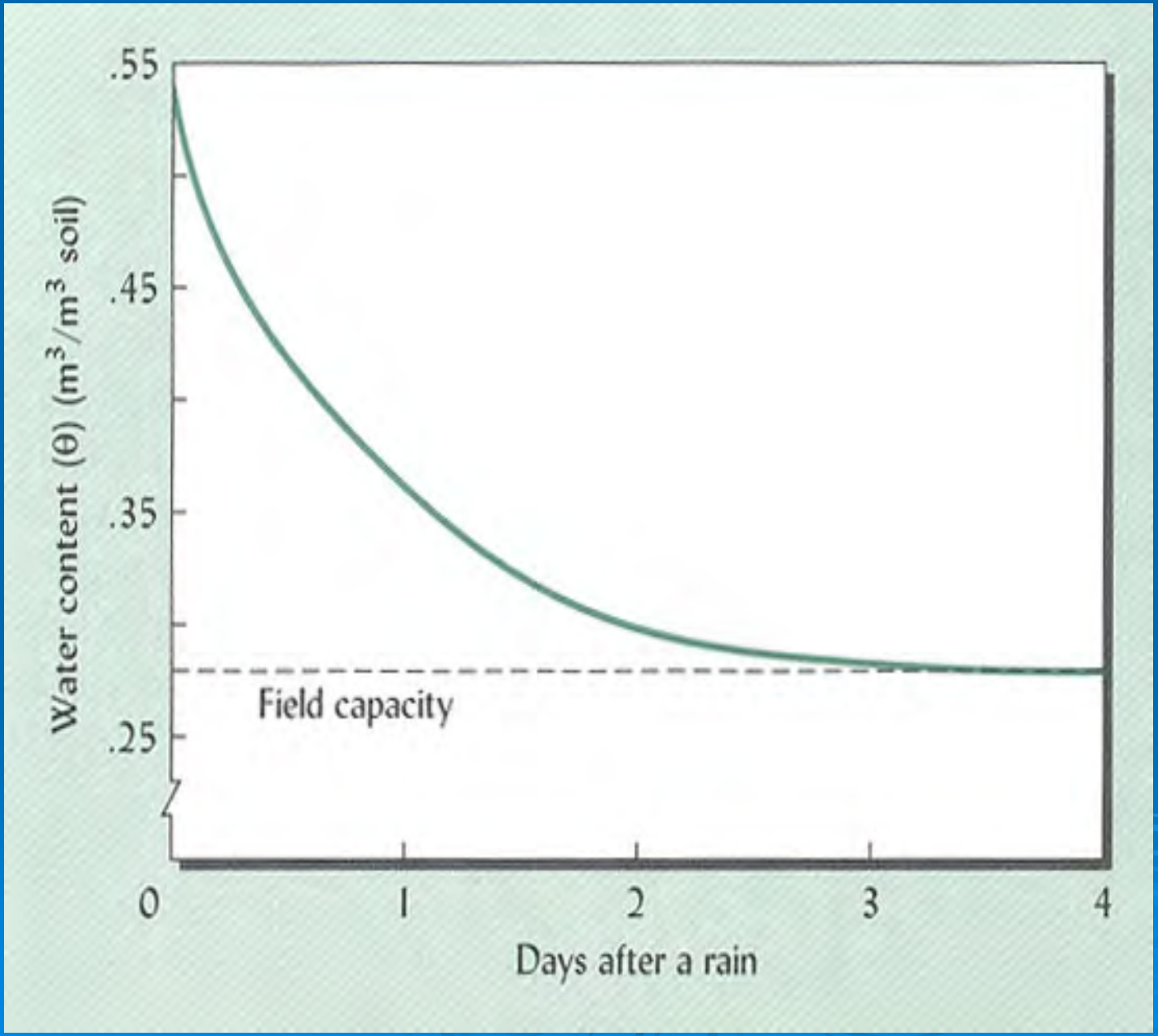
Approximate Equivalents of Energy Levels of Soil Water

Height of unit column of water (cm)	Soil water potential (bars)	Soil water potential (MPa)[a]
0	0	0
10.2	-0.01	-0.001
102	-0.1	-0.01
306	-0.3	-0.03
1,020	-1.0	-0.1
15,300	-15	-1.5
31,700	-31	-3.1
102,000	-100	-10.0

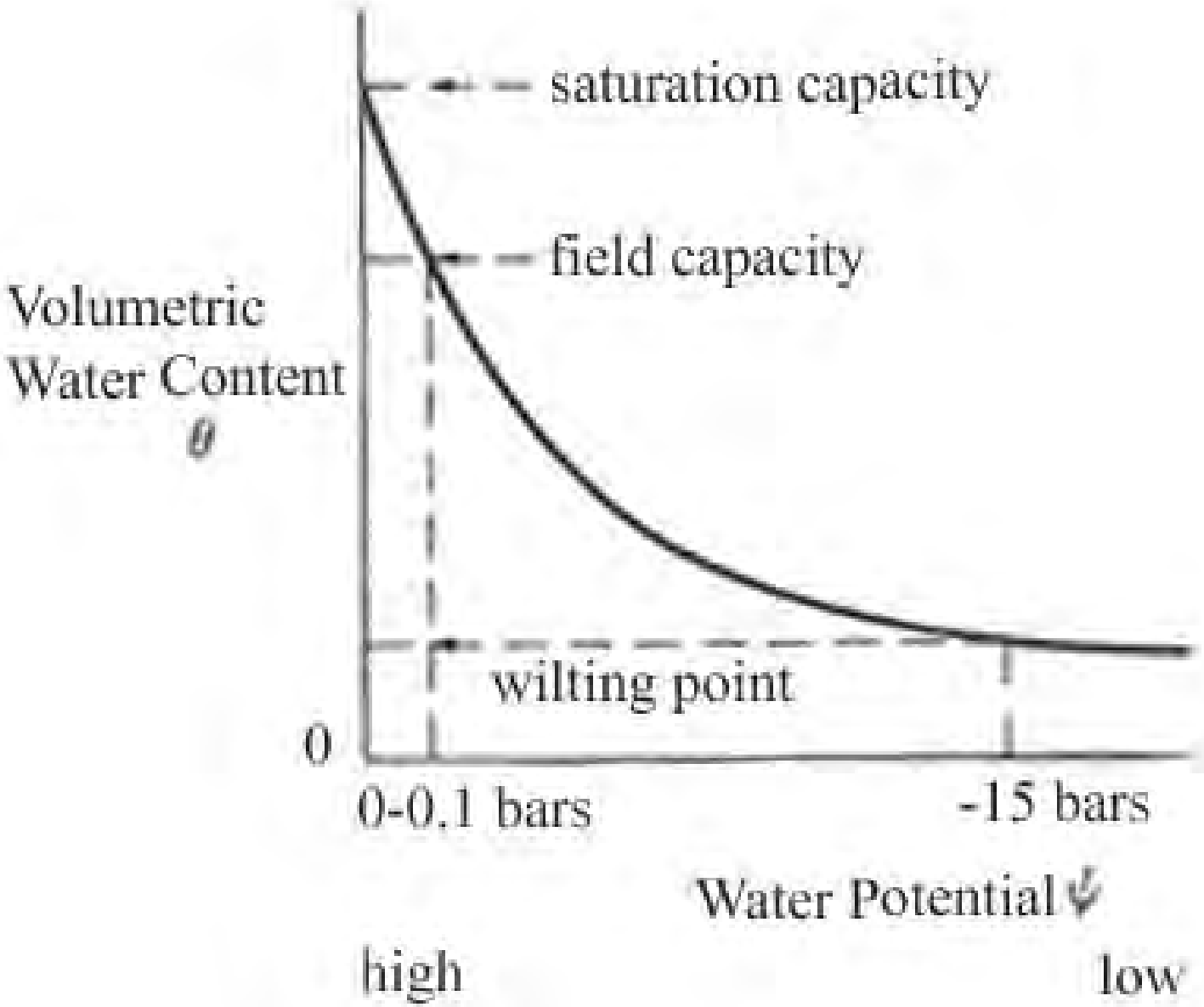
502 feet!

[a] The SI unit megapascal (MPa) is equivalent to 10 bars.

Water reaching field capacity at 2 days



Water Retention Curve



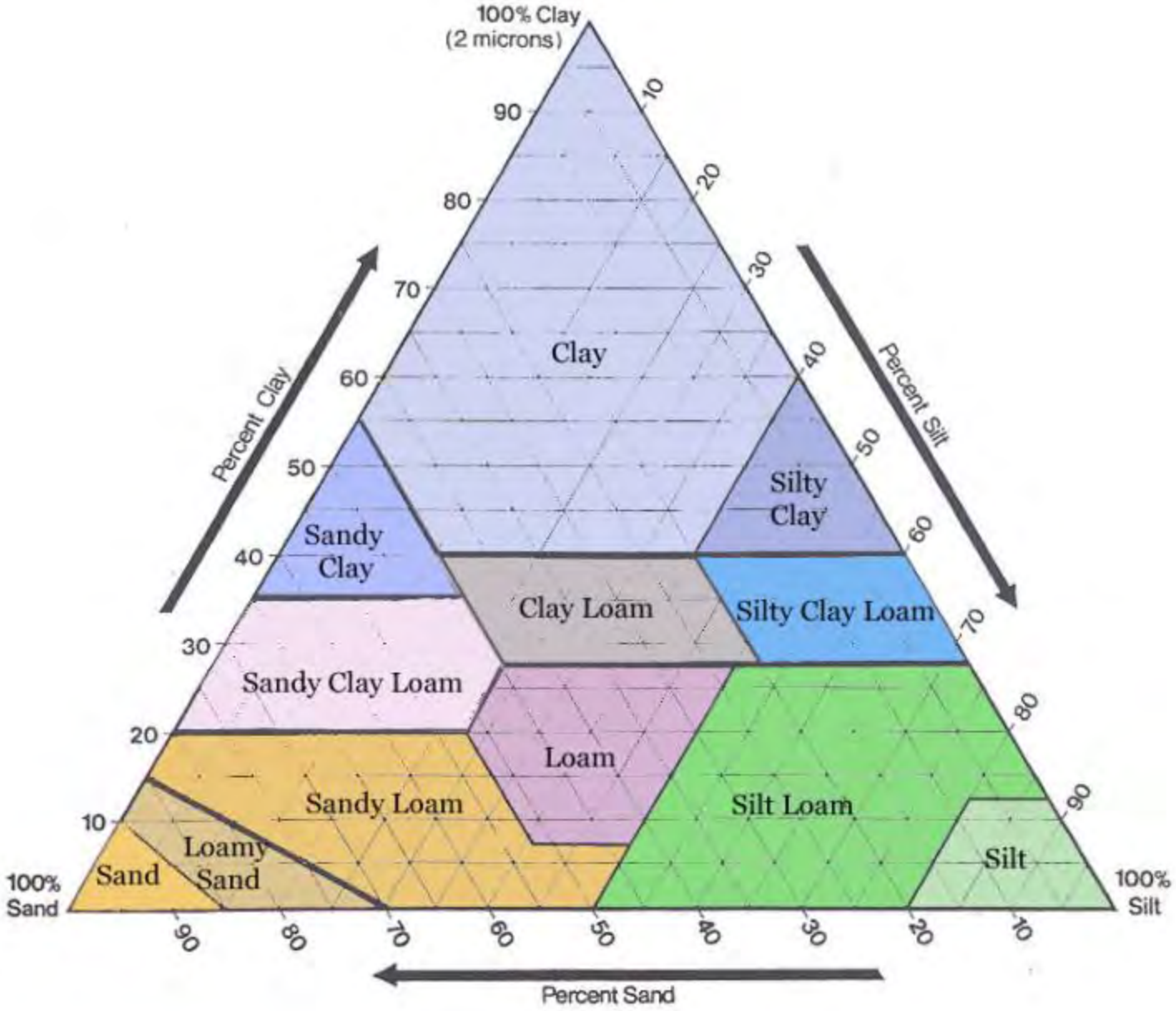
Plant Available Water

- Plant Available Water is
  equal
  to Volumetric Water at Field Capacity
  minus
  the Volumetric Water at Wilting Point.

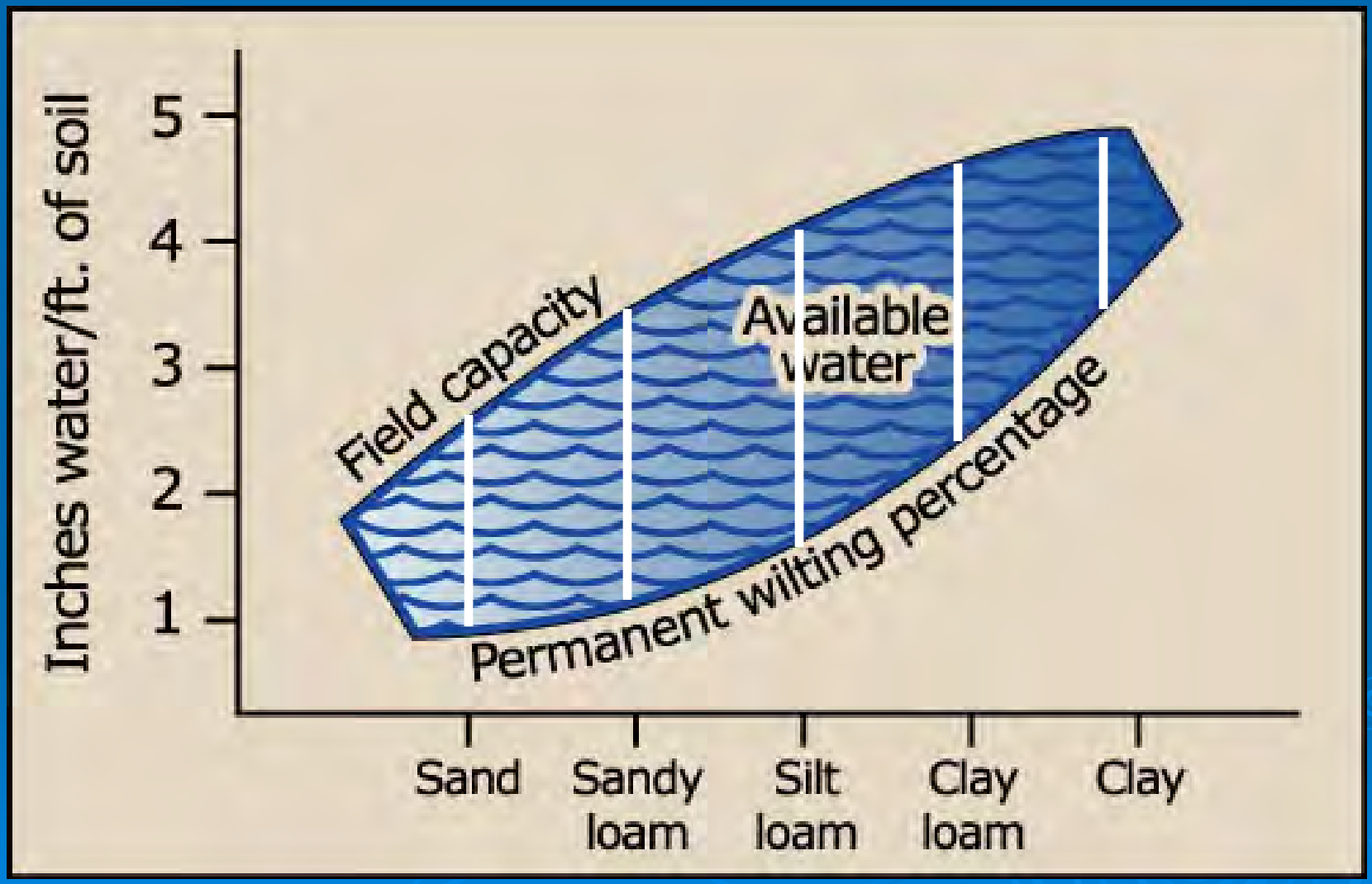
The Sponge “Model”

- Think of soil as a sponge
  - Many particles of different sizes
  - Many pores of different sizes
  - Able to adsorb water and hold it on the surfaces and in pores
- Some key differences
  - Types of minerals and charge
  - Interaction with plants, microbes
  - “Particle” management depends on tillage, compaction

Soil Textural Triangle



Water Volume / Soil Texture Class



Plant Available Water Capacity by Soil Texture

Texture	Plant Available Water Inches of Water/inch Soil
Coarse sand and gravel	0.03
Sands	0.04
Fine Sand	0.06
Loamy Sand	0.08
Loamy Fine Sand	0.09
Sandy Loam	0.12
Very Fine Sandy Loam	0.16
Loam	0.18
Silt Loam	0.22
Sandy Clay Loam	0.14
Clay Loam	0.18
Silty Clay Loam	0.19
Sandy Clay	0.16
Silty Clay	0.13
Clay	0.11

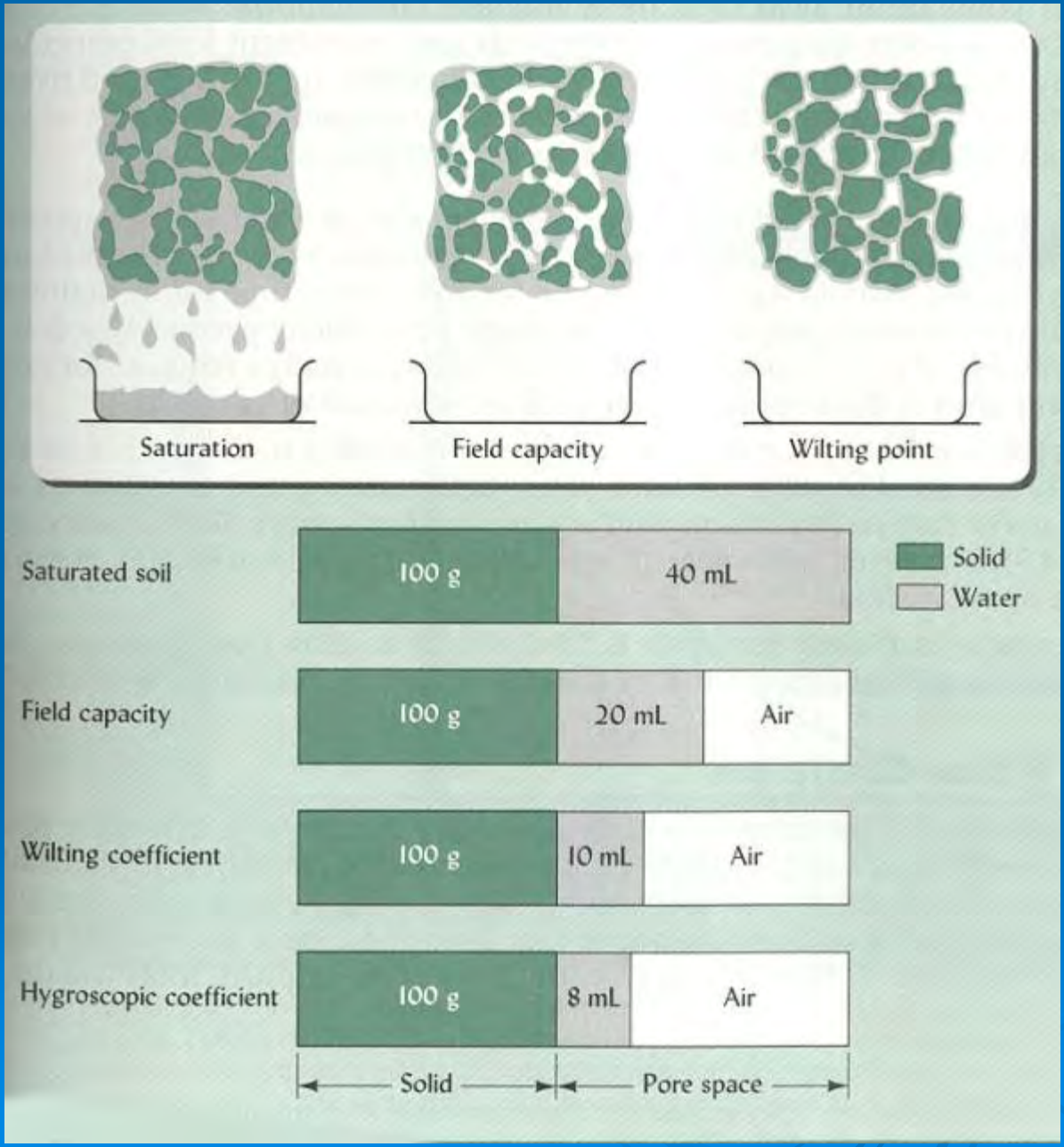
Soil Water Energy Concepts

- Water will move from HIGHER energy levels to LOWER energy levels

- HIGH  LOW
- WET  DRY

  - DIRECTION OF FLOW can be predicted by differences in Soil water potential (SWP) between two points in the soil (including upward!).

Volumes of Water and Air in Soil



- Rumford Soil
  - features sandy textures throughout

Rumford Soil

Horizon	Depth	Sand	Silt	Clay	PAW
	in	-------	---%--	-------	*in/in*
Ap	0-9	82	11	7	0.06
Bt	9-27	76	12	12	0.11
C	27-40	77	14	9	0.05

P.A.W. (Plant Available Water) / 36" soil = 3.07"
VALUES corn yield = 85 bu / acre

- Pamunkey Soil
  - Features medium textured well drained soil

Pamunkey Soil

Horizon	Depth	Sand	Silt	Clay	PAW
	in	--------	---%--	--------	*in/in*
Ap	0-10	46	32	22	0.18
Bt	10-30	39	33	32	0.16
C	30-60	50	30	20	0.14

P.A.W. (Plant Available Water) / 36" soil = 5.84"
VALUES corn yield = 160 bu / acre

- Dogue Soil
  - features fine textured soil in the sub-surface and some restriction in drainage

Dogue Soil

Horizon	Depth	Sand	Silt	Clay	PAW
	in	--------	---%--	--------	*in/in*
Ap	0-8	60	42	8	0.12
Bt	8-60	30	20	50	0.12

P.A.W. (Plant Available Water) / 36" soil = 4.32"
VALUES corn yield = 130 bu / acre

- Cecil Soil
  - features are red and clayey throughout

Cecil Soil

Horizon	Depth	Sand	Silt	Clay	PAW
	in	--------	---%--	--------	*in/in*
Ap	0-8	69	16	15	0.11
Bt	8-30	26	20	54	0.08
C	30-50	46	18	36	0.08

P.A.W. (Plant Available Water) / 36" soil = 3.12"
VALUES corn yield = 100 bu / acre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