Western Region CCA Exam Prep
Intro to Soil & Water

Franz Niederholzer, UCCE Farm Advisor
Colusa/Sutter/Yuba Counties
fjniederholzer@ucanr.edu
and
Sharon Benes, Professor
CSU, Fresno

What soil provides plants…

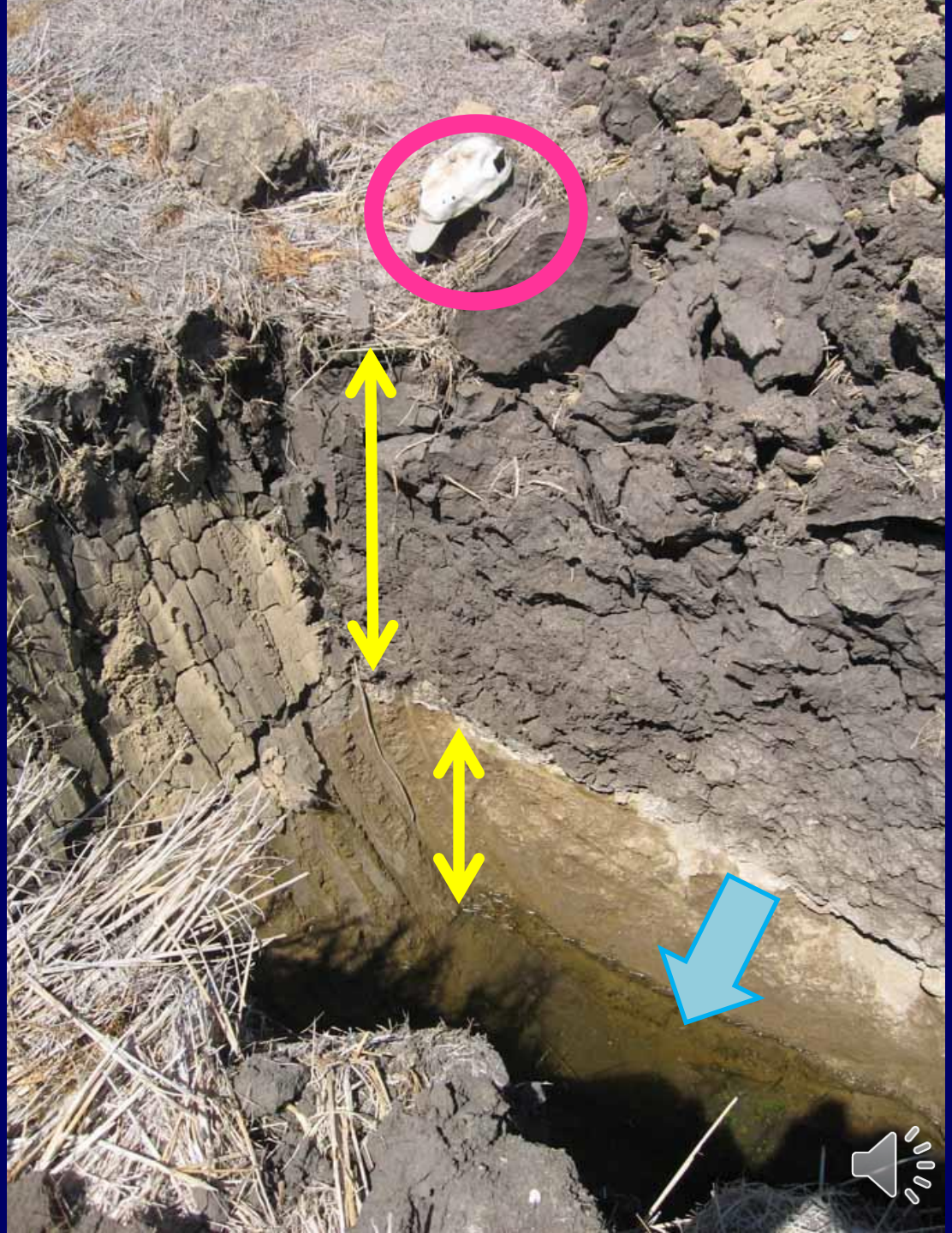
- Anchorage
- Water
- Nutrients
- Oxygen

- Physical soil properties
  - Texture
  - Structure
  - Bulk density/porosity
- Soil chemical properties
  - Exchange capacity
  - pH
- Water in soil
  - Field capacity (FC)
  - Permanent wilting point (PWP)
  - Available water (AW)
- Factors of Soil Erosion

A soil profile can have different physical and chemical properties depending on depth from the surface.


CAT

Oswald clay



http://www.cals.uidaho.edu/soilorders/histosols_07.htm

Composition of Mineral Soils

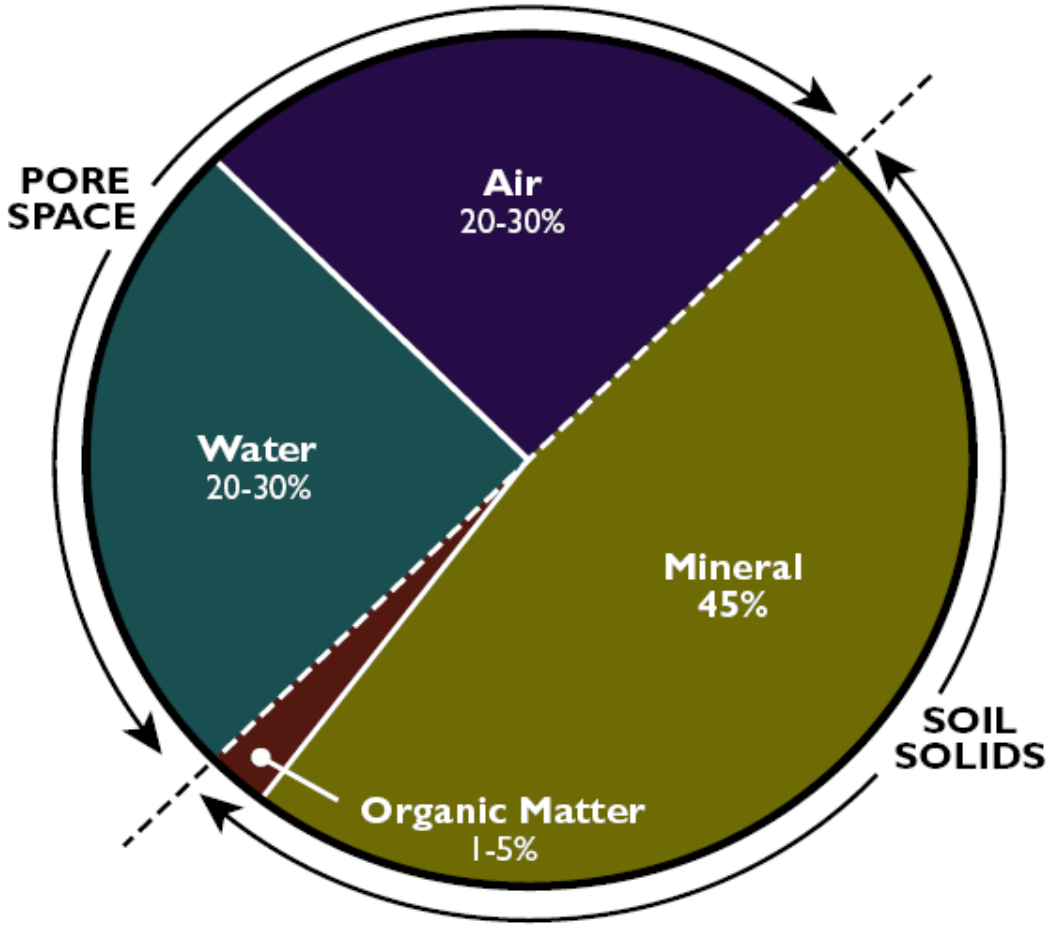
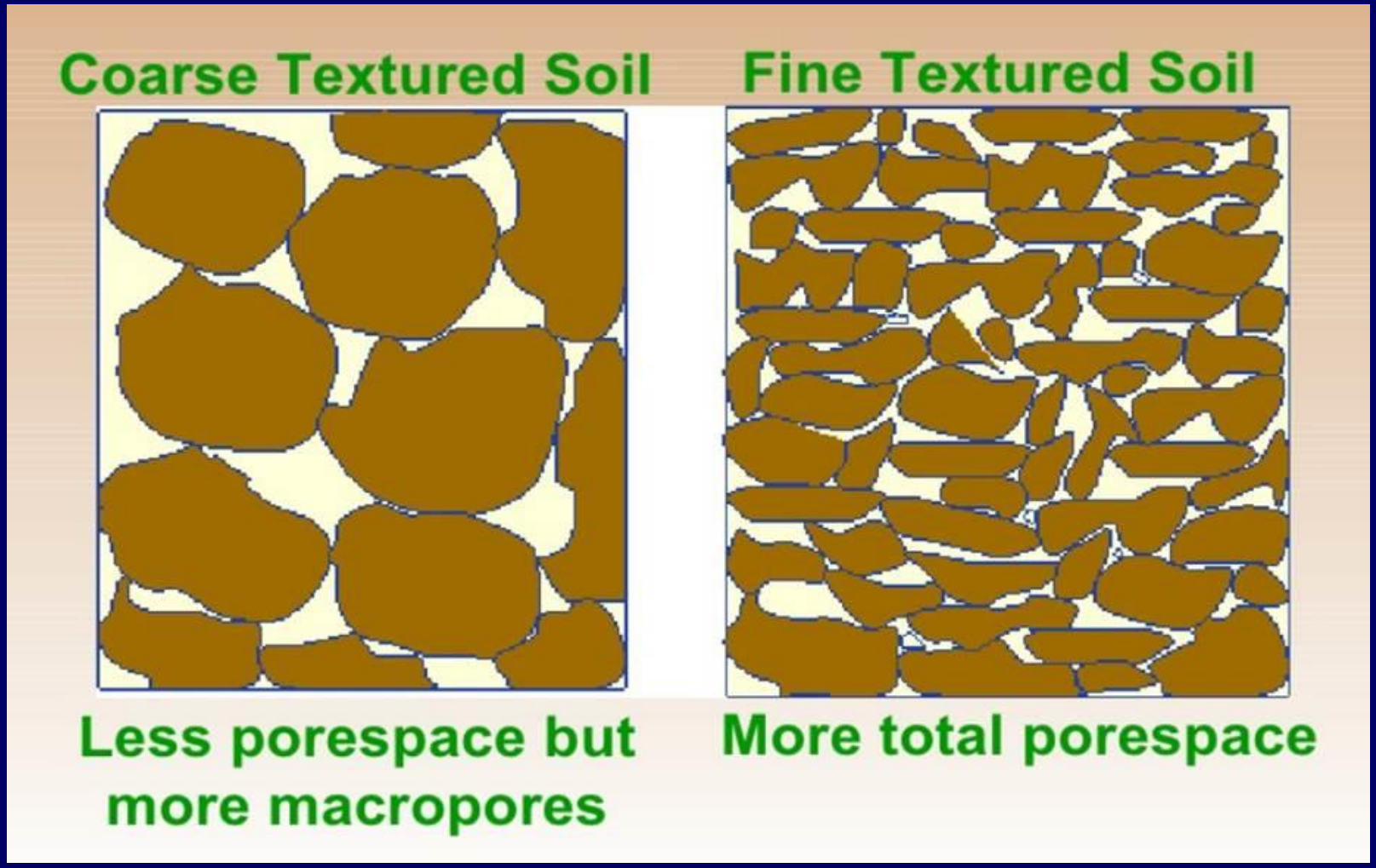


Figure 1. The four components of soil. Minerals and SOM make up the solid fraction, whereas air and water comprise the pore space fraction. A typical agricultural soil is usually around 50% solid particles and 50% pores. (Adapted from Brady and Weil, 2002)

How the pore spaces are arranged hugely impacts productivity.



I. Basic Physical & Chemical Properties of Soils

- Texture
- Structure
- Bulk Density / Porosity
- Organic Matter

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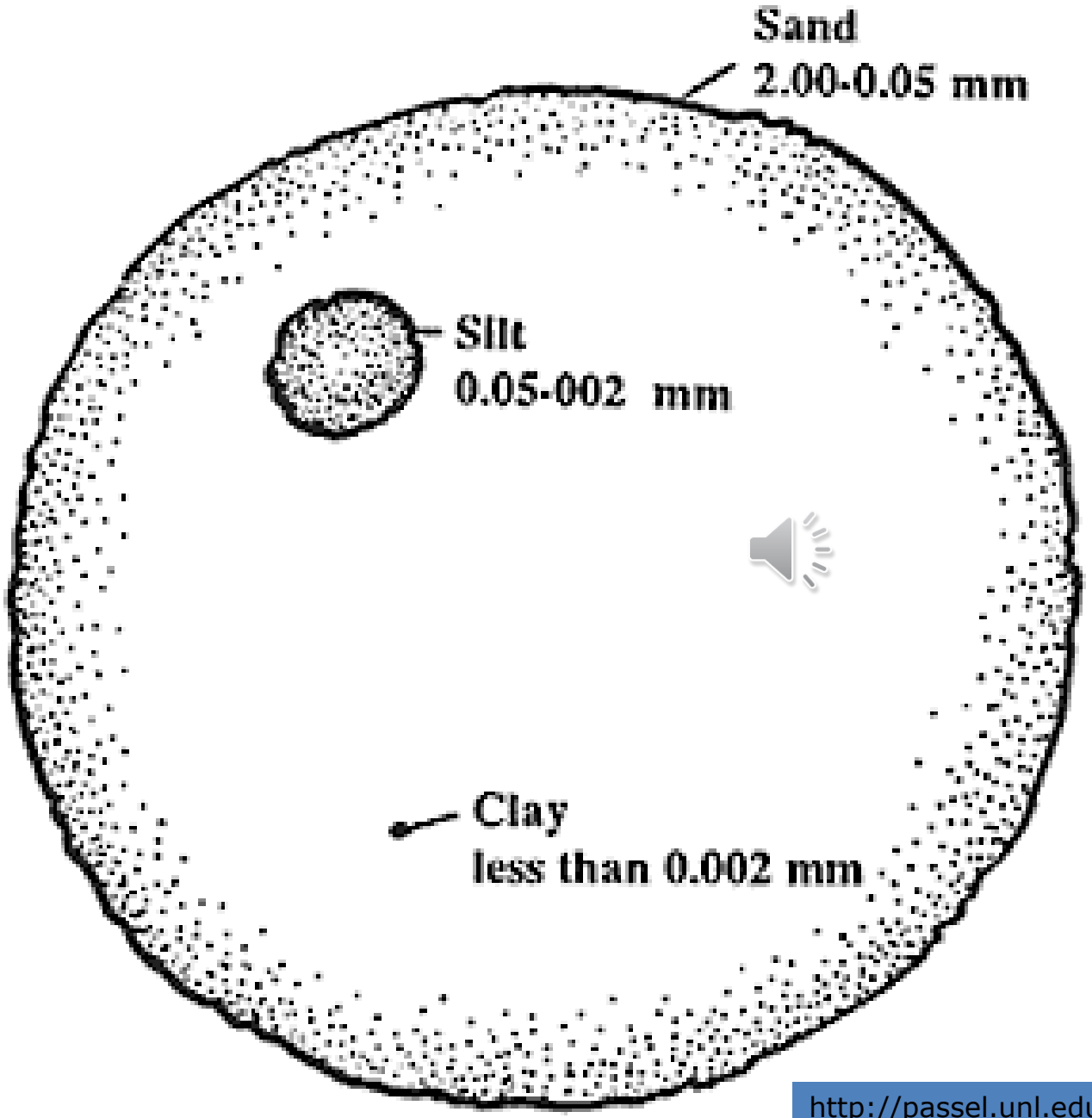
Texture

Percentage of sand, silt and clay in a soil after removal of:

- **Gravels/stones (>2mm)**
- **Organic matter**
- **Carbonates**

Particle size comparison



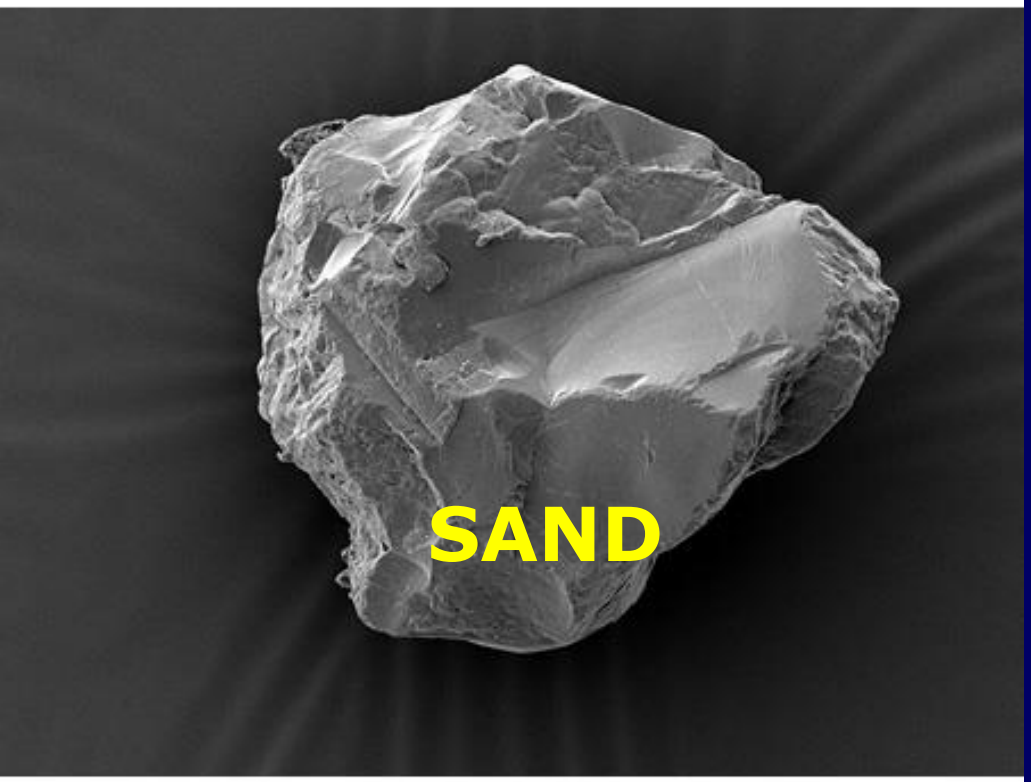
http://passel.unl.edu/UserFiles/File/Crp.%20Prod.%20Nat.%20Res.%20Mngmt/Soils%20lesson%202/Fig-2.2.gif

Why worry about texture?

Describes particle size distribution in a particular soil, which…

tells us a lot about

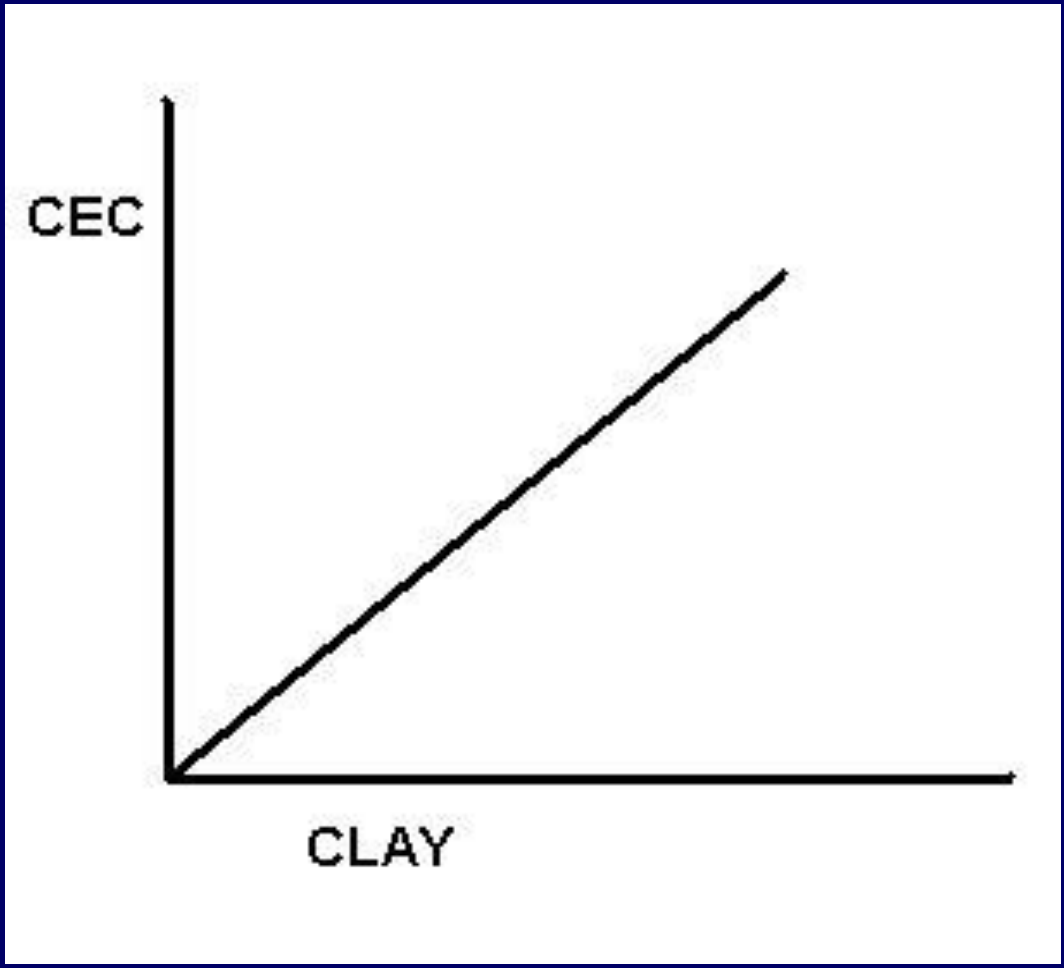
- Potential water holding capacity
- Rates of water movement
- Nutrient holding capacity.


SAND

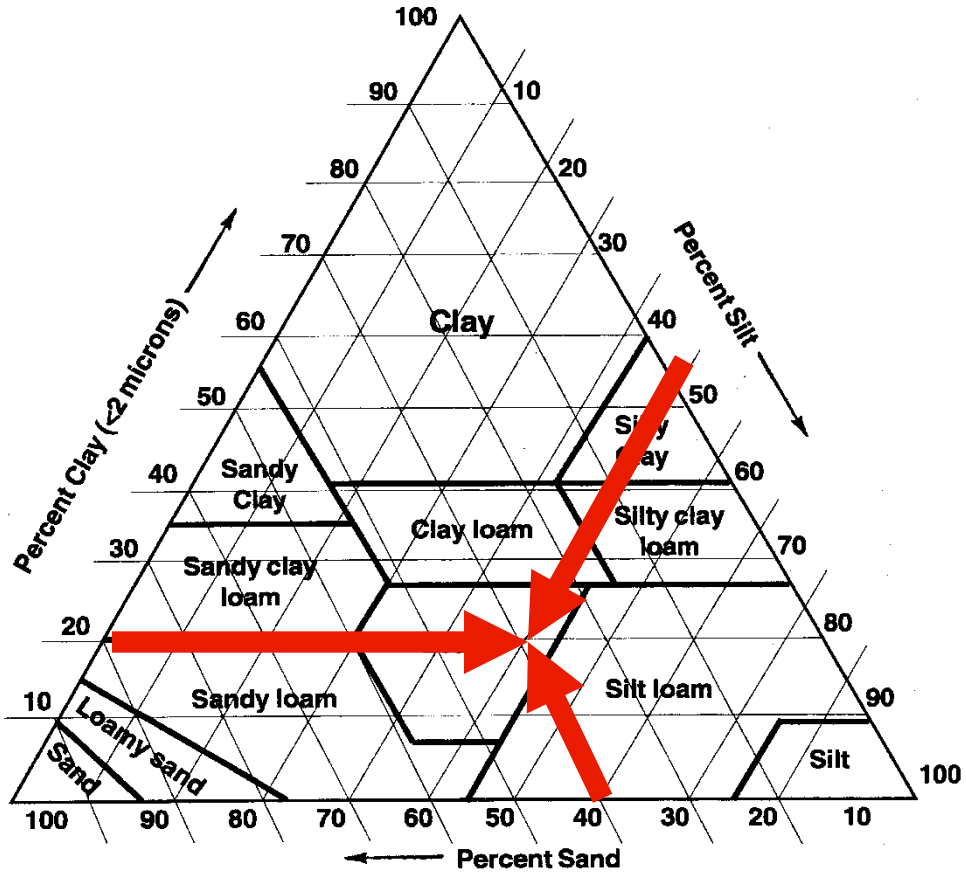

CLAY

So why is texture important?

The more clay in a soil, the higher the Cation Exchange Capacity.



Particle Size Analysis cont'd



50 g. O.D. soil

18 g. sand = 36%

22 g. silt = 44%

10 g. clay = 20%

So….the textural class is _LOAM_ ?

I. Basic Physical & Chemical Properties of Soils

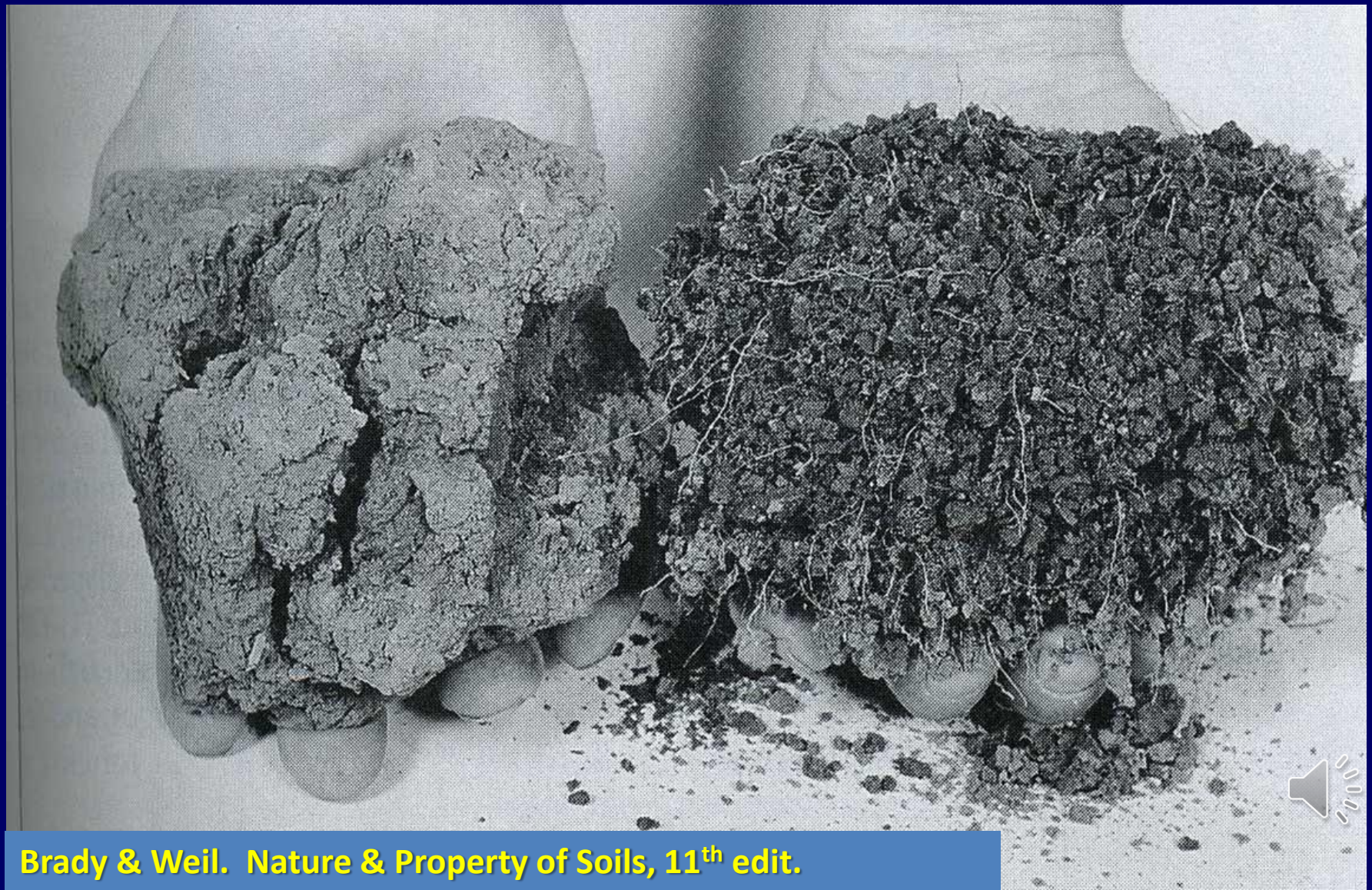
- Texture
- **Structure**
- Bulk Density / Porosity
- Organic Matter

Soil Structure

- Sandy soils generally have weak structure

- Clay soils can develop more structure

Good soil structure facilitates water entry & root penetration



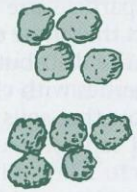
Brady & Weil. Nature & Property of Soils, 11th edit.

Spheroidal

Characteristic of surface (A) horizons. Subject to wide and rapid changes.

Granular (porous)

Crumb (very porous)

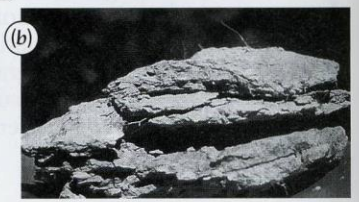


(a)

Plate-like

Common in E-horizons, may occur in any part of the profile. Often inherited from parent material of soil, or caused by compaction.

(b)



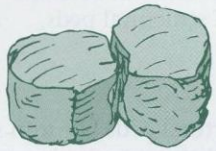
Block-like

Common in B-horizons, particularly in humid regions. May occur in A-horizons.

Angular blocky

(c)

Subangular blocky



(d)

Prism-like

Usually found in B-horizons. Most common in soils of arid and semi-arid regions.

Columnar (rounded tops)

(e)

Prismatic (flat, angular tops)

(f)

Soil Structure

Arrangement of sands, silts, & clays into stable aggregates

Held together by clay, humus and/or oxides

Brady & Weil. Nature & Property of Soils, 13th edit.

Why are texture and structure important to plant health?

	Coarse-textured	Fine-textured
Pore size	Larger	Smaller
Porosity (& surface area)	Lower	Higher
Infiltration (& drainage)	Faster	Slower
Water-holding capacity	Lower	Higher
Nutrient retention	Poor	Good
Aeration	Good	Poor
Easy of tillage	Easier	Harder
Shrink/ Swell	Low	High

Pore size vs. Porosity

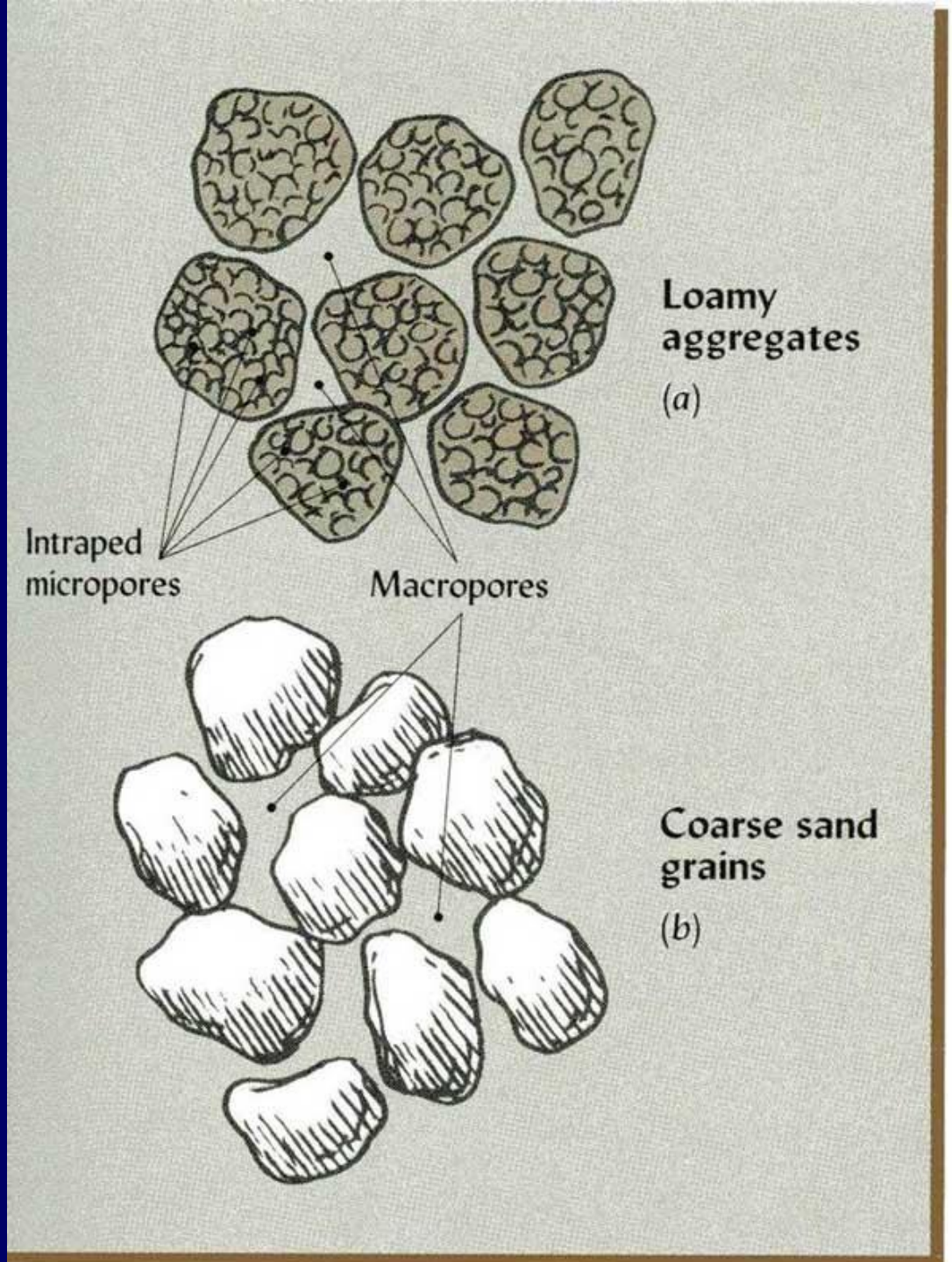
Coarse-textured soils

- **Larger pore size (diameter)**

Fine-textured soils

- **Smaller pore size**
- **Higher porosity (total pore space) due to small particle size**

→ *Best compromise of both attributes could be a loam soil*



Pore size is important for Infiltration & drainage

Porosity (% total pore space) is important for Water-holding capacity (WHC)

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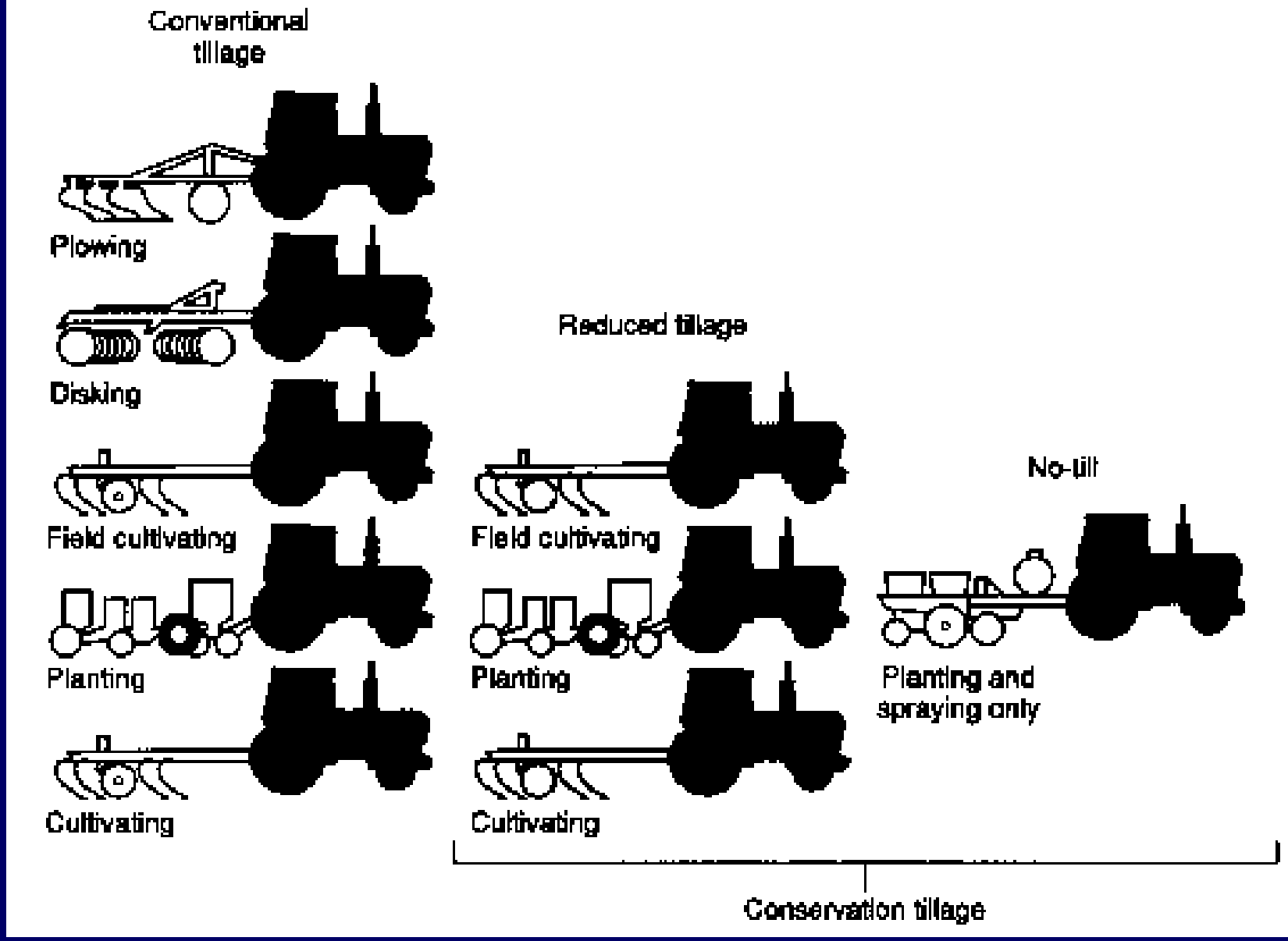
Can humans influence structure?


Conventional tillage
Plowing
Disking
Field cultivating
Planting
Cultivating
Reduced tillage
Field cultivating
Planting
Cultivating
No-till
Planting and spraying only
Conservation tillage

How do differences in texture potentially influence plant growth?

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Soil Organic Matter (3 fractions)

1) Plant & Animal Residues

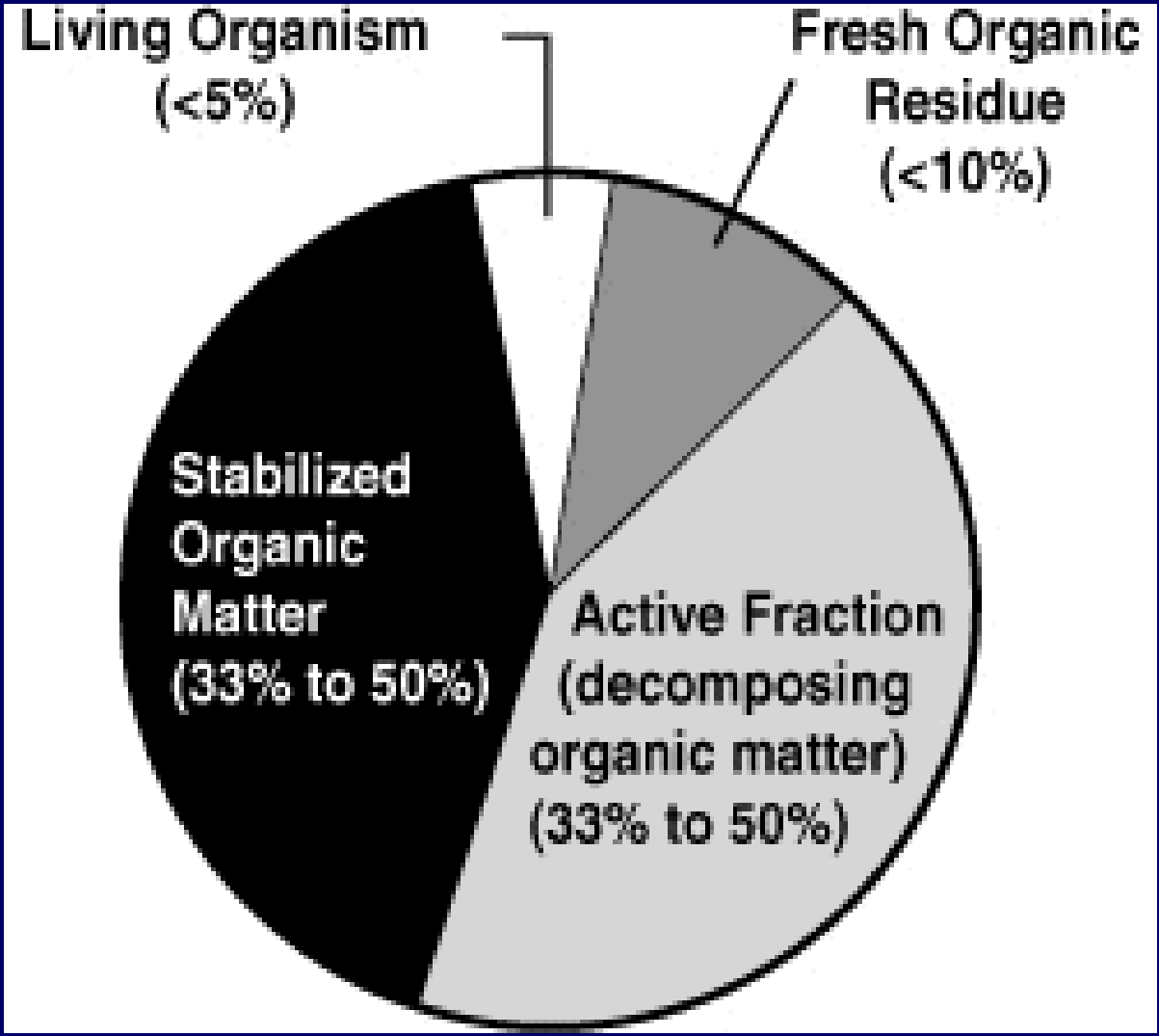
2) Soil organisms, esp. microbes (bacteria, fungi, etc.)

-- Give the soil its biological activity

3) Humus (residual SOM)

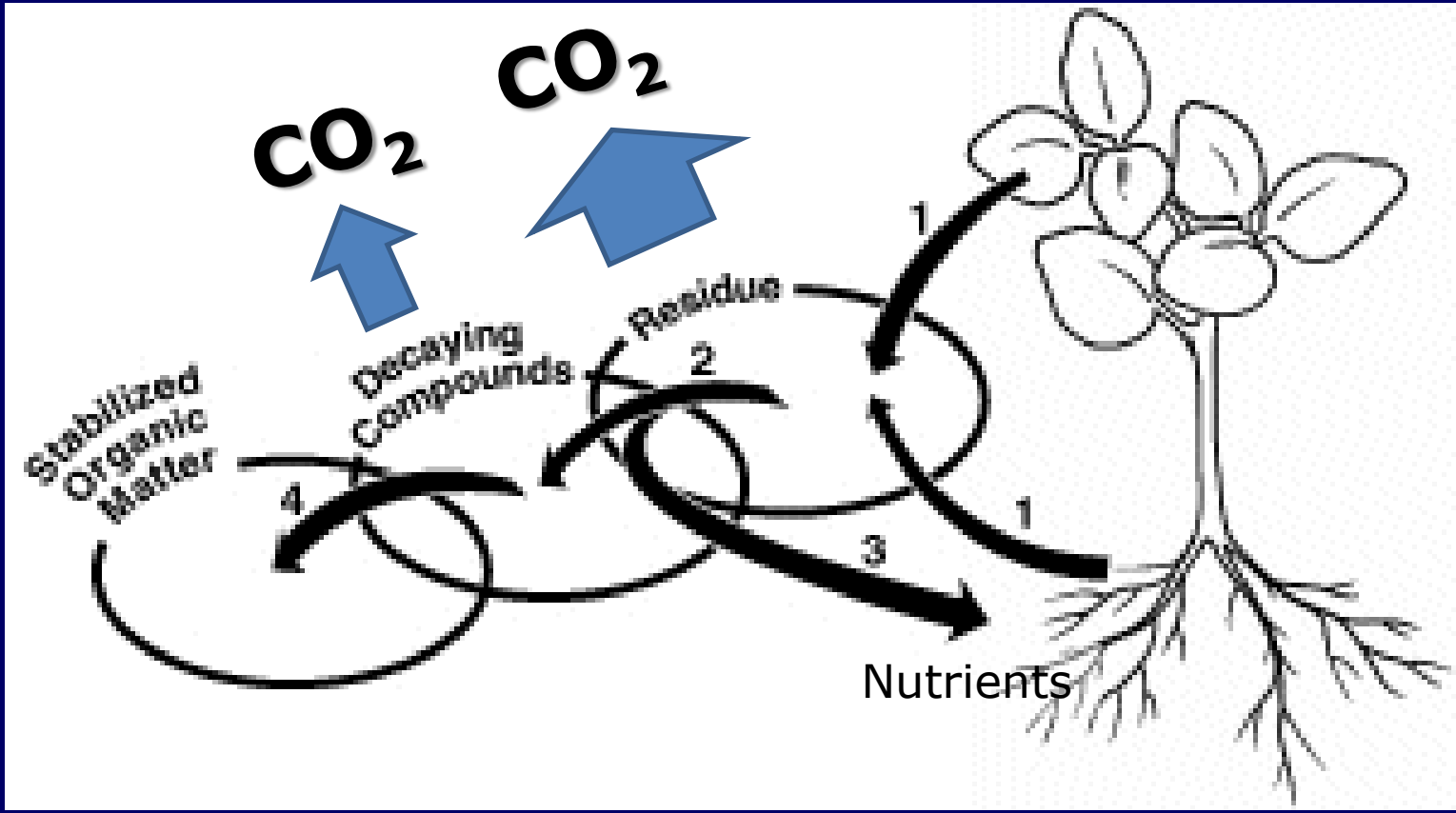
-- portion remaining after initial phase of decomposition and humification

“Snap shot” of soil organic matter components.



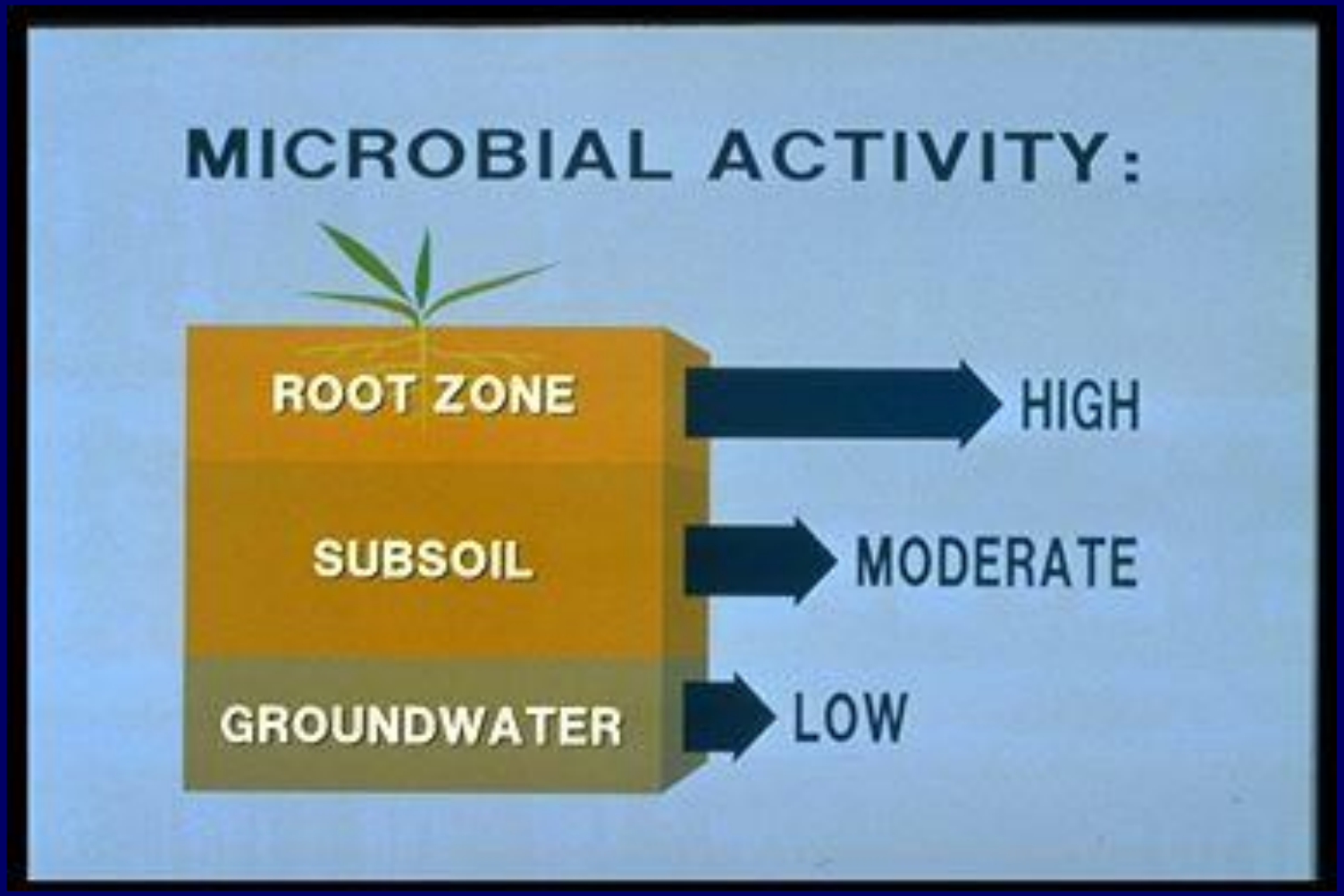
http://www.extension.umn.edu/distribution/cropsystems/components/7402_02.html

Flow of organic matter in soils



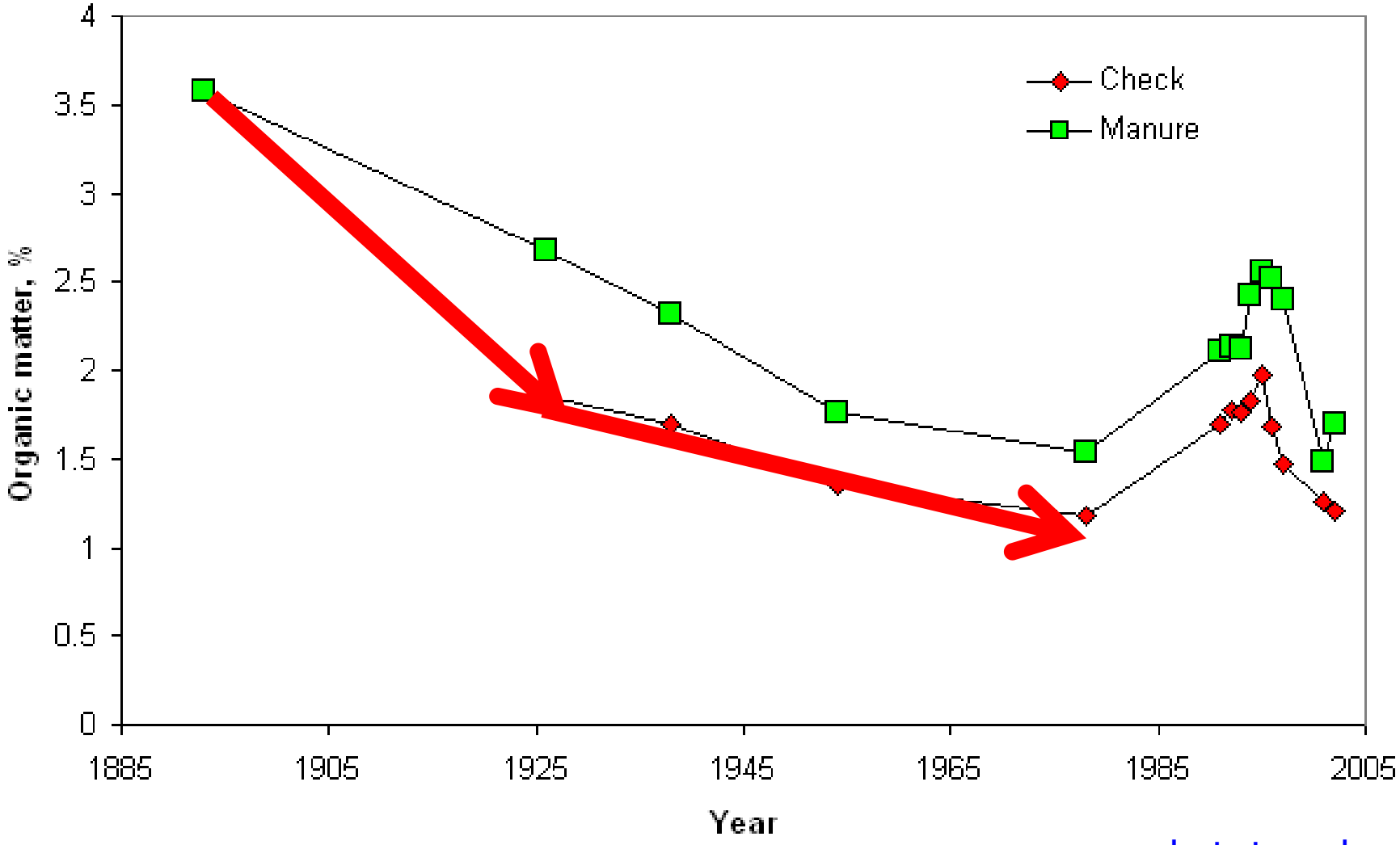
http://www.extension.umn.edu/distribution/cropsystems/components/7402_02.html

Where is the biological activity in soil?



www.microbewiki.kenyon.edu

Changes in soil organic matter over time under continuous winter wheat.



nue.okstate.edu

Humus is highly reactive.

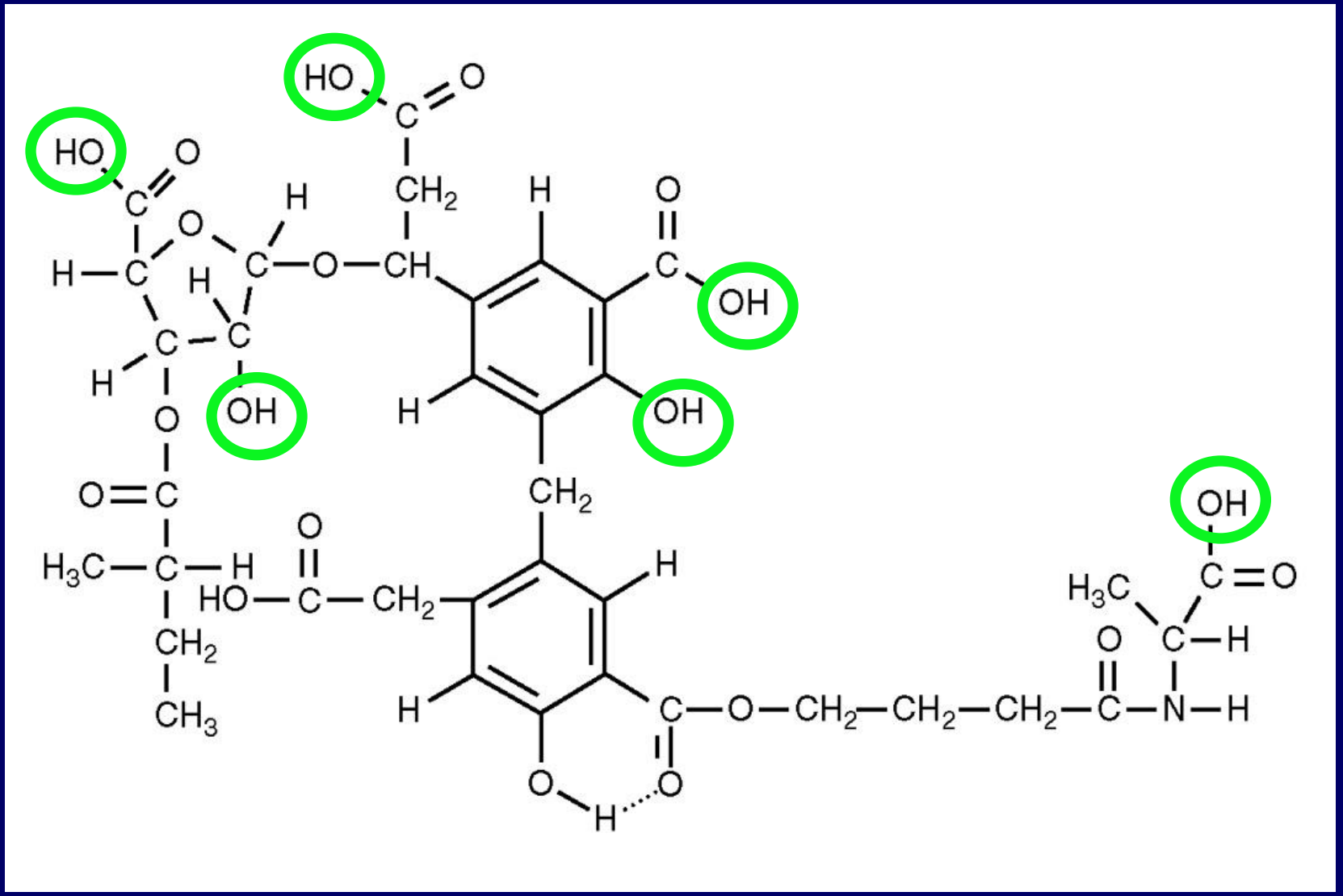


FIG. 4-7 "Average" structure of a fulvic acid from humus in one soil. (Source: Modified from Shin & Moon, 1996. "An 'Average' Structure Proposed for Soil Fulvic Acid," *Soil Science* **161** [1996], 250–256.)

Benefits of Soil Organic Matter

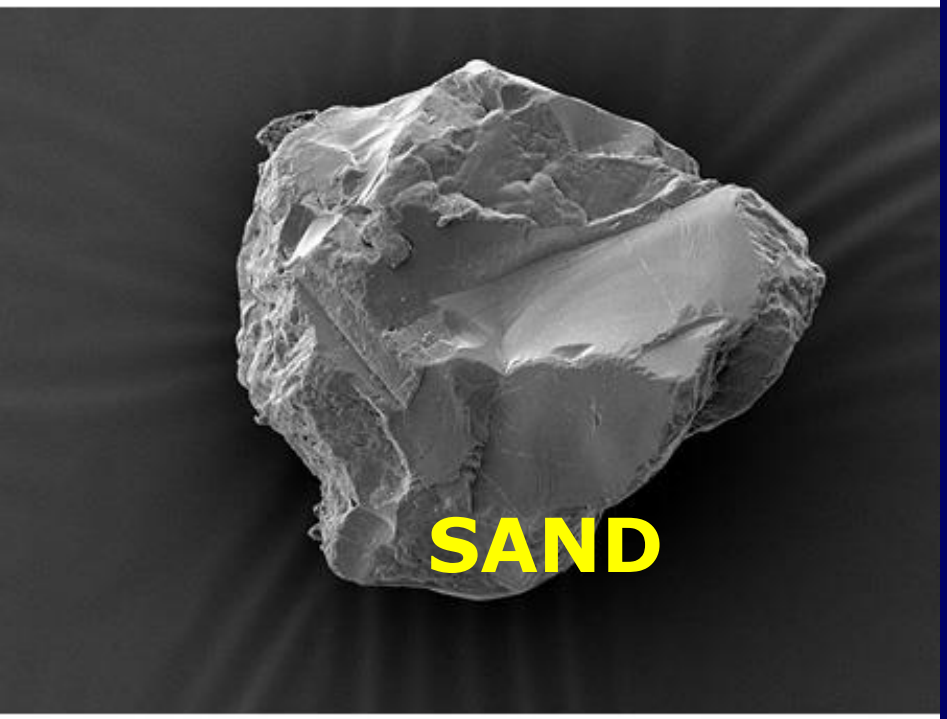
- Provide nutrients, esp. N, P, S
- Increase cation exchange capacity (CEC)
- Improve soil structure
- Improve water infiltration
- Improve water retention (WHC)
- Improves buffering capacity of soil (to nutrient depletion, acidity, etc.)
- Improves tilth (workability of soil)
- Surface mulch (erosion control & ↓ water loss)

Drawbacks of Organic Matter Additions

- Increasing soil acidity (manures)
- Adding salts and/or sodium (manures)
- Weed seeds
- Allelopathic compounds
  - (plant-based materials, occasionally)
- Cost/ transportation issues
- Cover crops don't have as many issues?

Chemical Properties of Soils

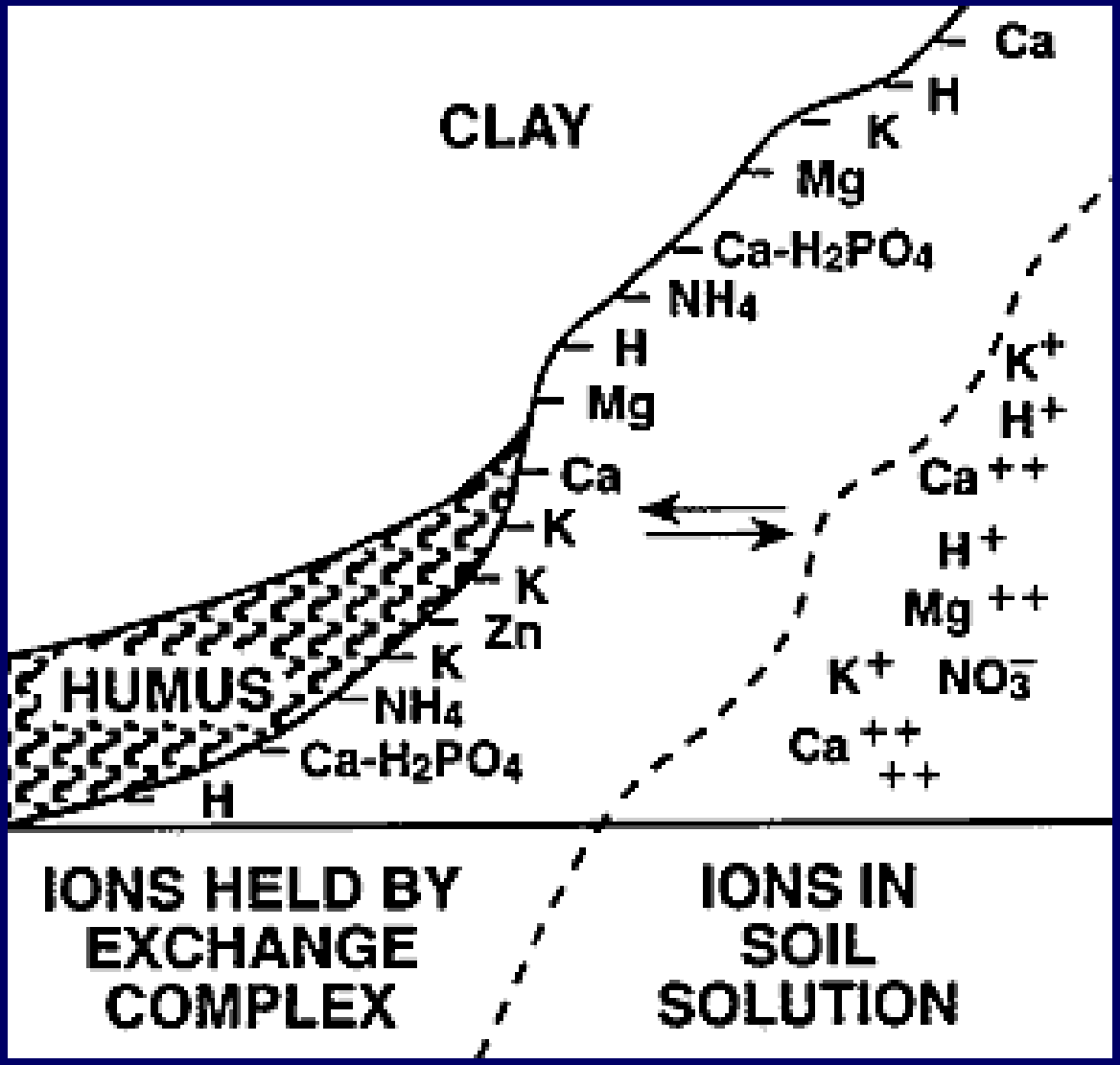
- Cation exchange capacity
- pH
- Specific binding



Soil weathering:

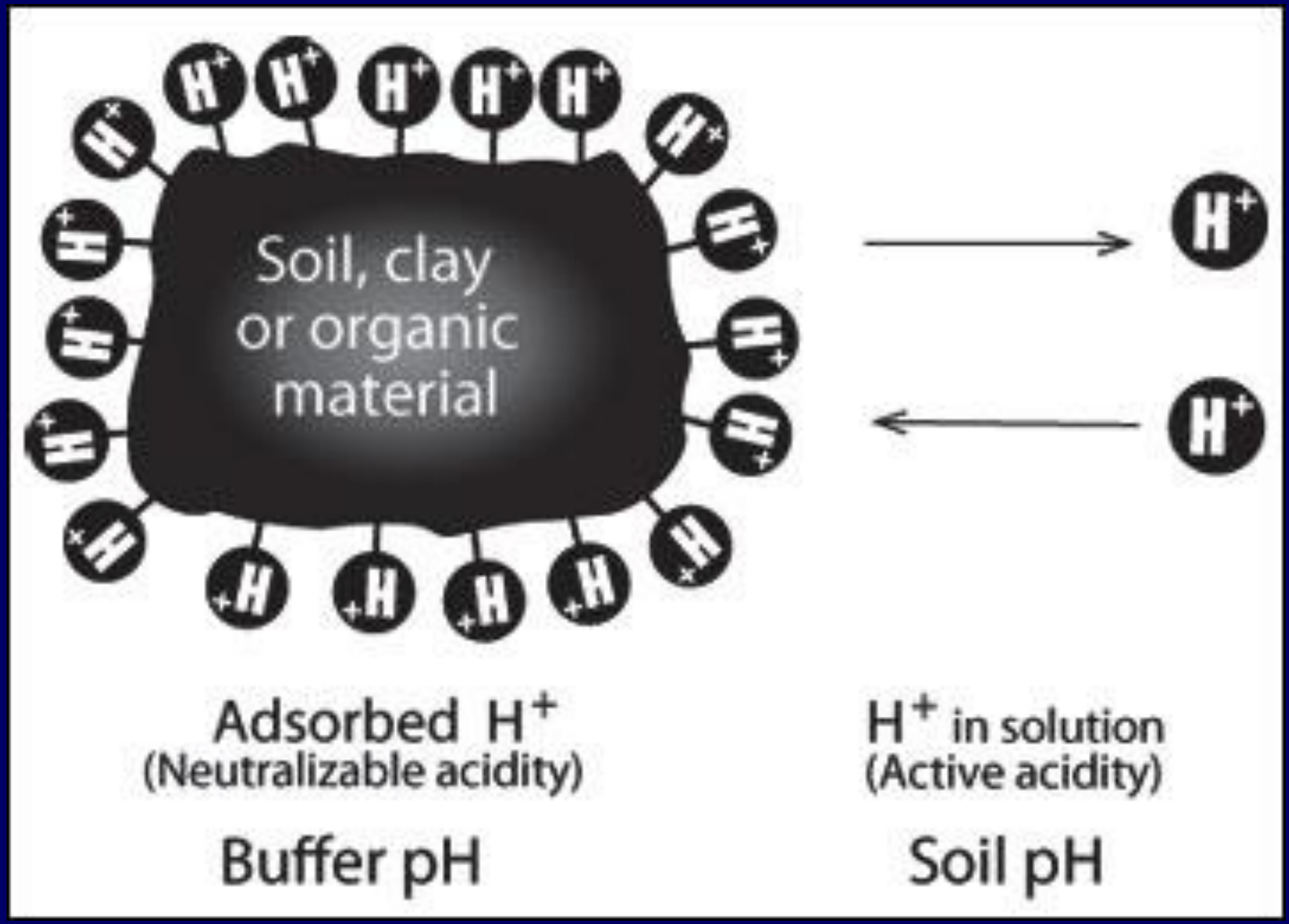
- **Water**
- **Plant material (organic acids)**
- **Oxygen (oxidation)**
- **Time**

Primary minerals weather to clay minerals with a net negative charge – a charge that can attract positively charged cations.



http://www.extension.umn.edu/distribution/cropsystems/DC6437.html

Soil buffering capacity for certain materials is linked to CEC.

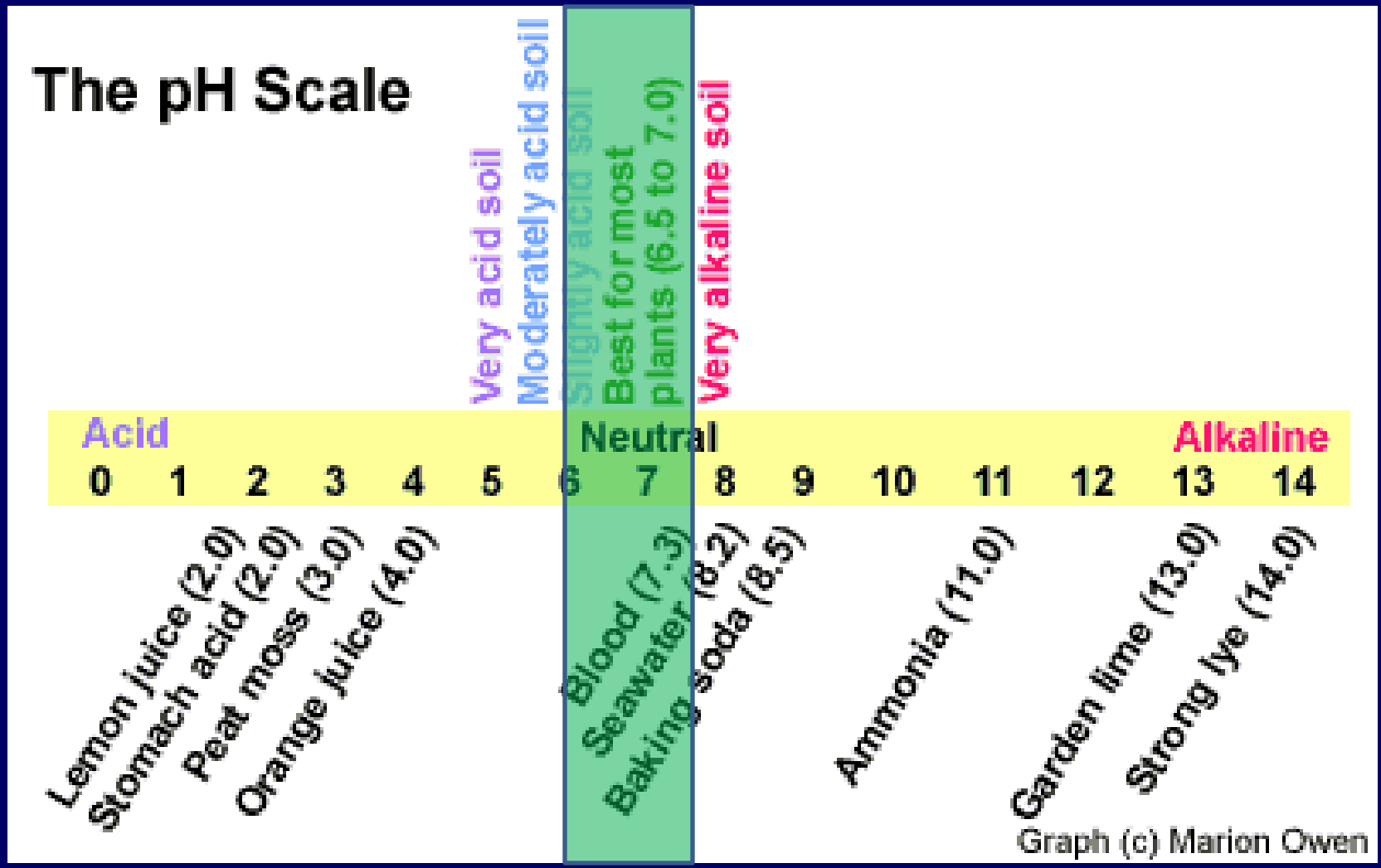


http://extension.missouri.edu/p/MG4

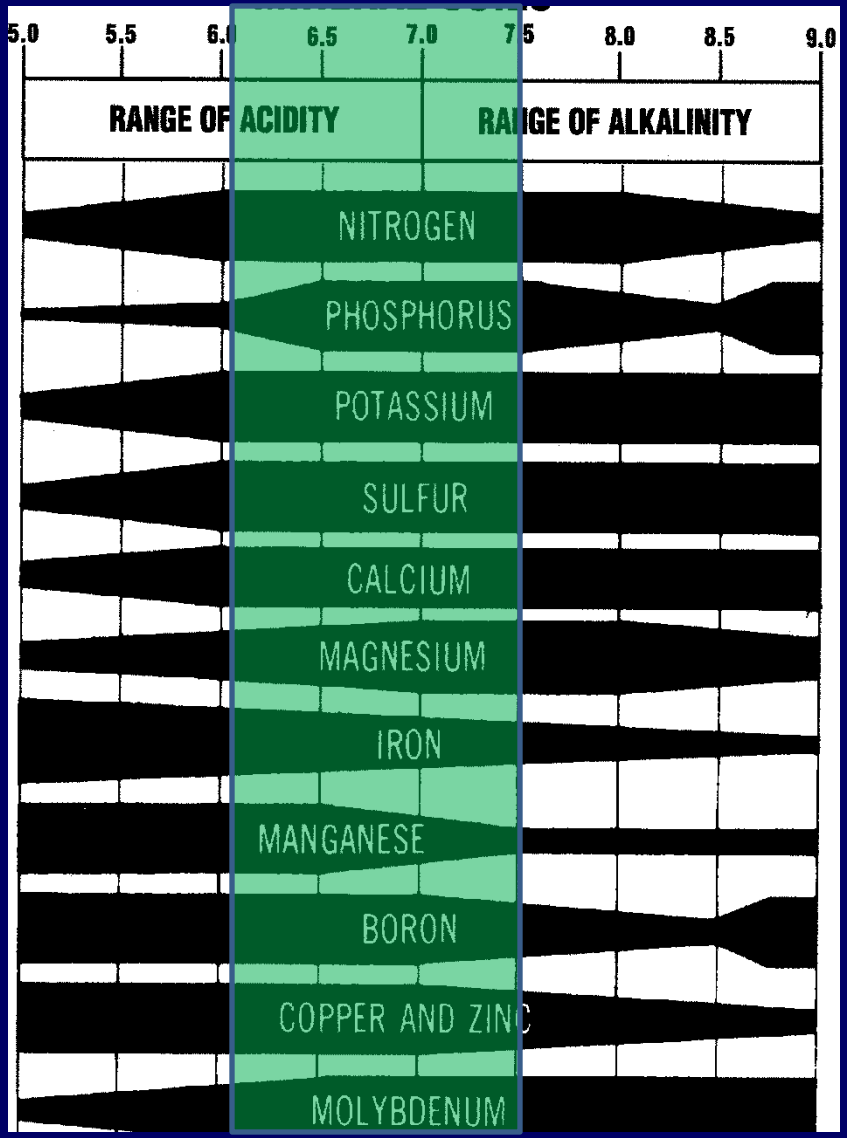
Cations commonly found on soil exchange sites include the following…

Basic cations	Acidic cations
Ca^{2+}	Al^{3+}
Mg^{2+}	H^{+}
K^{+}	
Na^{+}	

Soil pH


The pH Scale
Very acid soil
Moderately acid soil
Slightly acid soil
Best for most plants (6.5 to 7.0)
Very alkaline soil
Acid
Neutral
Alkaline
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14
Lemon juice (2.0)
Stomach acid (2.0)
Peat moss (3.0)
Orange juice (4.0)
Blood (7.3)
Seawater (8.2)
Baking soda (8.5)
Ammonia (11.0)
Garden lime (13.0)
Strong lye (14.0)
Graph (c) Marion Owen

Soil pH affects availability of certain nutrients.



Soil Water Availability, Movement, and Drainage

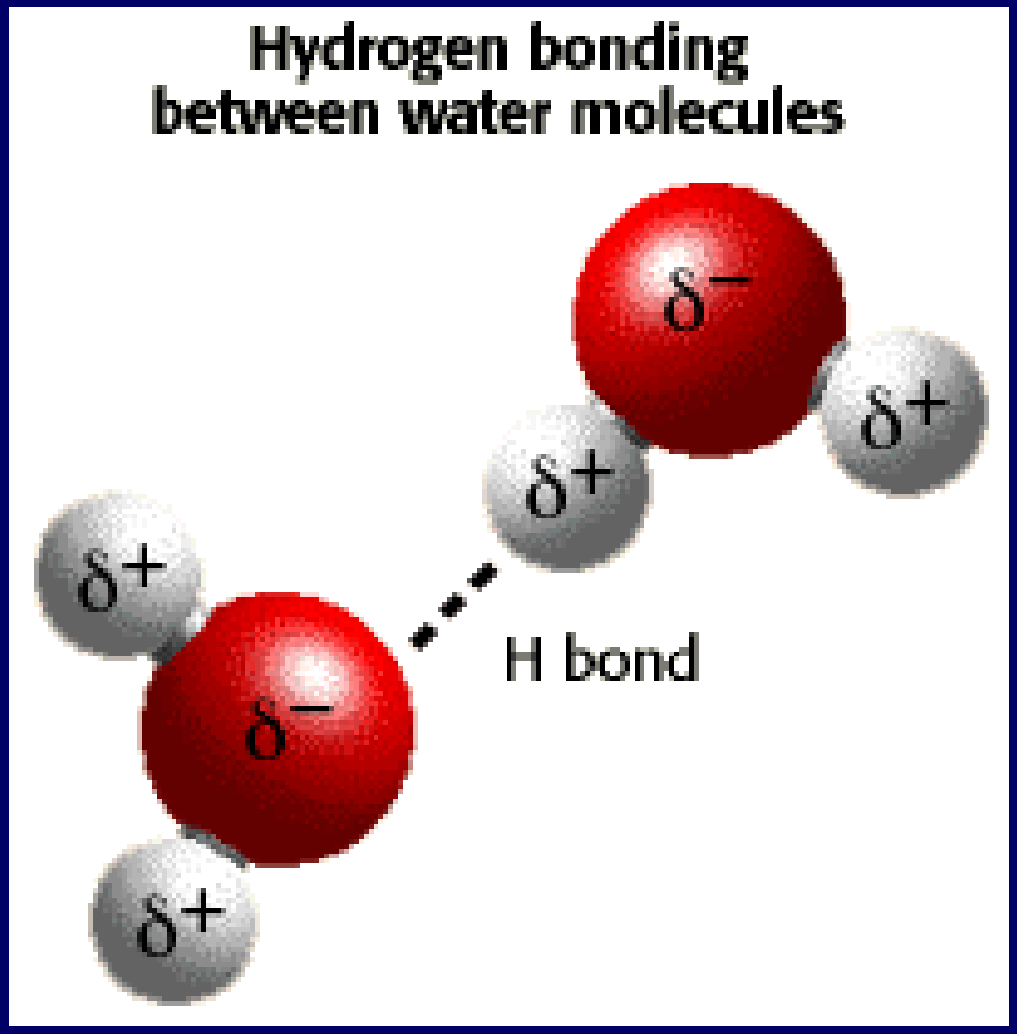
- Define plant available water and available water content.
- Relative amounts of available water held by soils of differing textures

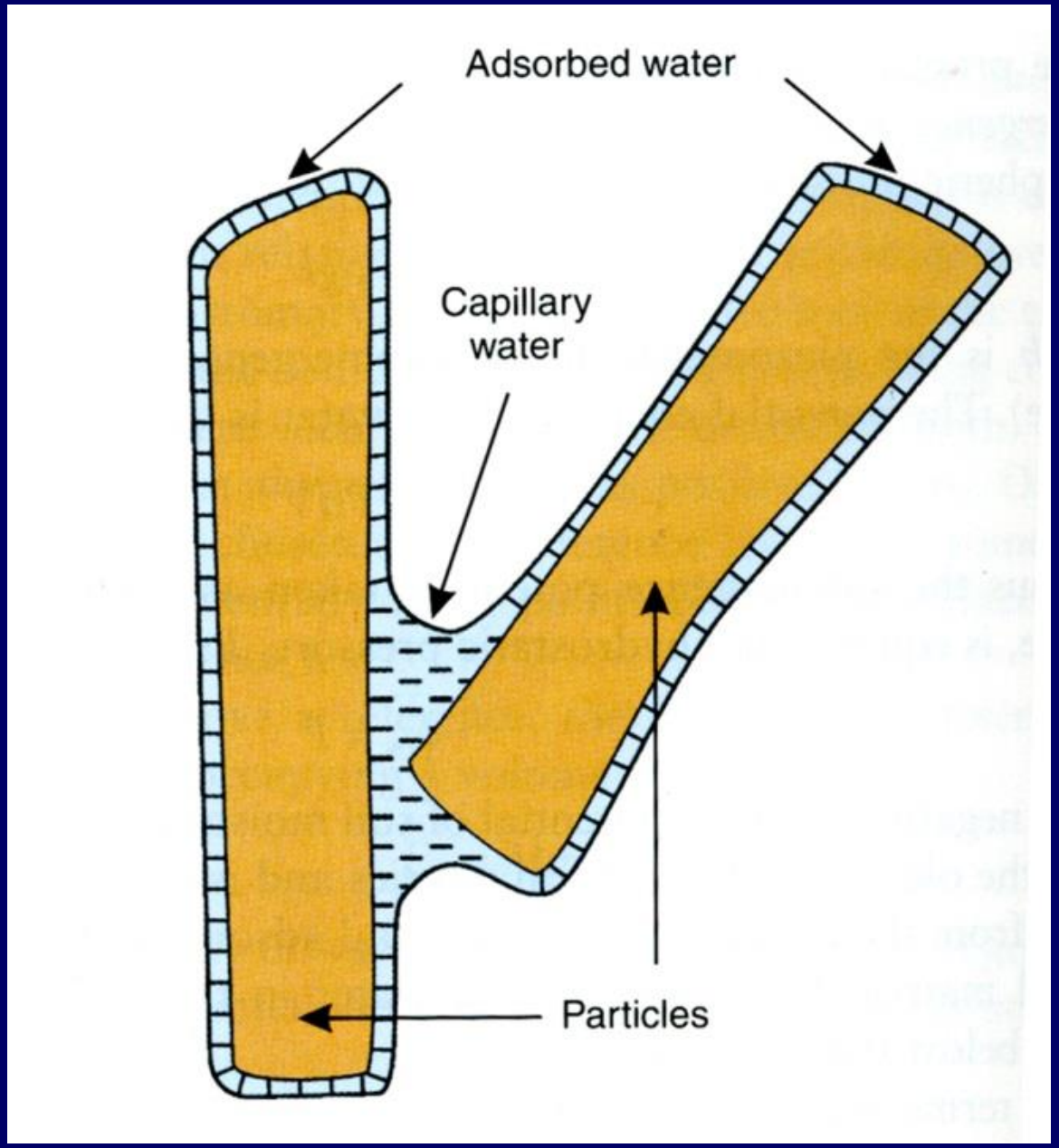
How Water is held in soil

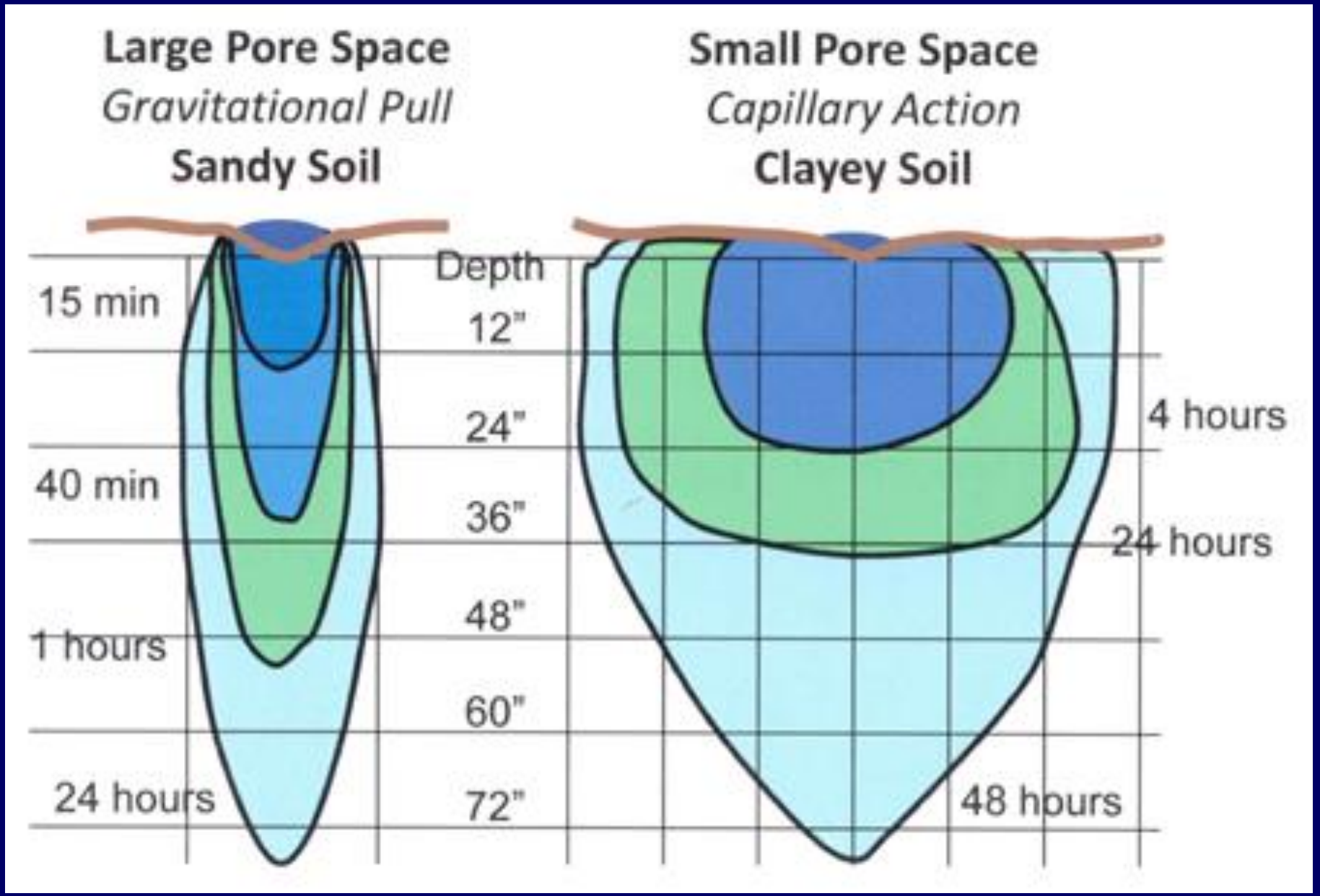
- Adhesion: attraction of water to solid surfaces (paper towel, soil particles)

- Cohesion: attraction one water molecule to another

Water is polar




Adsorbed water
Capillary water
Particles


Large Pore Space
Gravitational Pull
Sandy Soil
Small Pore Space
Capillary Action
Clayey Soil
Depth
15 min
40 min
1 hours
24 hours
12"
24"
36"
48"
60"
72"
4 hours
24 hours
48 hours

Field Capacity (FC)

= moisture status of a fully wetted & drained soil

Permanent Wilting Point (PWP)

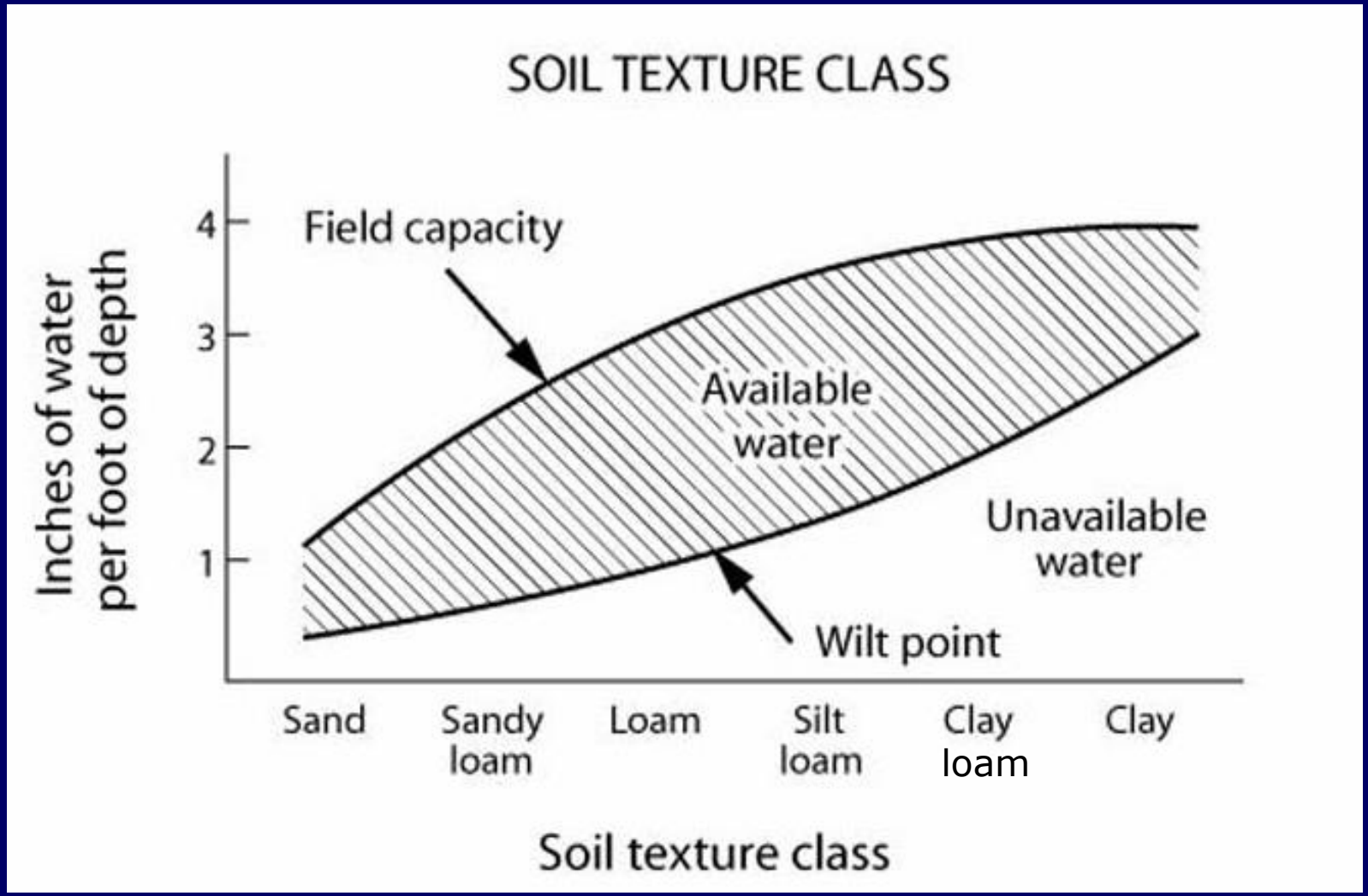
= moisture status when all "available water" is gone

Available Water (AW)

= fraction of soil water "available" to plants

(= FC - PWP)

Available water in relation to soil textural class

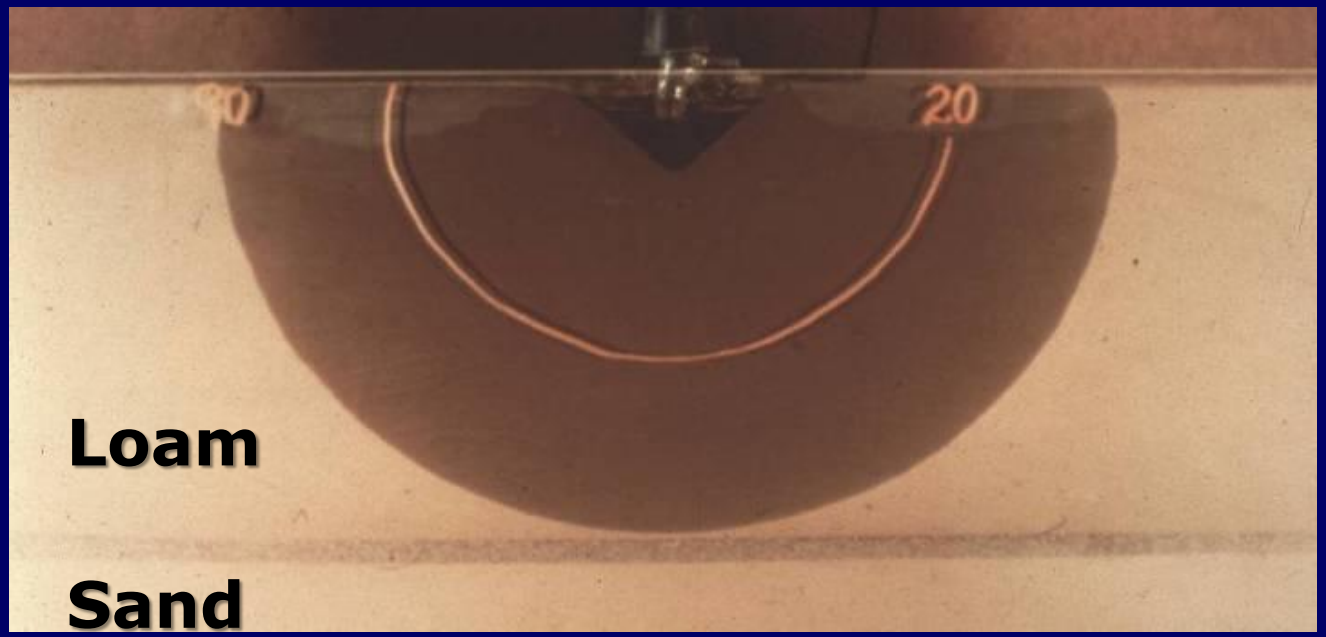


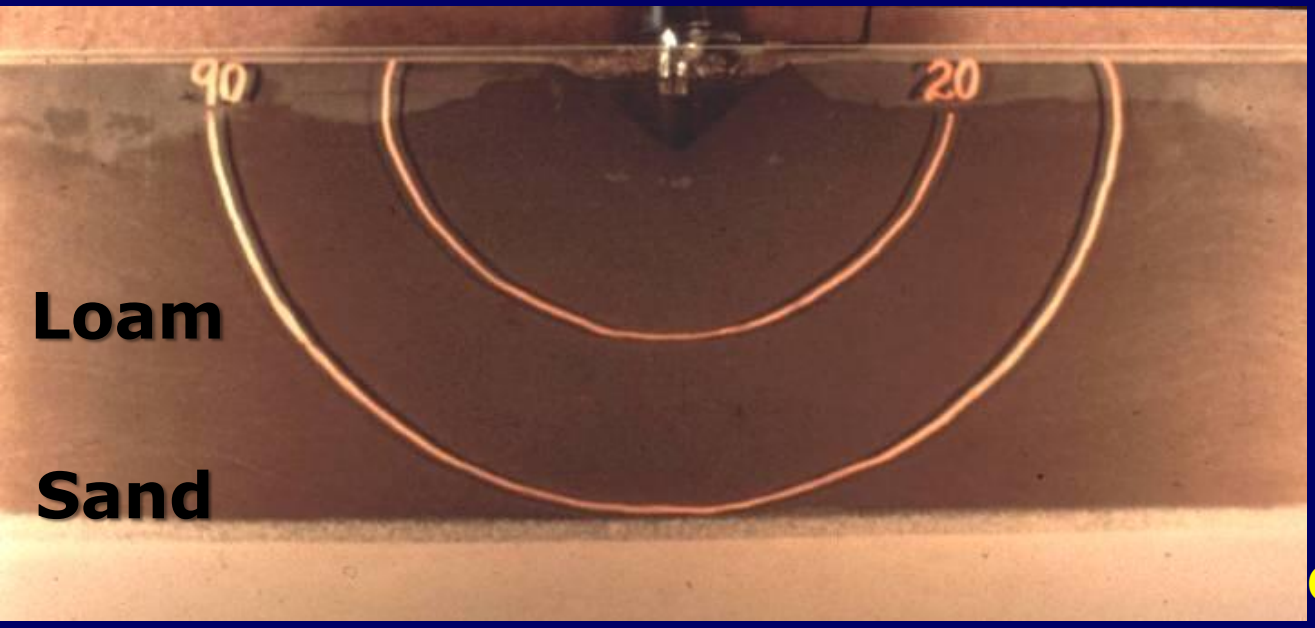
Available water capacity (AWC) by soil texture

Water Retention of Soils

Soil Texture	Field Capacity (In./ft.)	Permanent Wilting Point (In./ft.)	Available Water (In./ft.)
Fine Sand	1.4	0.4	1.1
Sandy loam	1.9	0.6	1.4
Fine sandy loam	2.5	0.8	1.8
Loam	3.1	1.2	1.95
Silt loam	3.4	1.4	2.03
Clay loam	3.7	1.8	1.95
Clay	3.9	2.5	1.4

From Plaster, Edward J., Soil Science and Managent 4th Edition, 2003.





Soil layering can influence water movement.

Chuck Ingels, UC ANR

Erosion

"Erosion is the wearing away of the land surface by rain or irrigation water, wind, ice or other natural or human originated activity that abrade, detach and remove soil from one point on the earth's surface and deposit it elsewhere."

Glossary of Soil Science Terms. Soil Sci. Soc. Am. 1997

Erosion moves top soil, rich in organic matter and nutrients.

http://www.soilerosion.net/

Practices to reduce erosion.

- Cover
  - Mulch
  - Cover crops
  - Strip cropping
- Engineering/mechanical
  - Terraces
  - Grassed water ways
  - Windbreaks
- Tillage practices
  - Minimum tillage
  - No tillage

Thank you