Understanding Soil Health Tests to Help Track Progress on Your Operation

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Soil Regen Forum

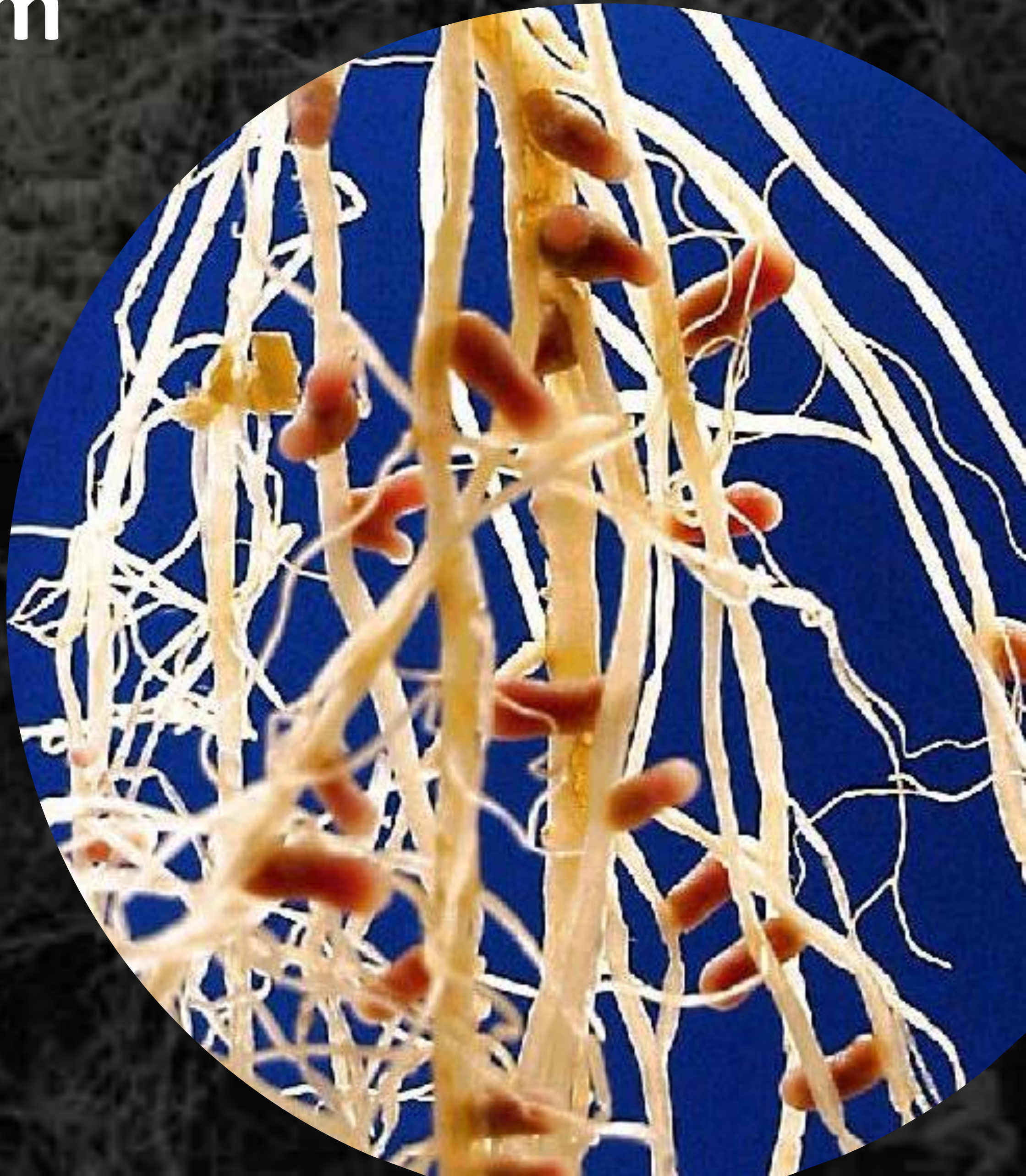
August 28th 2019

Soil as an Ecosystem

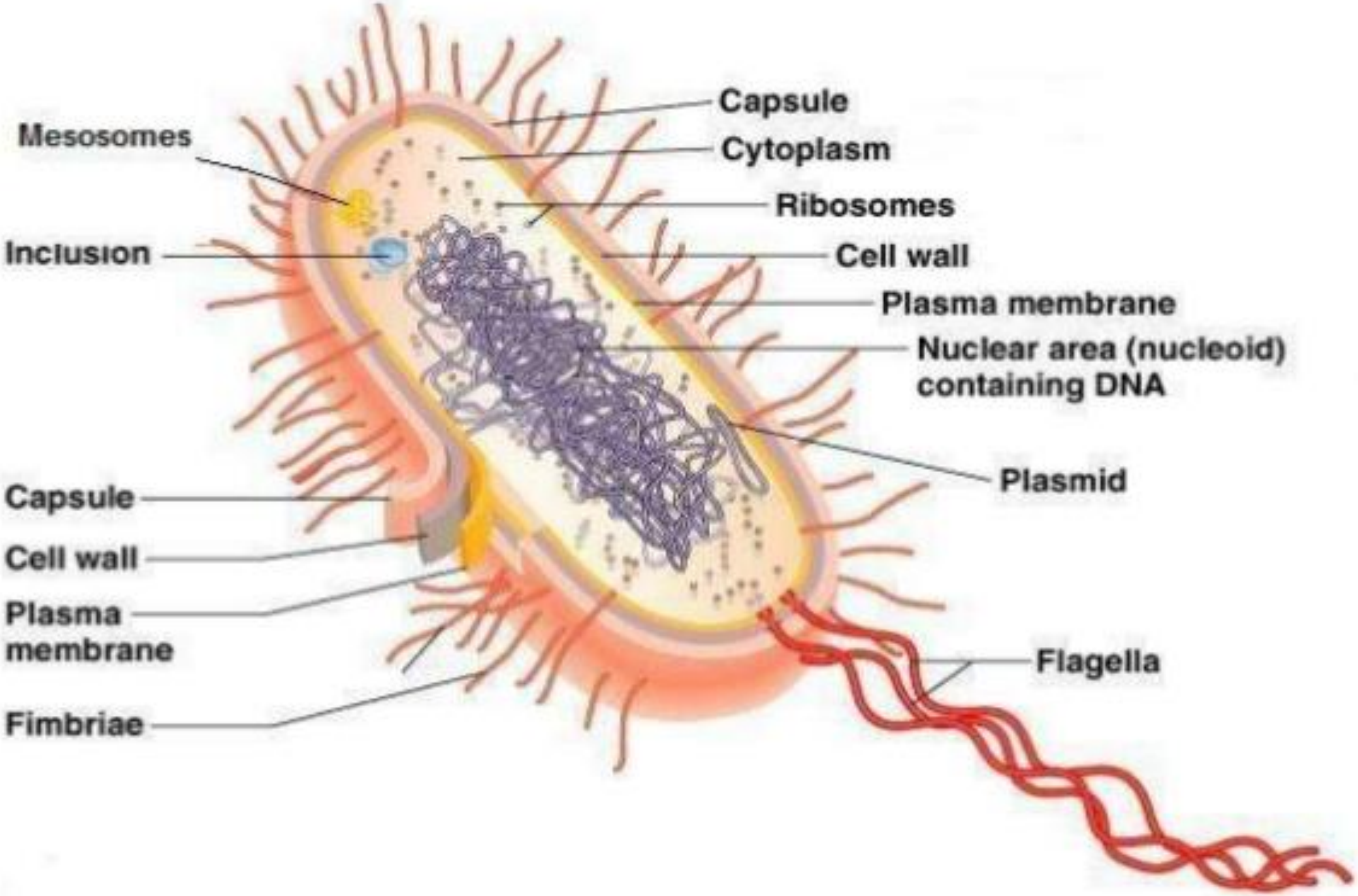
- Nutrient Cycling
  - Organic matter pools
  - N, P, C availability
  - Microbial predations

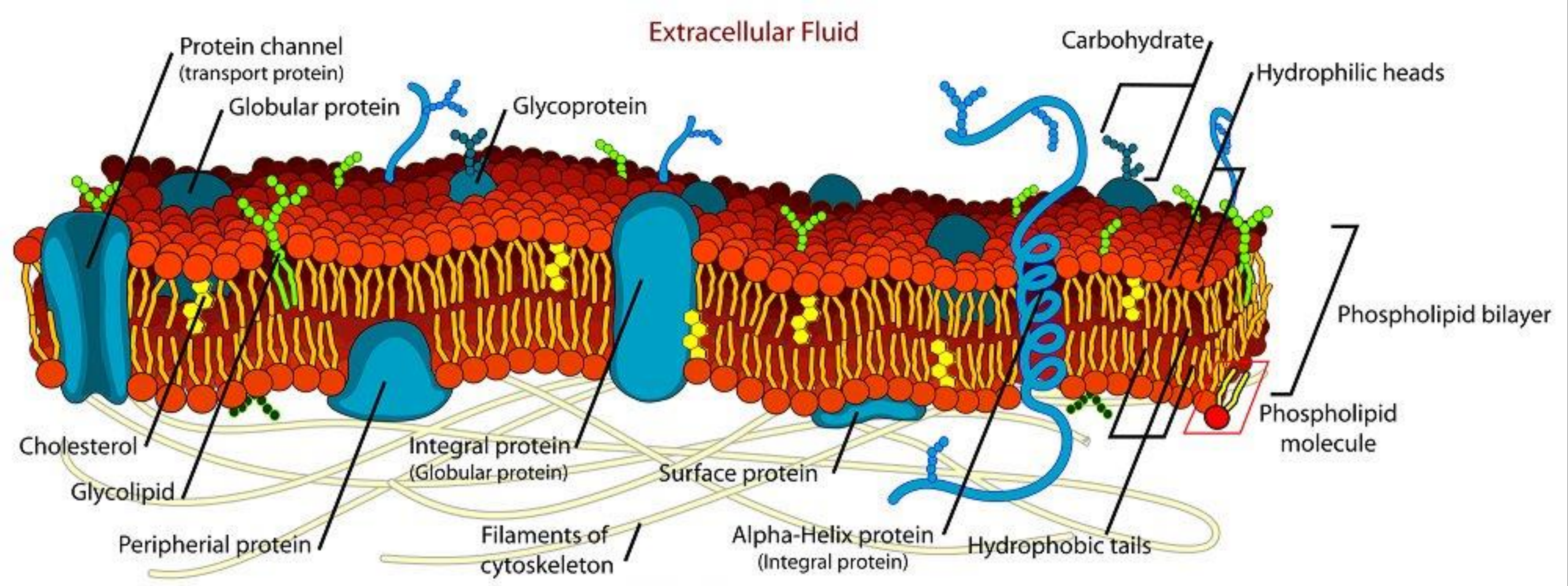
- Soil Aggregation
  - Glomalin and fungal hyphae
  - Increases soil stability
  - Increases water holding capacity

- Plant/Microbe Interactions
  - Symbioses
  - Nutrient uptake
  - Suppress disease



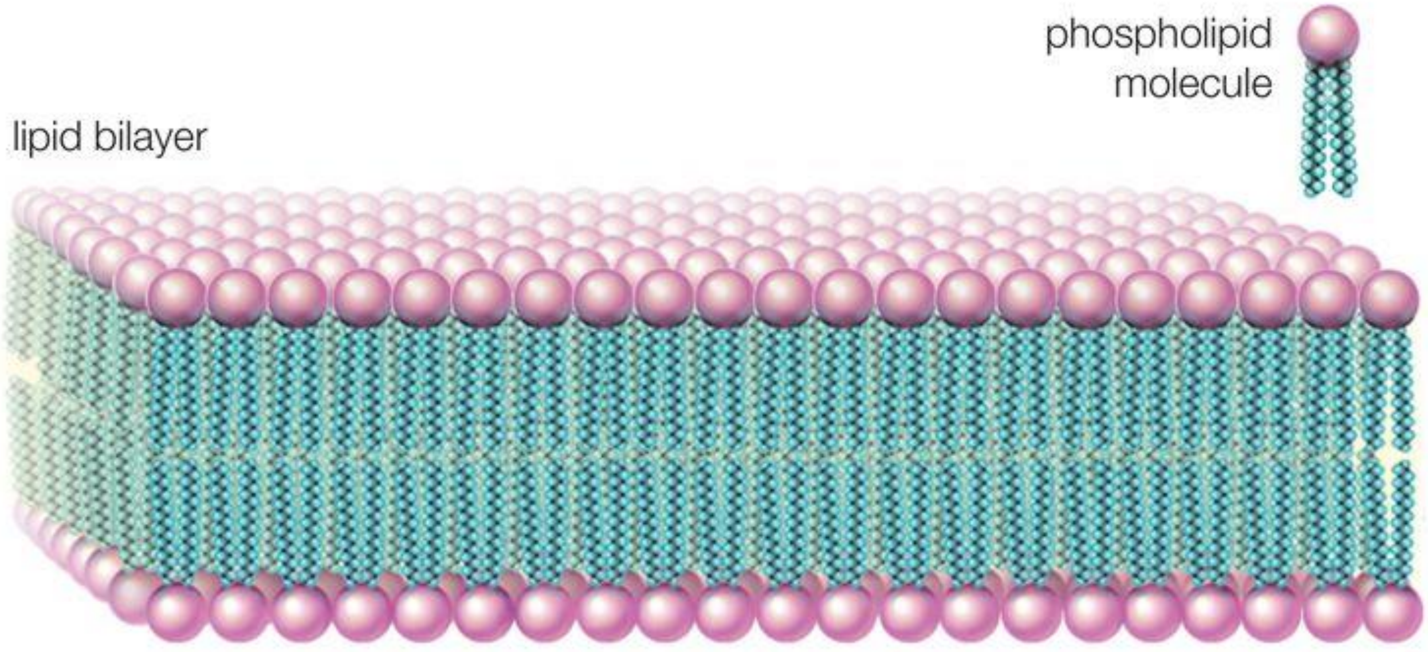
Anatomy of a Bacterial Cell





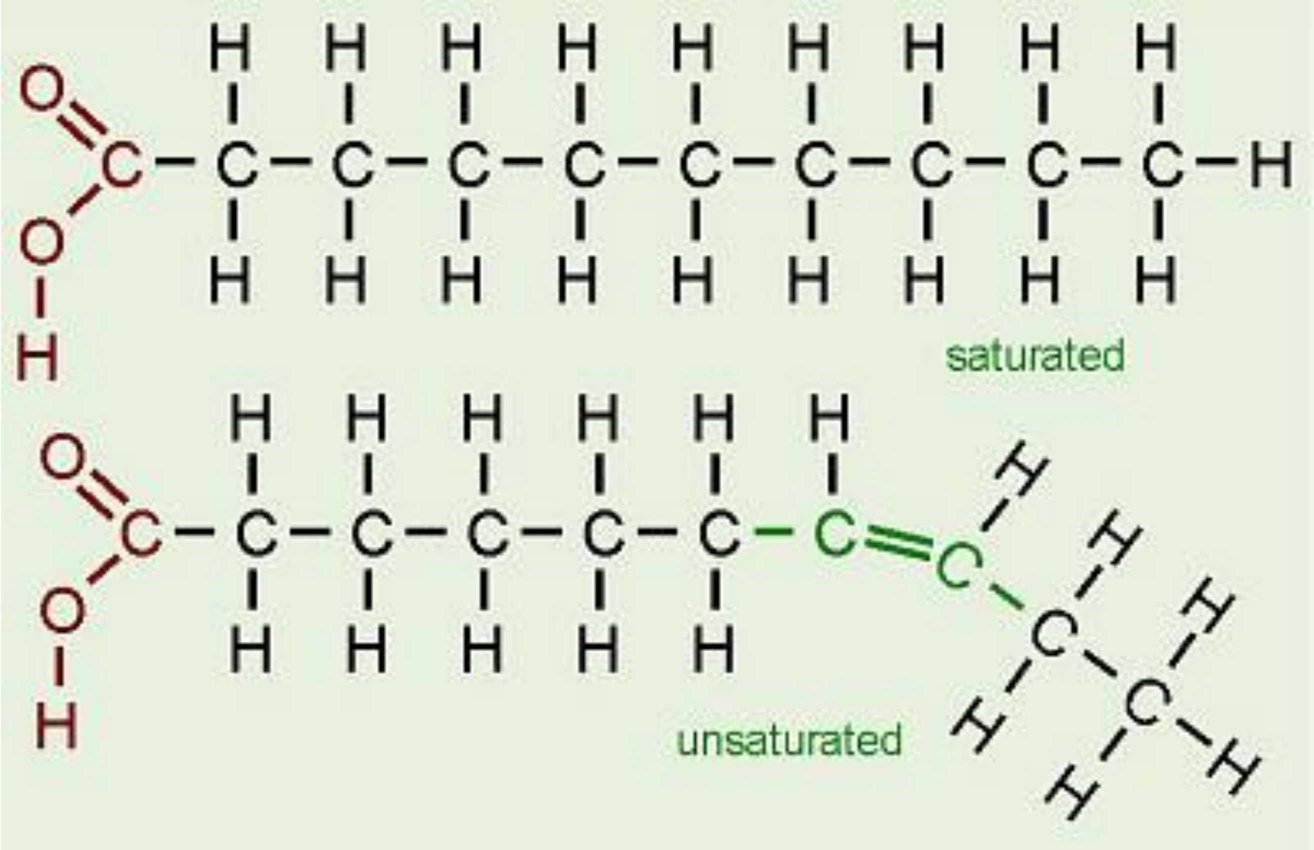
Bacterial Membrane

Lipid Bilayer



Phospholipid Fatty Acid (PLFA)

- Cell membrane
- Quantifiable
- Represent living biomass
- Degrade quickly upon death
- Influenced by environment and land management
- Snapshot in time



Interpreting PLFA

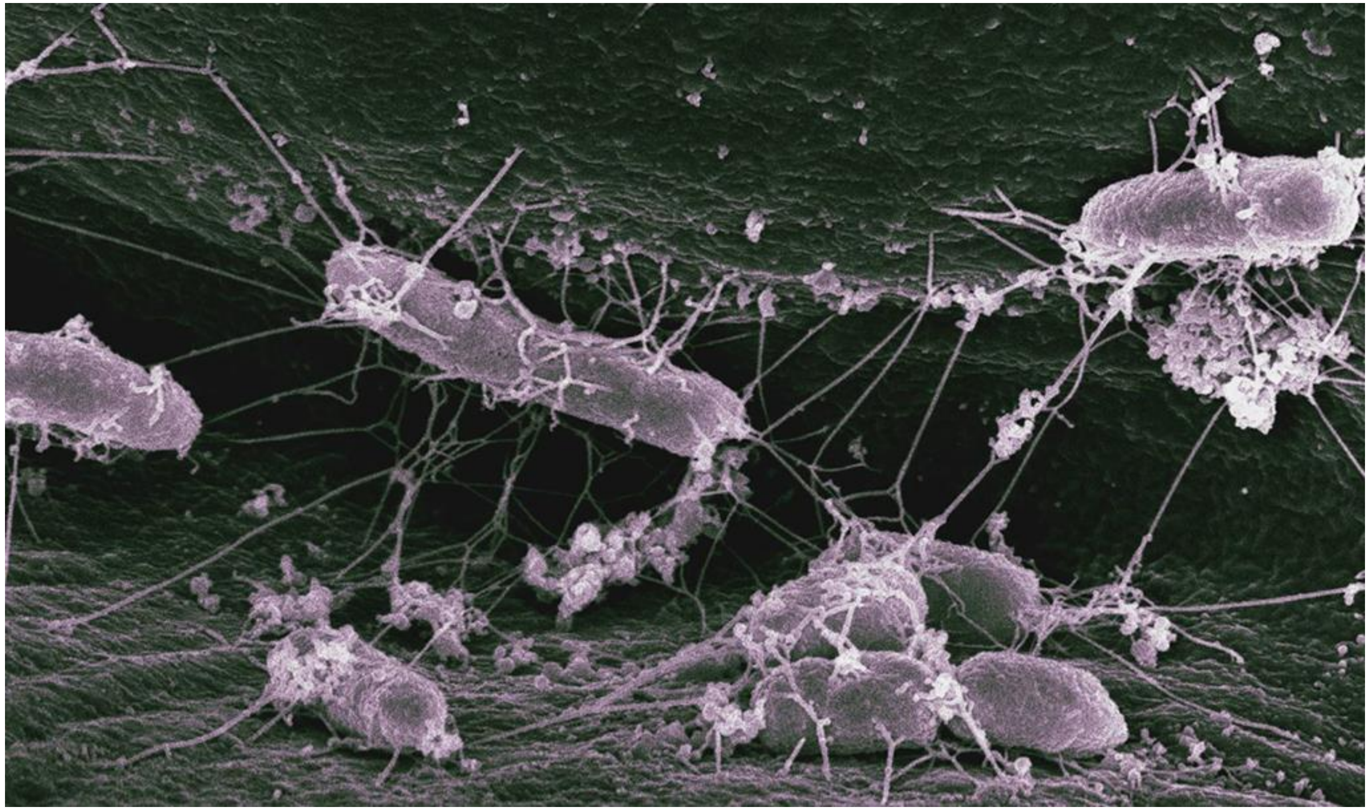
- Higher biomass and diversity are better
- No standard ranking established
- Dependent on soil type, climate, etc.

Total Biomass	Diversity	Rating
< 500	< 1.0	Very Poor
500+ - 1000	1.0+ - 1.1	Poor
1000+ - 1500	1.1+ - 1.2	Slightly Below Average
1500+ - 2500	1.2+ - 1.3	Average
2500+ - 3000	1.3+ - 1.4	Slightly Above Average
3000+ - 3500	1.4+ - 1.5	Good
3500+ - 4000	1.5+ - 1.6	Very Good
> 4000	> 1.6	Excellent

PLFA Report Ratios

- **Fungi:Bacteria**
- **Predator:Prey**
- **Gram(+):Gram(-)**
- **Sat:Unsat**
- **Mono:Poly**
- **Pre 16:1 to cy17:0**
- **Pre 18:1 to cy19:0**

Each of these ratios is provided on the second page of the PLFA report. They are important to better evaluate the microbial community as a whole.



Haney Test

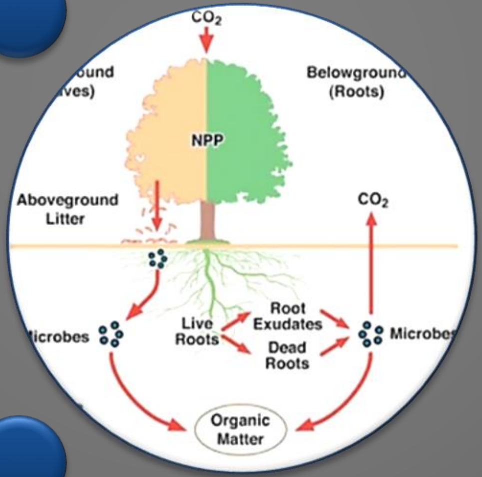
Soil Fertility

Soil Organic N and P

Microbial Biomass

Water Extractable C

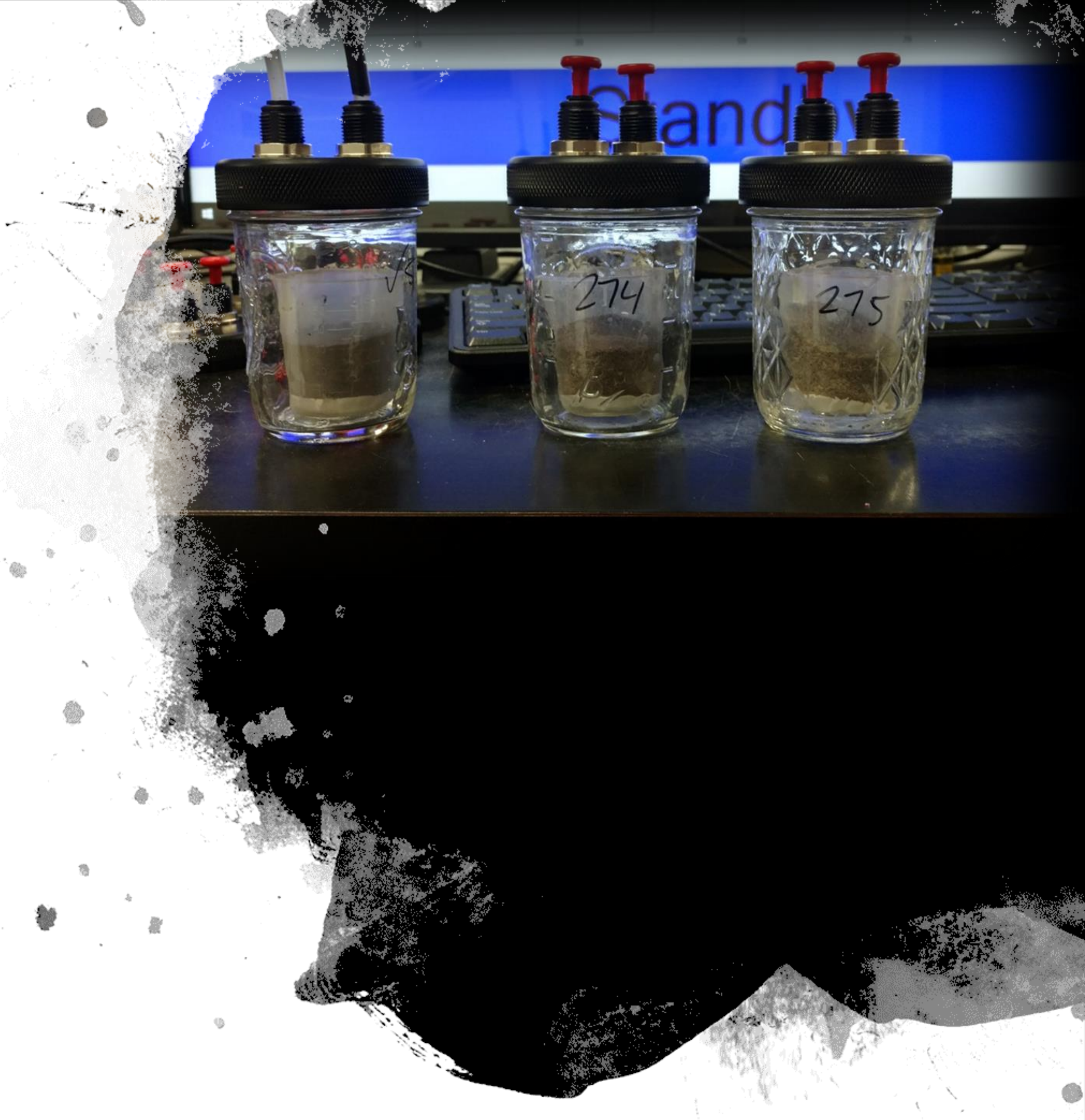
C:N balance



Dr. Rick Haney – USDA-ARS Temple, TX

Microbial Biomass

1-day CO2 Burst uses drying and rewetting techniques to mimic natural field events and represents the flush of microbial activity, leading to nutrient cycling. The amount of cycling is related to soil habitat including available food (WEOC) and soil fertility.



CO2-C	Ranking	Implications
0-10	Very Low	Very little potential for microbial activity; slow nutrient cycling and residue decomposition; high carbon residue may last >2-3 yrs. with limited moisture; Nearly no N credit given; Additional N may be required due to microbial immobilization
11-20	Low	Minimal potential for nutrient cycling; residue management can still be a problem; Very little to no N credit given
21-30	Below Average	Some potential for nutrient cycling; residue management can still be a problem with prolonged use of high carbon crops; Little N credit given
31-50	Slightly Below avg.	Low to moderate potential for microbial activity; Some N credit may be given
51-70	Slightly Above avg.	Moderate potential for microbial activity; Moderate N credit may be given; May be able to start reducing some N fertilizer application
71-100	Above Average	Good potential for microbial activity; Moderate N credit may be given depending on size of organic N pool; Can typically reduce N application rates
101-200	High	High potential for microbial activity; more carbon inputs may be needed to sustain microbial biomass; moderate to high N credit from available organic N pools may be given; N fertilizer reduction can be substantial
>201	Very High	High to very high potential for microbial activity; residue decomposition may be <1 yr.; keeping the soil covered could be a problem in some systems; high potential for N mineralization and N credits from available organic N pools may be given; N fertilizer reduction can be substantial

Nature's Solvent – $H2O$

Water Extract

- Organic C
- Total N
- Nitrate
- Ammonium

Calculated

- Organic N
- Organic C:N
- Organic N Release
- Soil Health Score

Microorganisms have the greatest access to nutrients and food that are either suspended, dissolved, or solubilized in soil water.

Therefore, the water extract represents what the microbes see in their soil environment.

C:N Balance

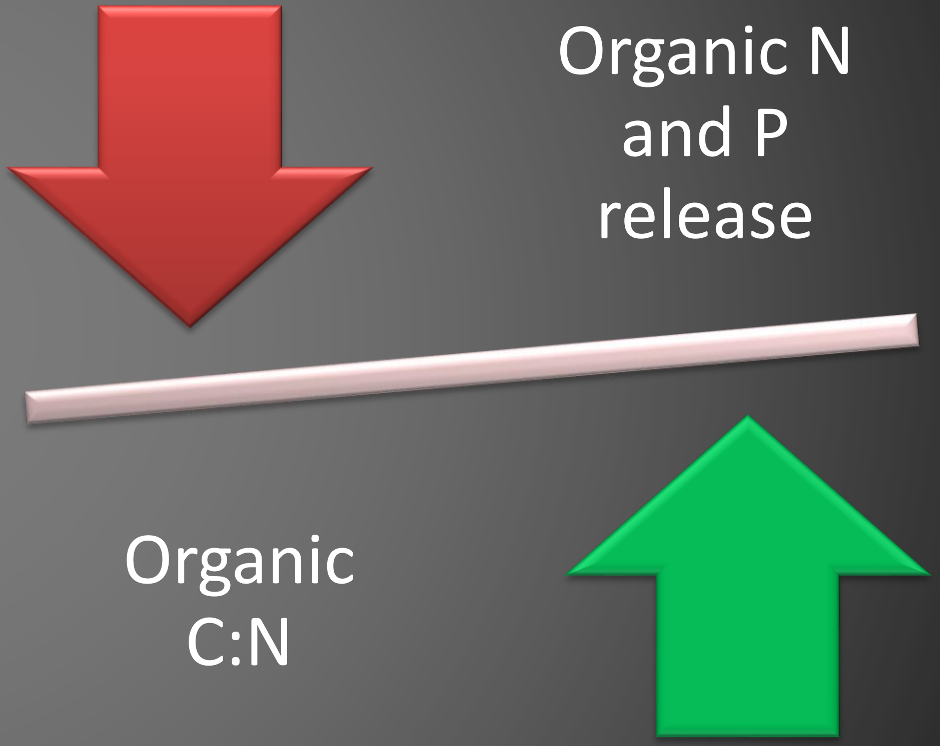
Organic C and N have to be balanced to get the highest potential return from the WEON bank account.

Above 20:1 = **No net N-mineralization**

- N is limiting and remains tied up in microbial biomass.

Ideal 8:1 to 15:1

- Microbes release inorganic or plant available N and P to feed the plants



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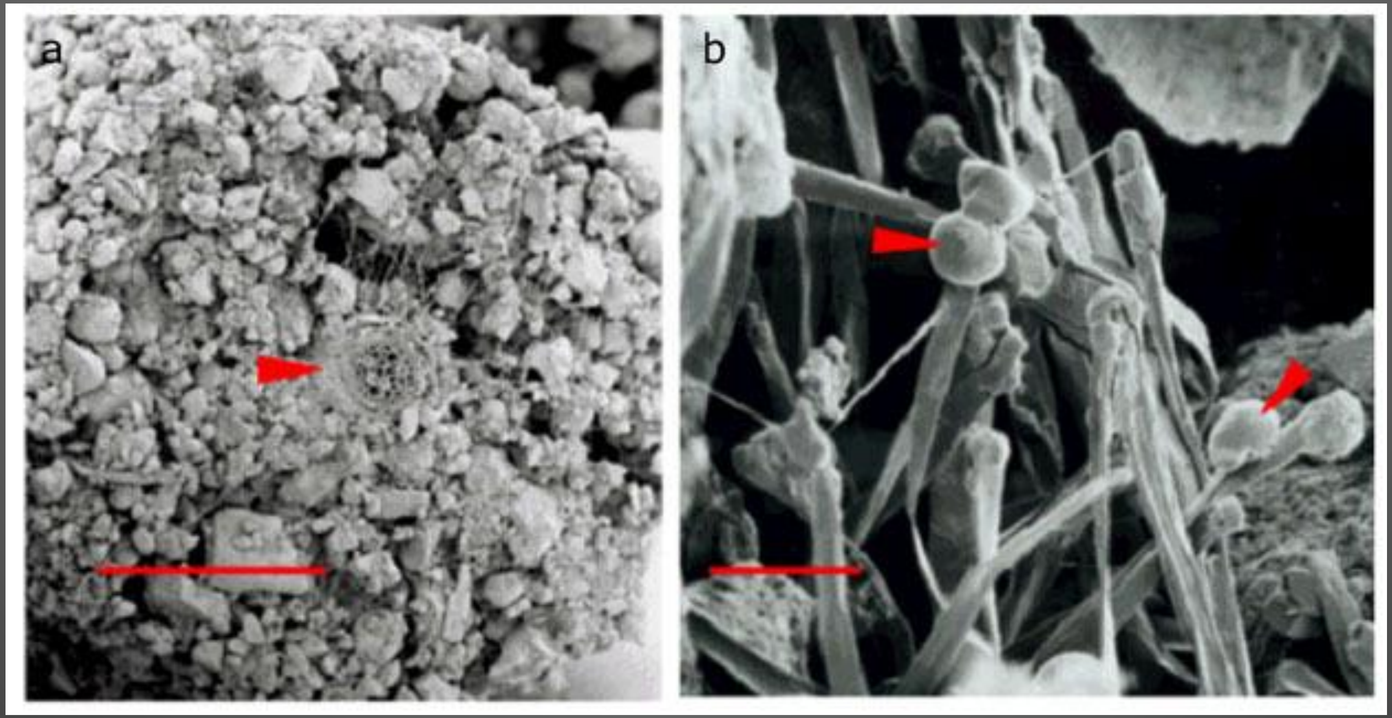
Ratio Result	Ranking	N Implications	Management Needs
>20:1	Poor; Too much organic C and/or not enough organic N	N tie up by microbes: No N credit given from WEON pool	Increase legumes in rotation or covers; reduce high carbon inputs; graze longer to reduce carbon
15:1 – 20:1	Marginal	Some N tie up; Slower mineralization; Lower N credit from WEON	Increase legumes in rotation or covers; reduce high carbon inputs; graze longer to reduce carbon
8:1 – 15:1	Good	Less N tie up; greater potential for N mineralization; higher credit from WEON	Make slight adjustments if near the boundaries to keep within this range
10:1 – 12:1	Ideal	Greatest potential for N mineralization from WEON pool; good balance of available energy and N for microbes	Increase intensity to drive both WEOC and WEON up together to help increase biological processes
<8:1	Poor; Too little organic C and/or too much organic N	Limited energy for microbial activity; N credit may still be high if soil respiration and WEON are also high	Increase carbon inputs; graze shorter to retain carbon

Green Chemistry – H3A

A soil extractant that mimics soil solution by using organic acids produced by living plant roots to temporarily change soil pH and increase nutrient availability.



http://www.nature.com/scitable/knowledge/library/the-rhizosphere-roots-soil-and-67500617

Fertility Recs

Some values from the Haney Test will not be the same as you are used to seeing. This is due to various extract strengths or abilities to pull certain nutrients out of the soil. Therefore, we cannot always use traditional recommendation equations designed for other extracts UNLESS we make an adjustment to certain H3A values.

Example: Bray P-2 vs. Mehlich 3 vs. Bray P-1 vs. H3A vs. Olsen P vs. H2O

Exceptions: Soluble nutrients such as NO3

The N-umbers

- CONVENTIONAL
- Corn @ 200 bu/A

  220 lbs of N req'd
- N credits

  10ppm NO3 or 20lbs/A

  Soybeans past crop – 40lbs

  ??? Or assumed to be 25lbs

- HANEY
- Corn @ 200 bu/A

  220 lbs of N req'd
- N credits

  10ppm NO3 or 20lbs/A

  5ppm NH4 or 10lbs

  Organic N Release – 30lbs

  Soybeans past crop – 40lbs

  ??? Or assumed to be 25lbs

The N-umbers

- CONVENTIONAL
- Corn @ 200 bu/A

  220 lbs of N req'd
- N credits

  Total Credit = 85 lbs

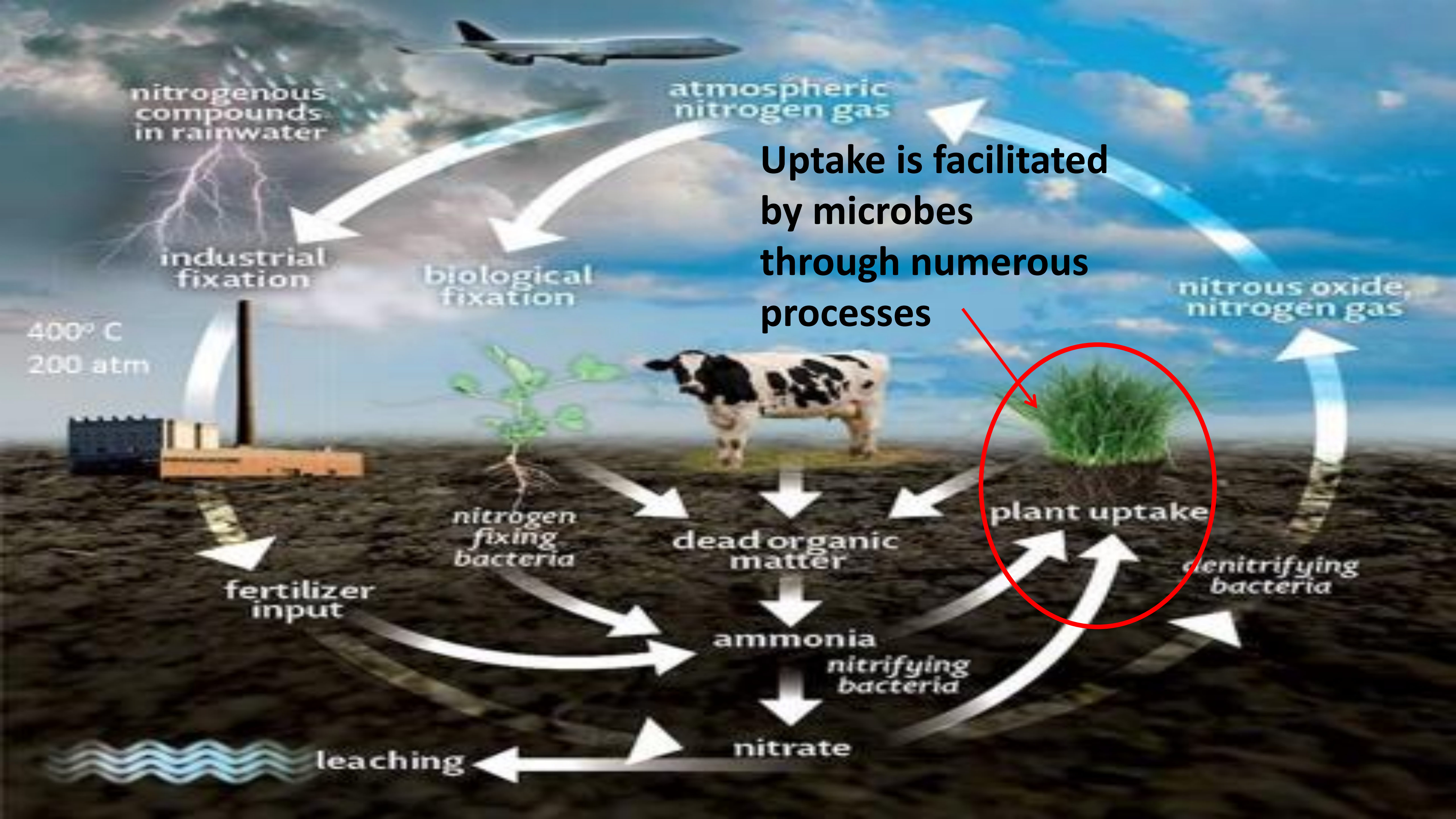
  Rec = 135 lbs

- HANEY
- Corn @ 200 bu/A

  220 lbs of N req'd
- N credits

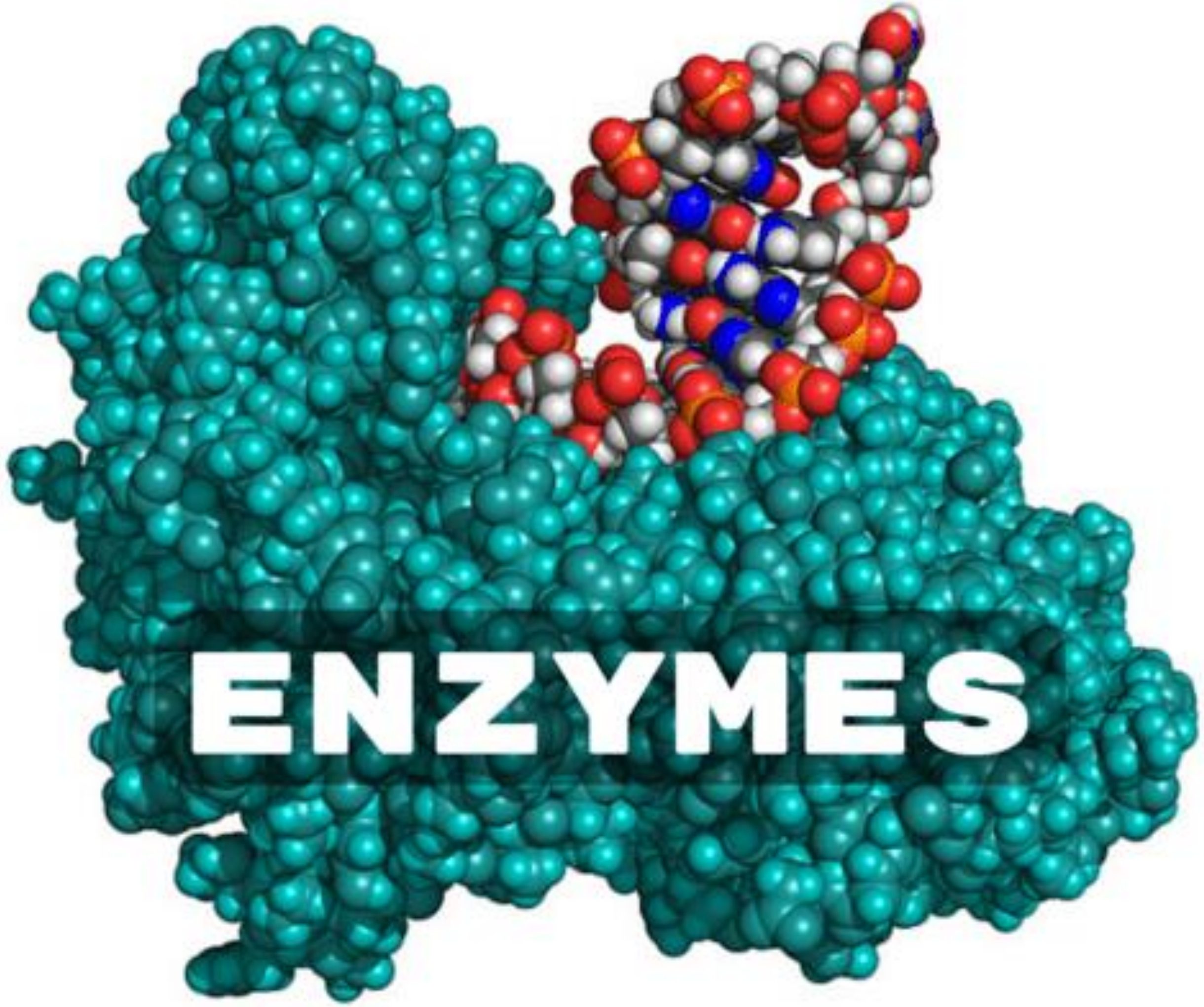
  Total Credit = 125 lbs

  Rec = 95 lbs

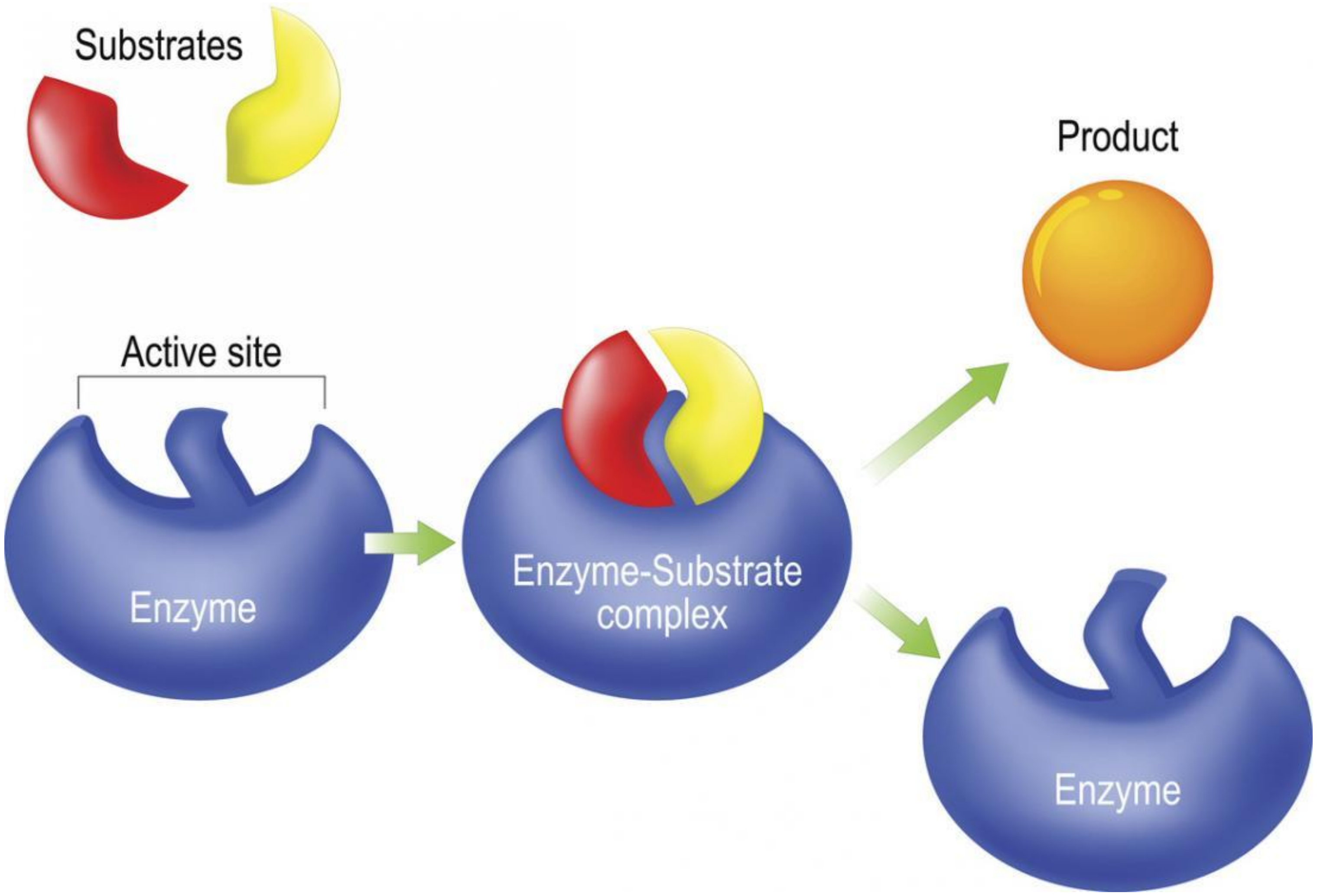

Uptake is facilitated by microbes through numerous processes
nitrogenous compounds in rainwater
atmospheric nitrogen gas
industrial fixation
biological fixation
400° C
200 atm
nitrous oxide, nitrogen gas
plant uptake
nitrogen fixing bacteria
dead organic matter
denitrifying bacteria
fertilizer input
ammonia
nitrifying bacteria
nitrate
leaching

The Soil Health Effect

- Improving soil health and biological function increases nutrient use efficiency by the crop.
- Using conventional tests and fertilizer requirements can lead to excess fertility being applied.
- Healthier soils require fewer fertility inputs due to the increased ability of plants to acquire necessary nutrients.


ENZYMES

Enzyme Function

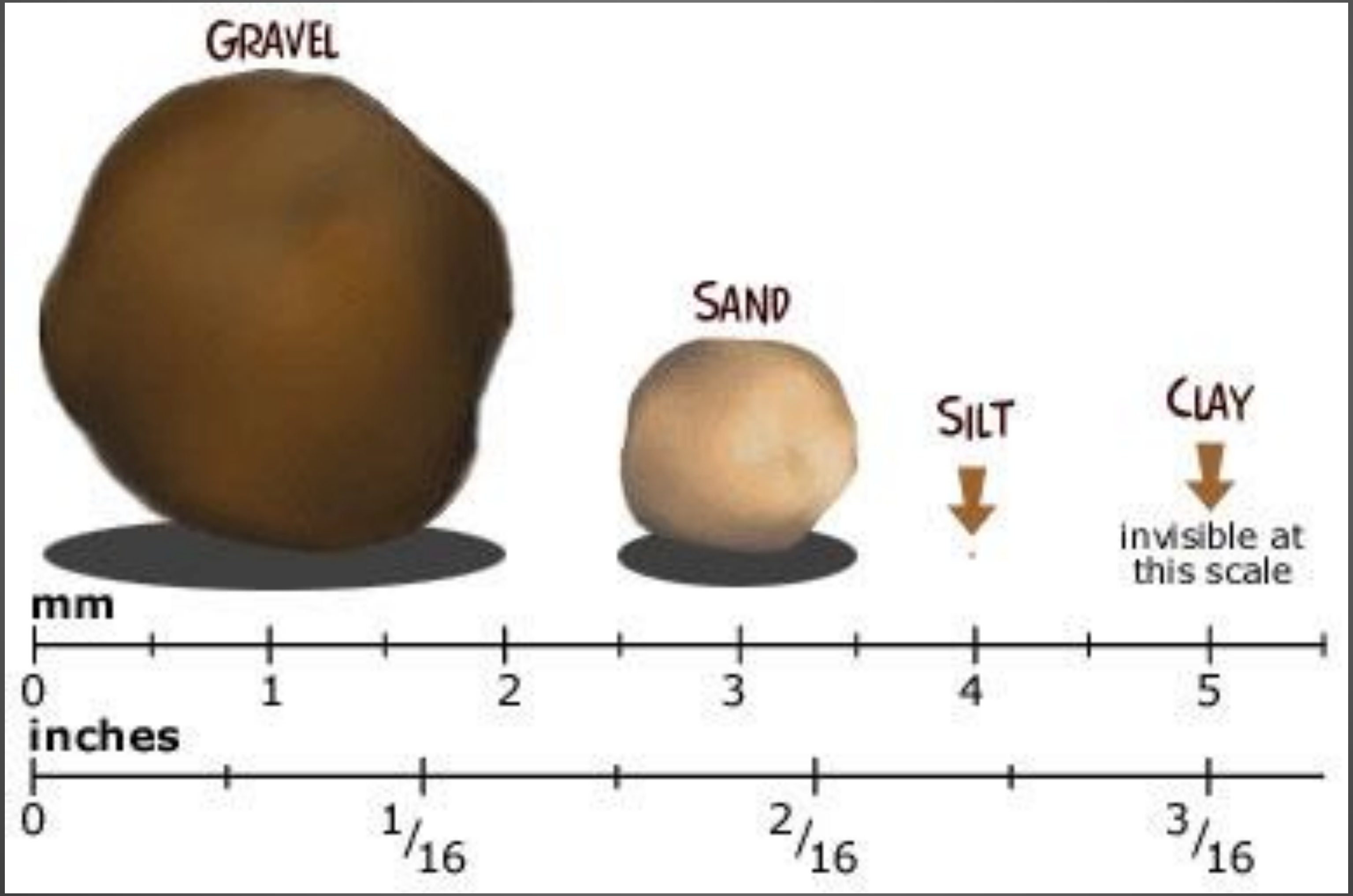


Important Functions

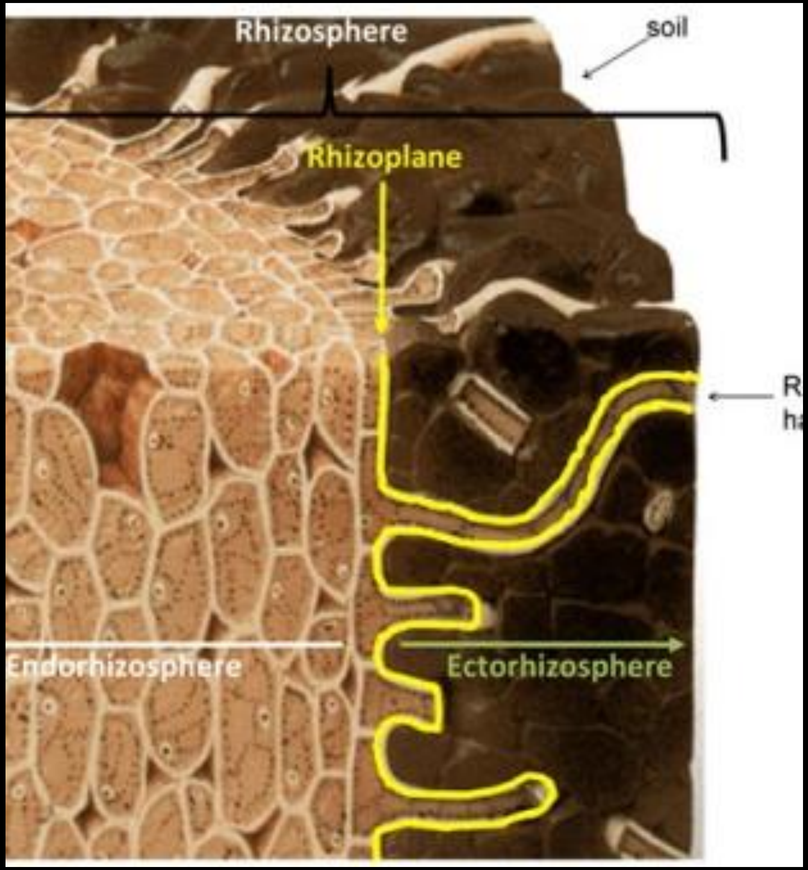
Enzyme	Soil Process	Soil Product	Significance	Nutrient Cycle
β-glucosidase (BG)	Cellulose Degradation	Glucose	Energy for microbiology	Carbon / OM Decomposition
N-acetyl-β-glucoseaminidase (NAG)	Chitin Degradation	Amino Acid N	Important source of N	C and N cycling
Phosphodiesterase	Degradation of nucleic acids, phospholipids (Organic P Degradation)	Phosphomonoesters	Intermediate P products	P cycling
Phosphatases (Alkaline, Acid)	Degrade phosphomonoesters	Phosphate	Plant available P	P cycling
Arylsulfatase (ARS)	Degradation of ester sulfates	Sulfates	Plant available S	S cycling

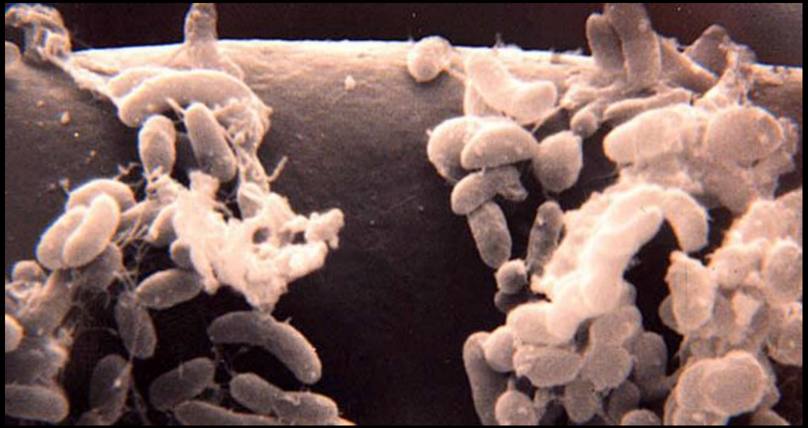
Aggregate Stability

Soil Particles



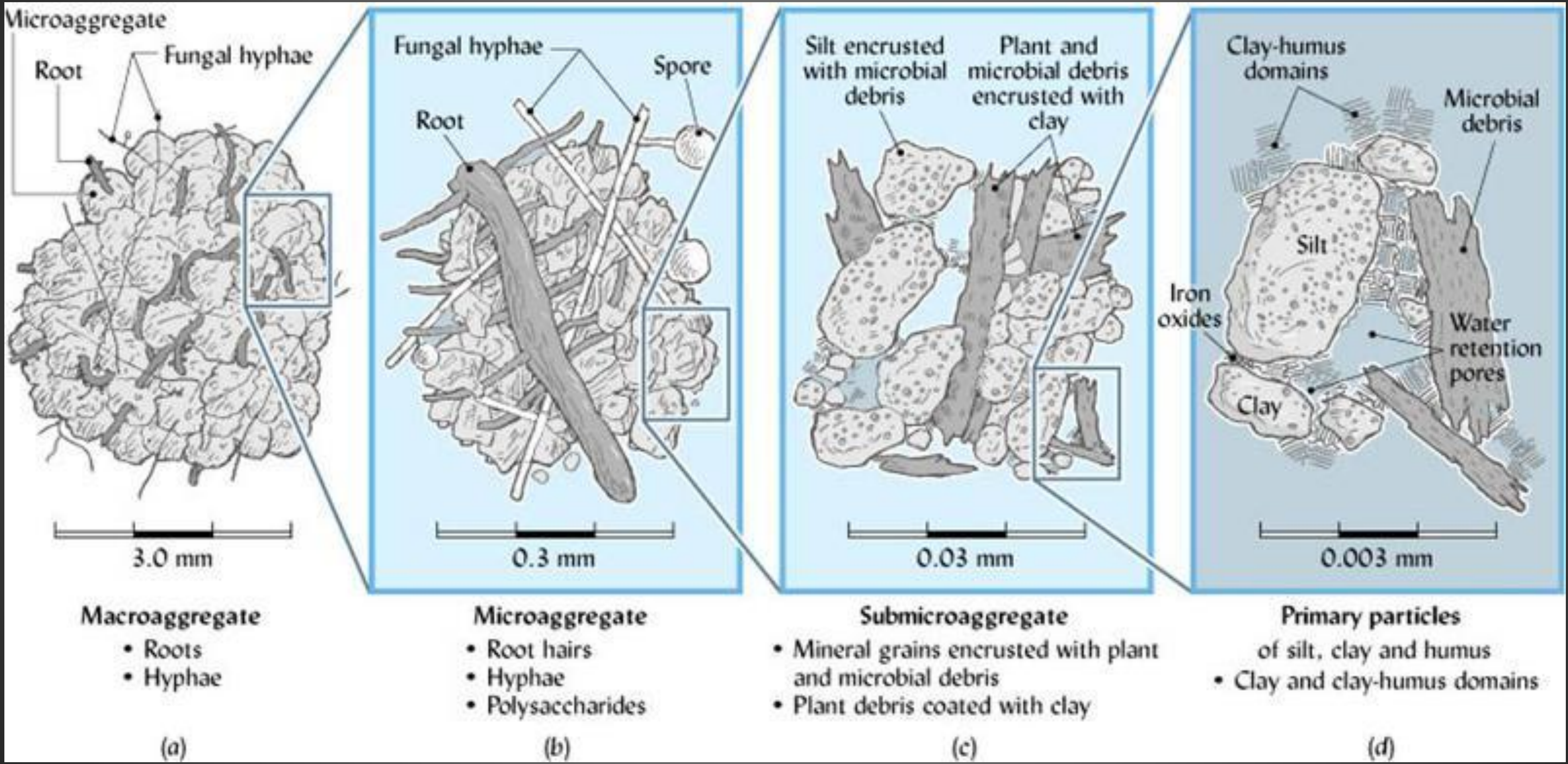
Soil Structure





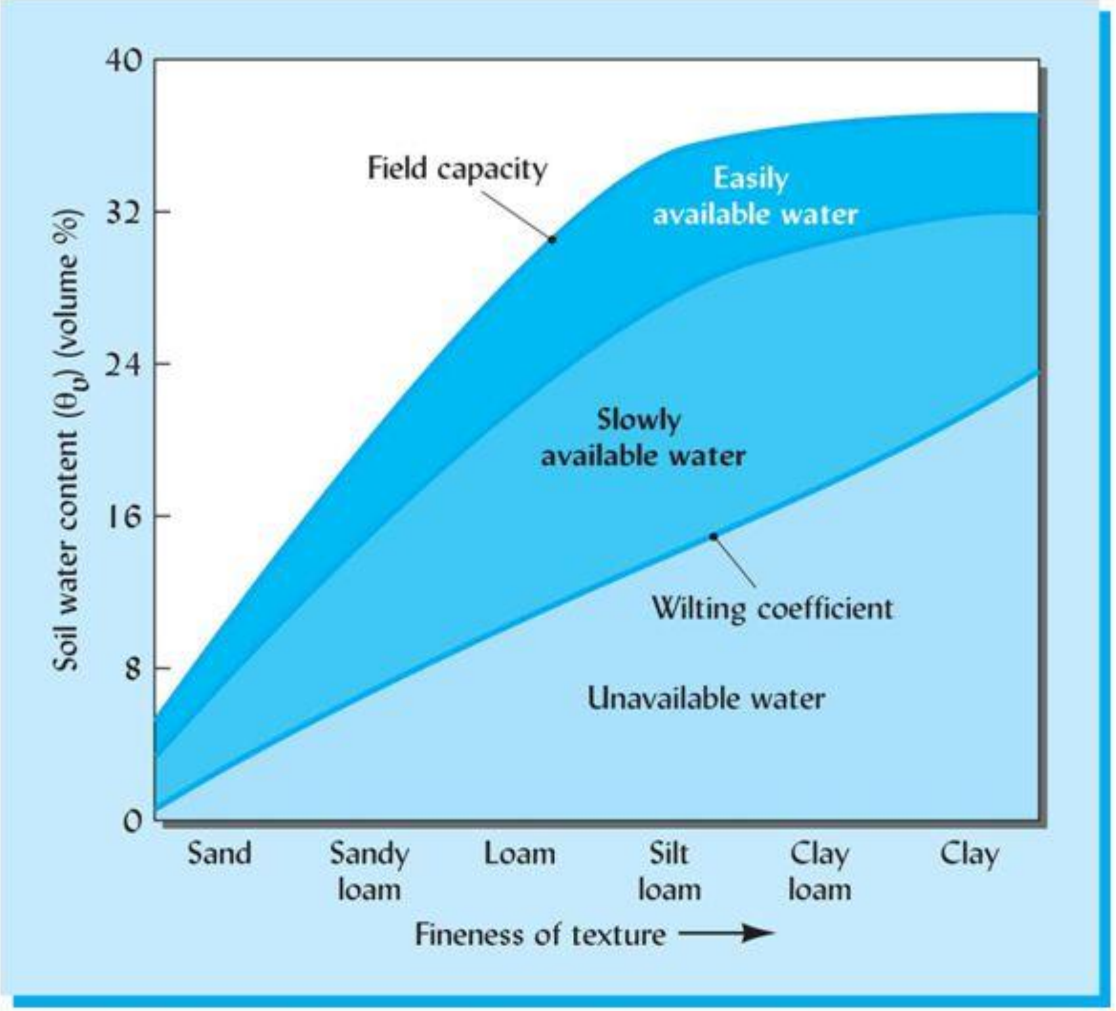
The Rhizosphere

Aggregate Formation



Water Holding Capacity

General relationship between soil water characteristics and soil texture. Note that the wilting coefficient increases as the texture becomes finer. The field capacity increases until we reach the silt loams, then levels off. Remember these are representative curves; individual soils would probably have values different from those shown.



When and How to Use Soil Health Tests

- Comparing two different systems
- Tracking change over time
- Troubleshooting problems
- Spring and/or Fall when soil temps >50°

Questions?

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