Soils and Fertilizers

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White House Garden

When I go into the garden with a spade, and dig a bed, I feel such an exhilaration and health that I discover that I have been defrauding myself all this time in letting others do for me what I should have done with my own hands.

- *Ralph Waldo Emerson*

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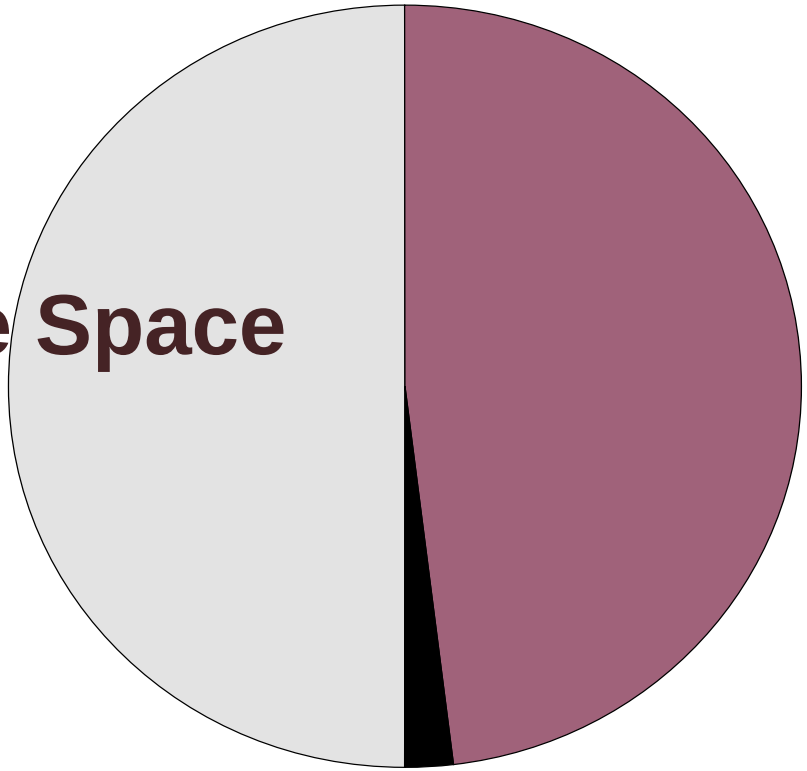
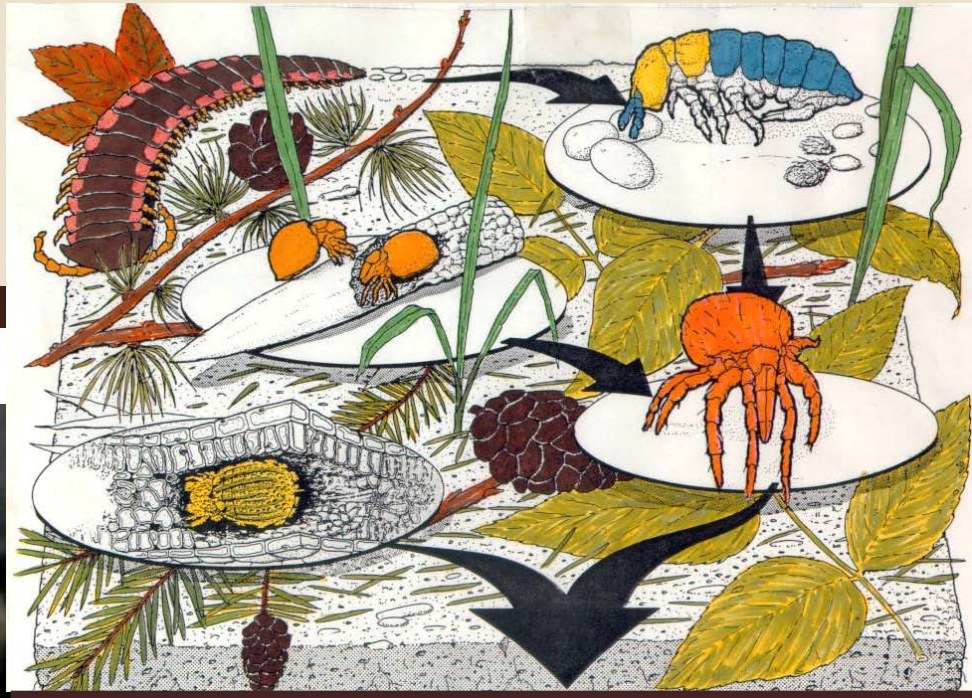
To forget how to dig the earth and to tend the soil is to forget ourselves.

- Gandhi

Soil Components



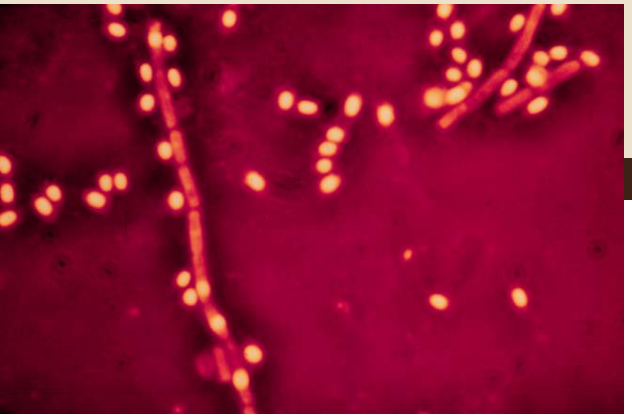
The Soil Ecosystem



Residue decomposition
Nutrient cycling
Aggregation and porosity
Enhance plant growth
Break down contaminants

The soil is the great connector of our lives, the source and destination of all. - Wendell Berry

Soil Organisms



Bacteria, fungi, actinomycetes, protozoa, nematodes, arthropods, earthworms

Pictures courtesy D. Collins, M. Fauci and D. Bezdicek

Soil Air and Water

- Water Movement
  How quickly water moves through soil
- Water Holding Capacity
  How much water a soil can hold available for plant growth

Pore Space and Air-Water Relations

- **Soil acts like a sponge**
- **Macropores control infiltration and drainage**
- **Capillary pores control water holding capacity**
- **Micropores hold unavailable water**

What Affects the Size of the Soil Pores?

- Soil texture
- Soil structure
- Compaction and disturbance
- Organic matter

To be a successful farmer one must first know the nature of the soil. - Xenophon, 400 B.C.

- Texture
- Structure
- Compaction
- Organic Matter

Texture: Soil Particle Sizes

Sand	.05-2 mm
Silt	.002-.05 mm
Clay	<.002 mm

Coarse Fragments >2 mm

Texture: Approximate surface area of a 1 tablespoon sample

Coarse sand: one dollar

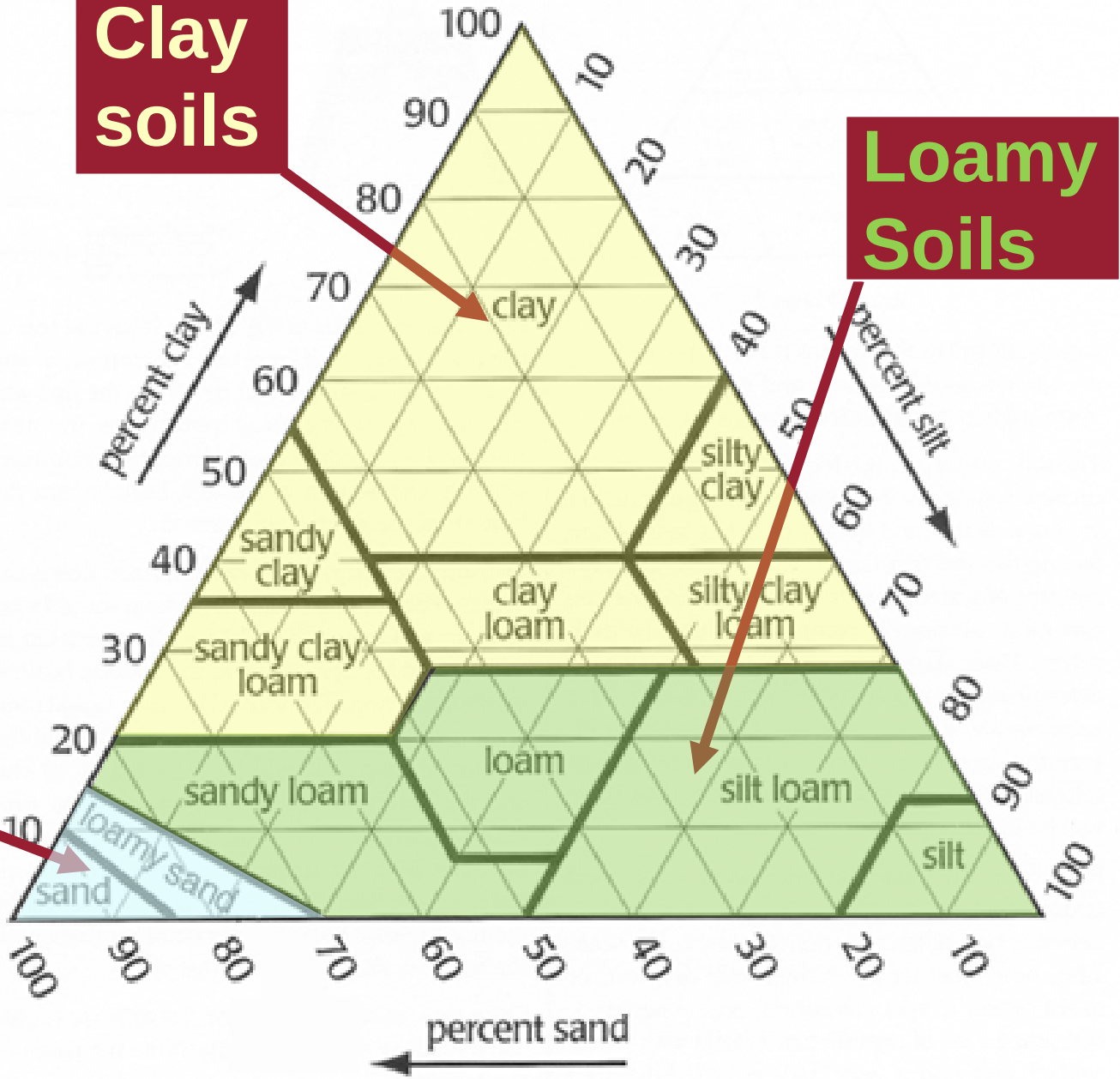
Fine clay: soccer field

Textural Triangle

Clay soils

Loamy Soils

Sandy soils



- Texture
- **Structure**
- Compaction
- Organic Matter

Soil Structure

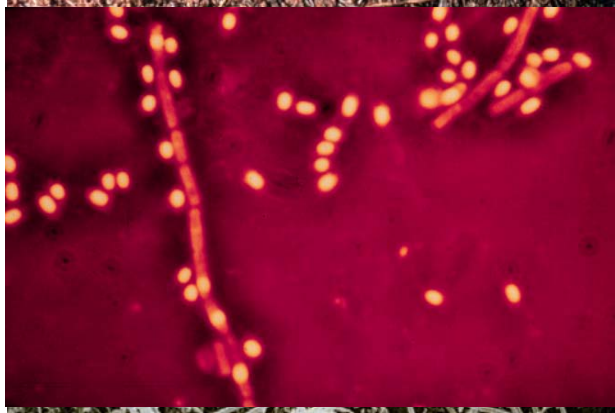
Aggregation of Sand, Silt, and Clay Particles

Structure affects:

- Macroporosity
- Infiltration
- Aeration

Formation of Soil Structure

- Growth of roots and movement of organisms create pores and aggregates
- Soil organisms break down organic residues, producing glues that stabilize aggregates
- Fungi provide structural support to aggregates
- Physical, chemical processes also involved



- Texture
- Structure
- Compaction
- Organic Matter

Natural Compaction:

- Basal glacial till
- Very compact
- Nearly impermeable

Human Compaction:

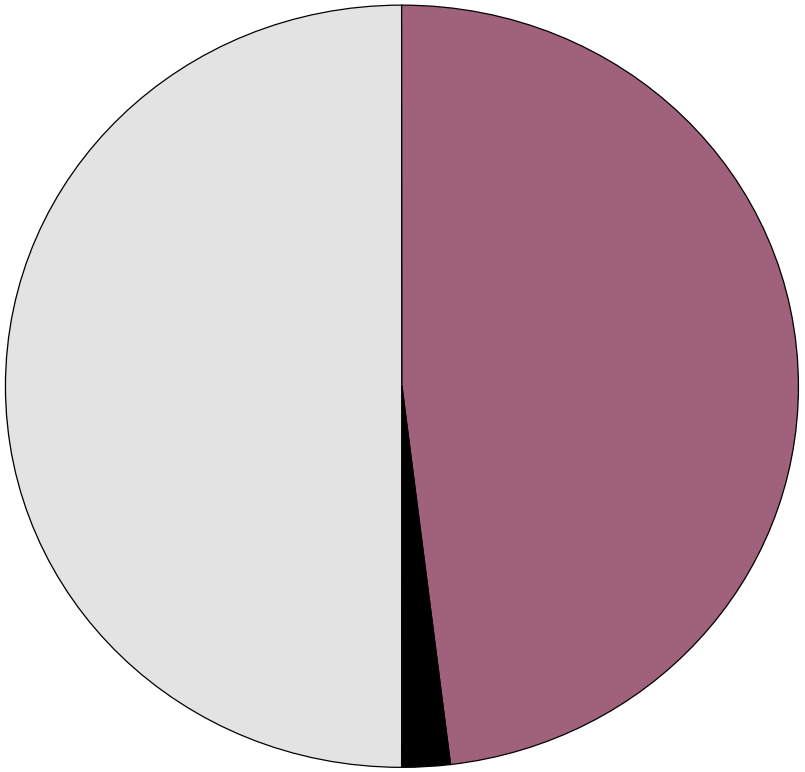
- Clearing
- Construction
- Traffic

- Texture
- Structure
- Compaction
- Organic Matter

Why is Organic Matter Important?

- Structure and macropores
- Water holding capacity
- Infiltration
- Nutrient supply
- Biological activity
- Improved root environment

One-Minute Drill



What soil components does this pie chart show?

How Does Topography Affect Soil Water?

One-Minute Drill

What is soil structure and why is it important?

Plant Nutrients

Major Nutrients

- Nitrogen
- Phosphorus
- Potassium
- Calcium
- Magnesium
- Sulfur

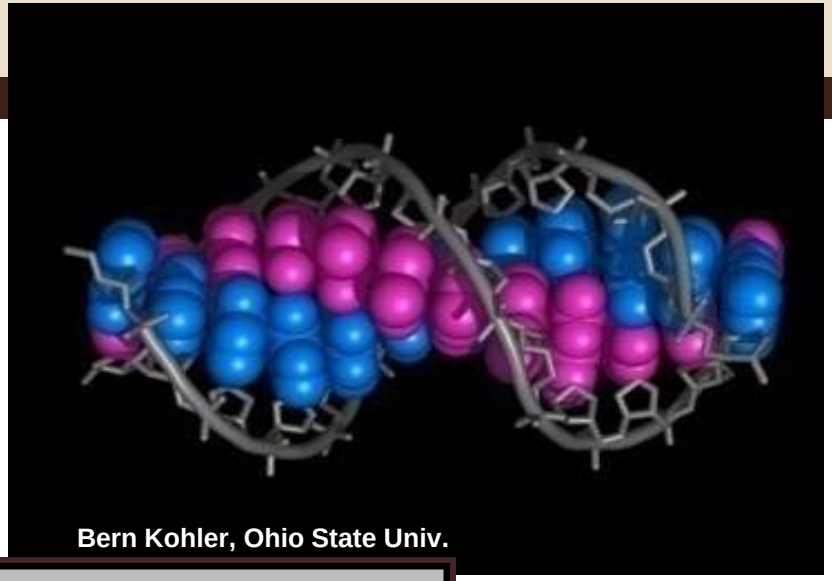
Micronutrients

- Boron
- Iron
- Manganese
- Zinc
- Copper
- Chloride
- Molybdenum

What Do Nutrients Do?

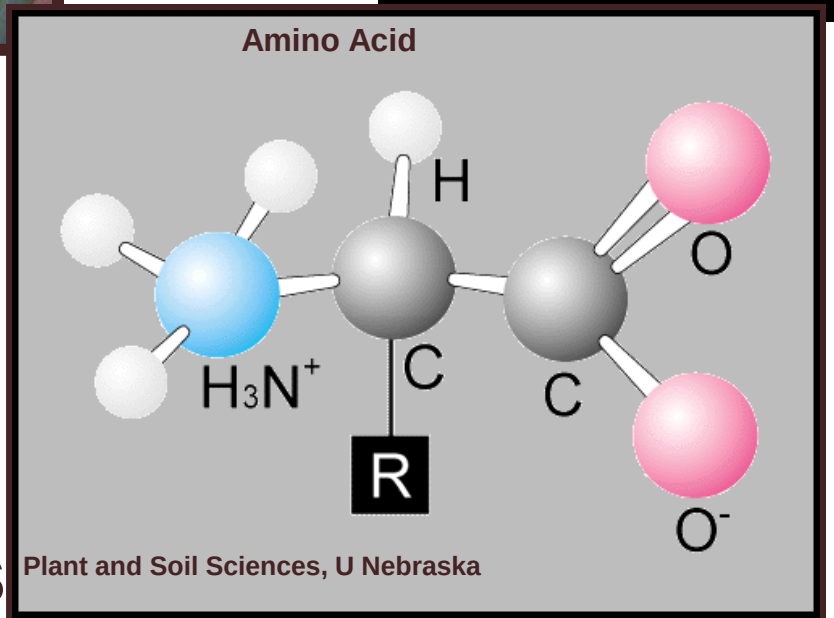
Example: Nitrogen

Chlorophyll – photosynthesis



Bern Kohler, Ohio State Univ.

DNA



Amino acids and proteins

Nutrient Deficiencies

- Reduce plant growth, health, and yield.
- Nutrient deficiencies can sometimes be identified by observing symptoms.

P deficiency in corn

Mg deficiency in corn

Problems with Excess Nutrients

Nitrogen:

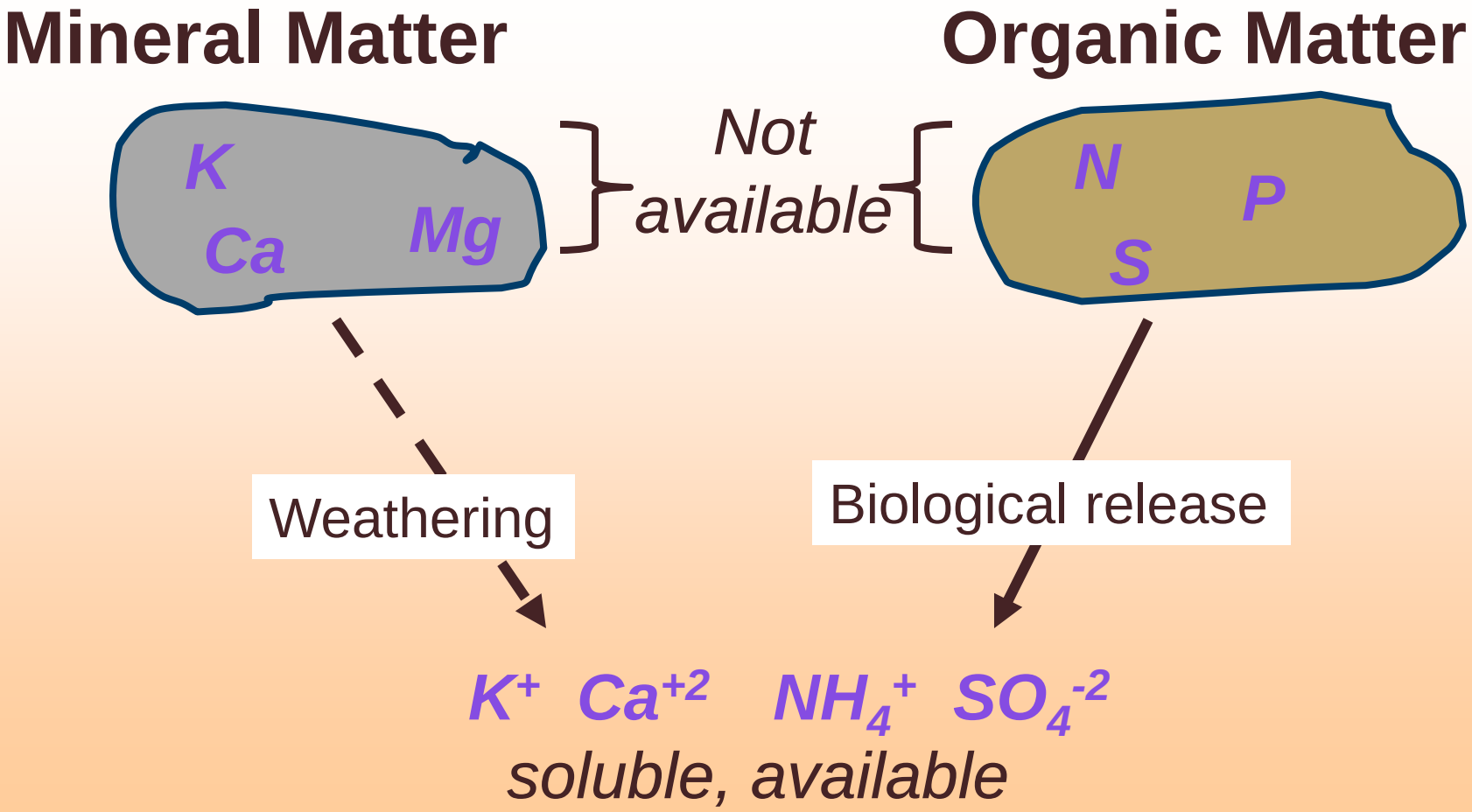
- Plant health, fruit yield and quality
- Groundwater quality

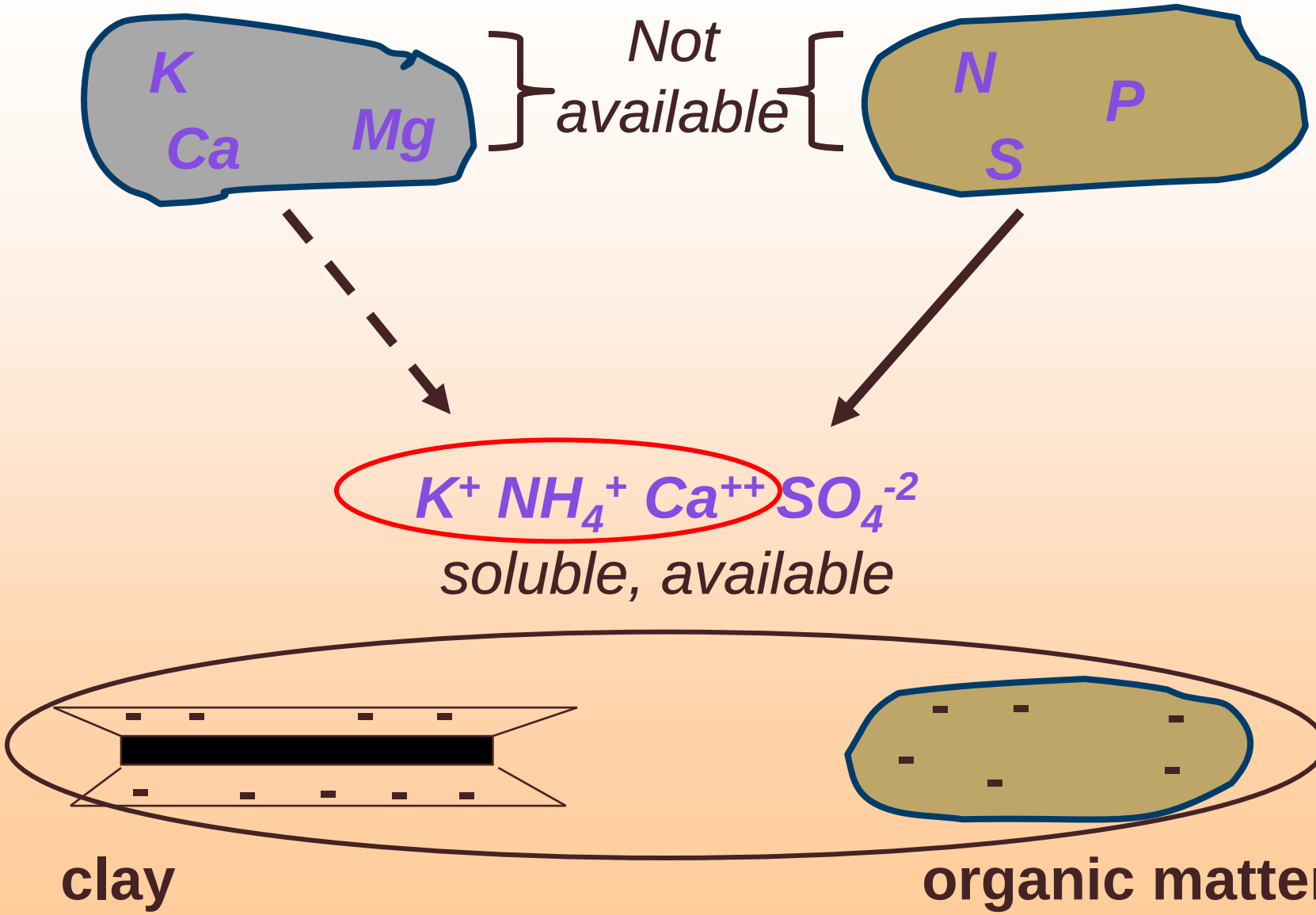
Boron:

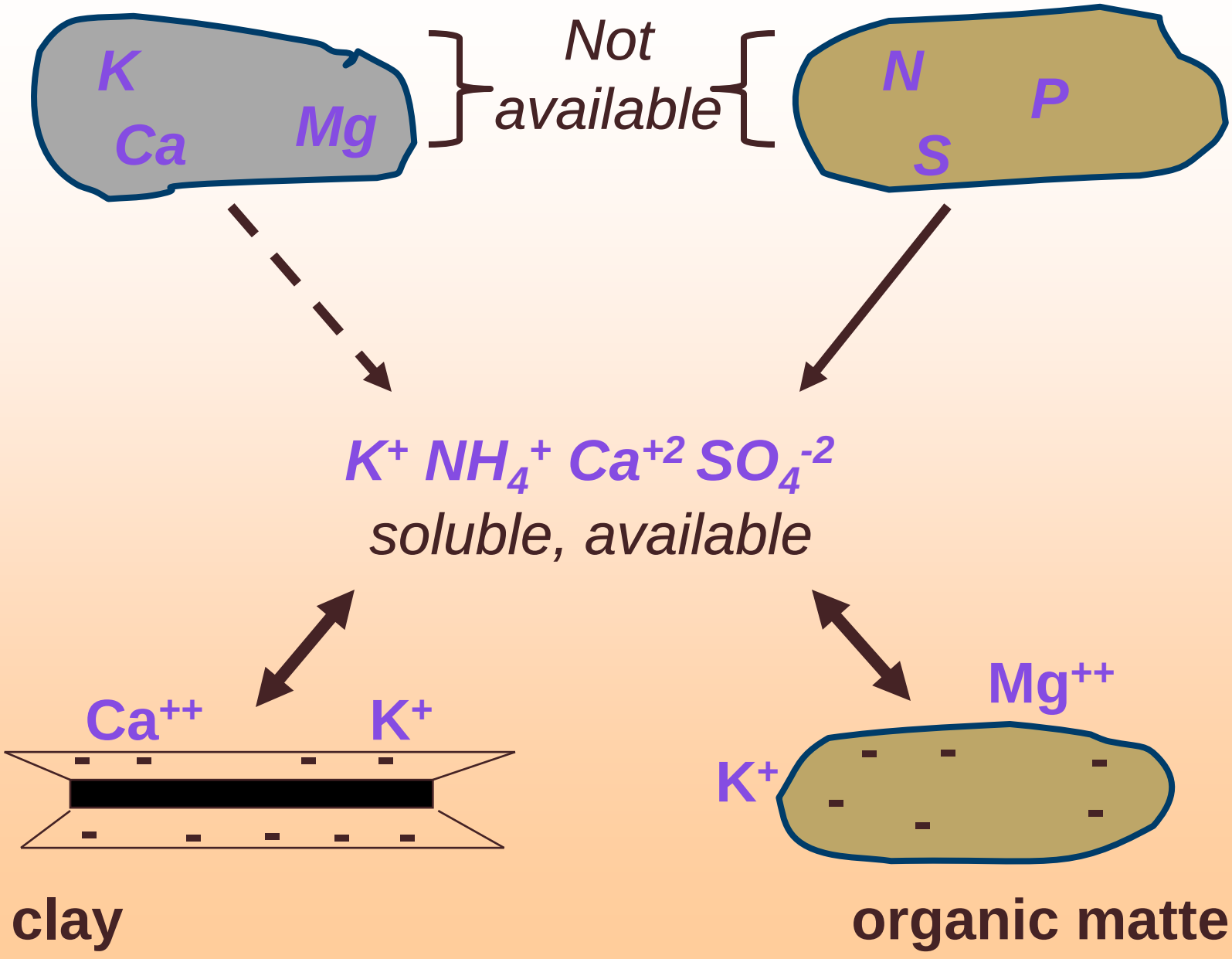
- Toxicity

How Do Nutrients Become Available to Plants?

What Happens to These Nutrients When It Rains?




K
Ca
Mg
Not available
N
P
S
K^+ NH_4^+ Ca^{++} SO_4^{-2}
soluble, available
clay
organic matter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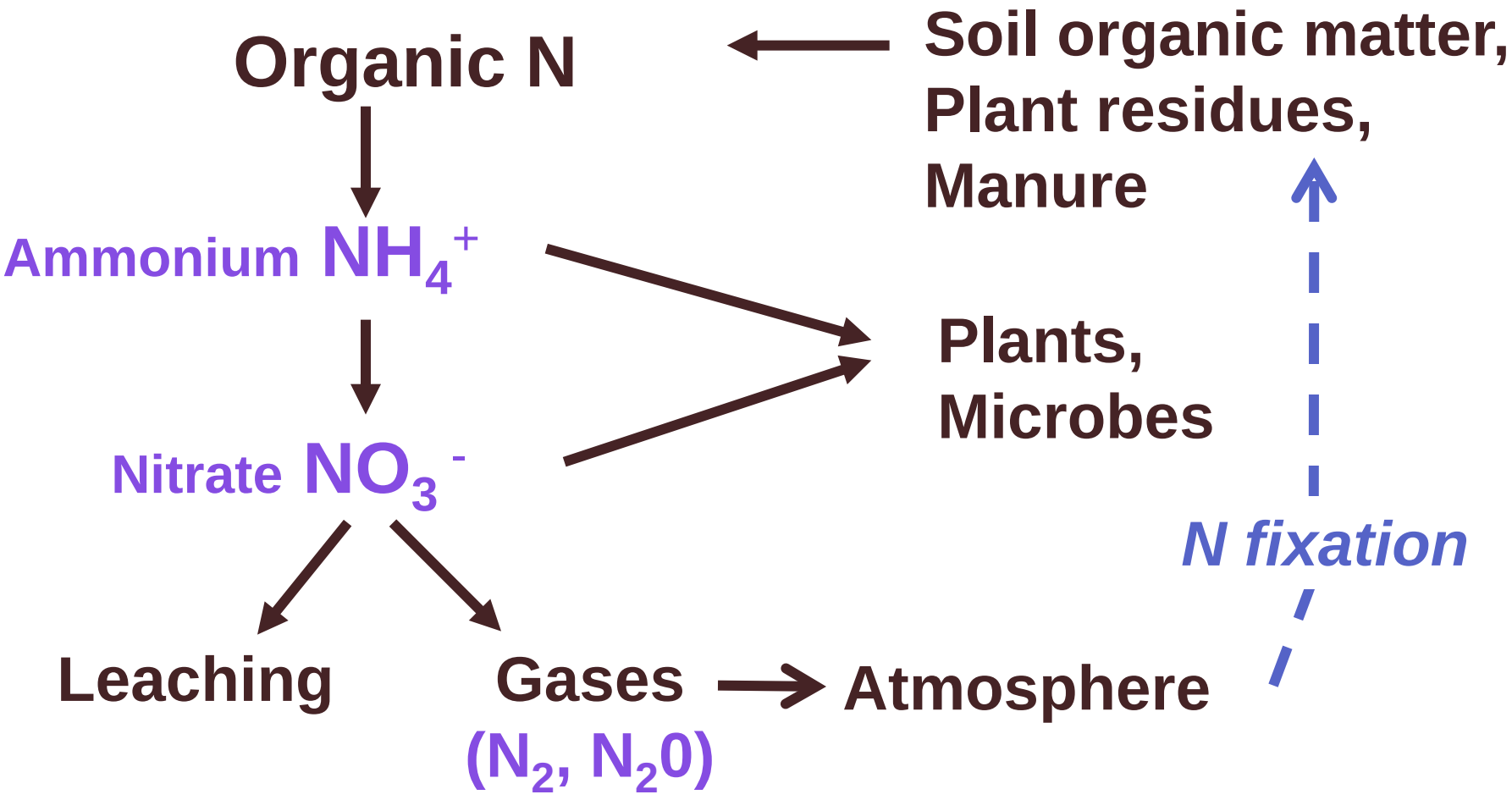
Nitrogen Cycle



Comparing Organic and Processed Fertilizers

Organic

- Little or no processing
- Low analysis
- Usually slow release
- Often unknown analysis
- Usually a source of OM

Processed

- Industrial processing
- High analysis
- Usually fast release
- Known analysis
- No OM

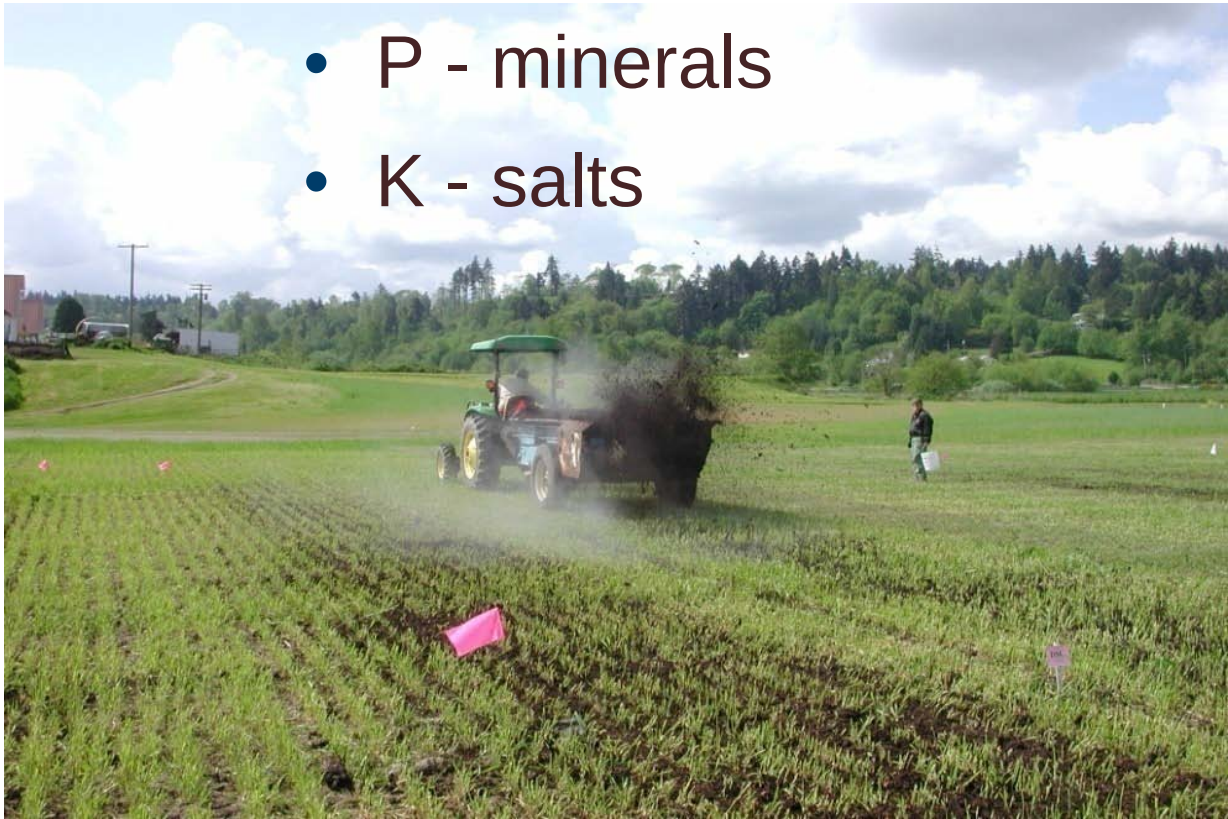
Fertilizer Sources

Organic

- Manure
- Wood ashes
- Bone meal
- Biosolids
- Blood meal
- Others

Processed

- N - air
- P - minerals
- K - salts

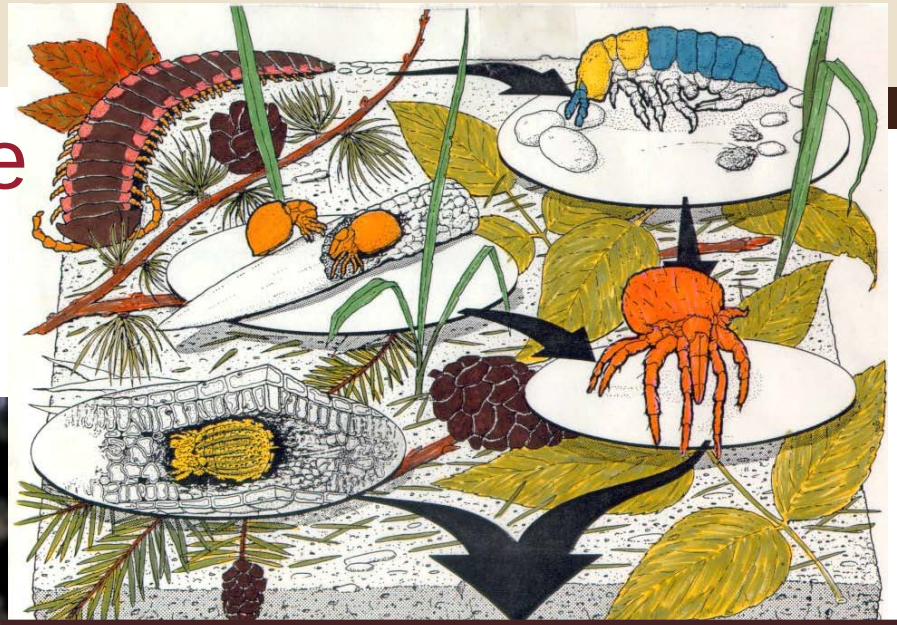


Nutrient Uptake

The forms of nutrients taken up by plants are the same –

Whether the source of the nutrients is the soil, an organic fertilizer, or a manufactured fertilizer.

But, our management must maintain soil organic matter over the long run.



The nation that destroys its soil, destroys itself.

-Franklin Delano Roosevelt

Fertilizer Labels

5 – 10 – 10

% Nitrogen – % Phosphate – % Potash

Phosphate = units of P

1 lb P = 2.3 lb phosphate (P_2O_5)

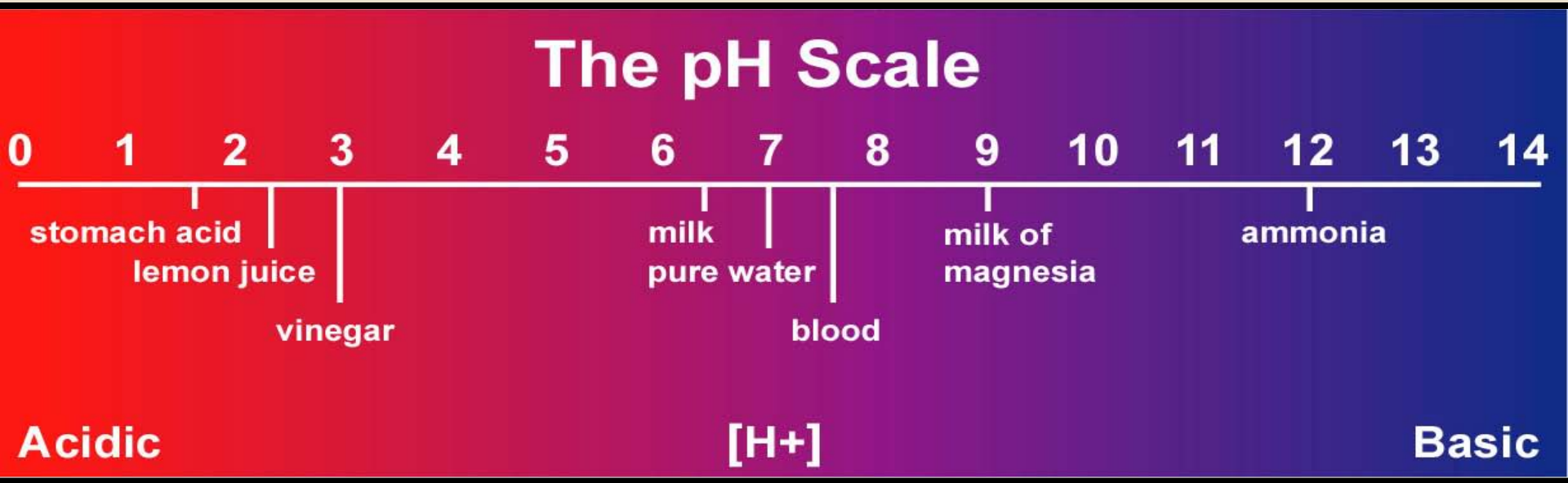
Potash = units of K

1 lb K = 1.2 lb potash (K_2O)

How Much Fertilizer Do I Use?

Soil pH

- Indicates relative acidity or alkalinity
- pH 7 = neutral; less than 7 = acid; more than 7 = alkaline or basic
- Logarithmic scale



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Why is pH Important?

- Nutrient availability
- Availability of toxic metals
- Microbiological activity

Soil Acidification

- A natural process in humid areas
- Accelerated by fertilizers
- Sulfur and ammonium sulfate are strong acidifiers

Desirable pH Ranges

Vegetables	6 to 7.5
Pastures	5.5 to 8
Acid loving plants	4.5 to 5.5

Increasing pH

- Lime ($CaCO_3$) neutralizes acidity
- Lime supplies Ca, which is often deficient in acid soils
- Dolomite lime also supplies Mg
- Apply lime based on soil test, and lime only those crops that need it.
- For gardens without soil test: 50 lb/1000 sq ft/year

What a Soil Test Tells You

- Relative levels of nutrients in your soil
- Fertilizer recommendation
- Standard soil test: P, K, Ca, Mg, B, pH, lime
- No good soil test exists for nitrogen requirement

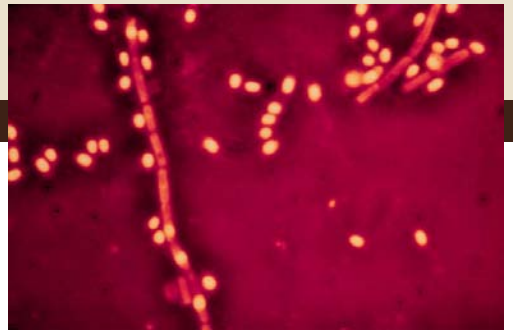
Taking a Sample

- Sample defined area
- Take 10 or more subsamples (0-8” deep)

- Dry and mix <u>well</u>

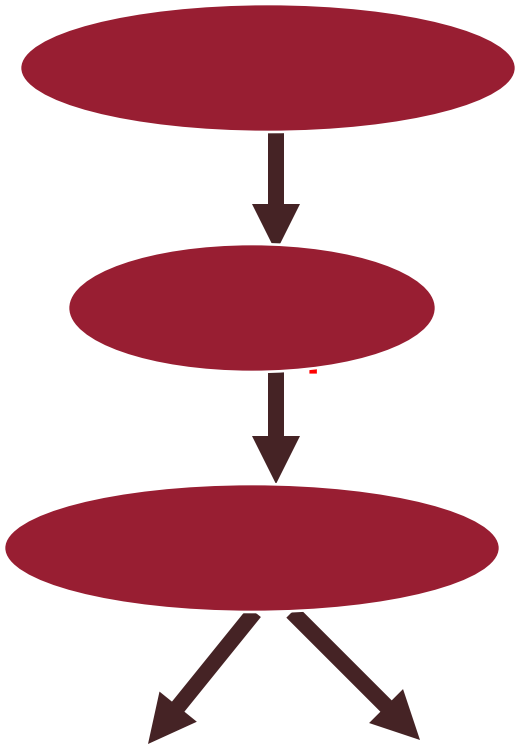
- Subsample mixture and fill sample bag

Roles of Soil Organisms



- Residue decomposition
- Nutrient cycling
- Aggregation and porosity
- Contaminant breakdown
- Nitrogen fixation
- Enhance root function
- Pathogens
- Predators

One-Minute Drill



Leaching Gases → Atmosphere

- What are the three most common forms of nitrogen in soils and soil amendments?
- Which of these forms are available to plants?

One-Minute Drill

What are three important differences between organic and processed fertilizers?

Organic Amendments

Management depends on C:N ratio and stability of material

Carbon:Nitrogen Ratio

- Ranges from <5:1 to >500:1 in organic materials
- Low C:N supplies N to plants
- High C:N ties up N by biological immobilization

Types of Organic Amendments

Hot stuff – C:N <10:1

Cool stuff – C:N 15:1 to 25:1

Woody stuff – C:N > 30:1

Hot Stuff

- Poultry manure
- Seed meals
- Fish and feather meals
- Fresh grass clippings
- Fresh rabbit manure
- Dewatered or dried biosolids

Hot Stuff C:N < 10:1

- Rapid N availability
- Use as a fertilizer
- Over application leads to excess nutrient levels in soil -- potentially harming crop and water quality.

Cool stuff

- Compost (yard debris, most manures, biosolids)
- Fresh materials:
  - o Yard debris
  - o Cover crop residues
  - o Dairy manure solids
  - o Coffee grounds

Cool stuff, C:N 15:1 to 25:1

- Slow N availability
- Can add large amounts without risk of over-fertilization
- Use as a soil amendment
- N immobilization (tie-up) likely with fresh materials in first few weeks after application
- Compost organic matter lasts a long time in soil

Woody stuff

- Straw
- Sawdust
- Paper waste
- Horse manure rich in bedding

Woody stuff, C:N > 30:1

- N immobilization
- Need to add N along with organic amendment
- Use as mulch or bulking agent for compost

Organic Application Guidelines (middle-of-the road estimates)

- Poultry manure: 3-5 gal/100 sq. ft.
- Rabbit manure: 20-40 gal/100 sq. ft.
- Horse manure, dairy solids: 1 inch
- Compost: 1 inch per year in annual bed
- Compost: Up to 30 to 50% by volume when making raised beds.
- Seed and animal by-product meals: Use like inorganic fertilizers

Compost

- Home or municipal
- Good source of OM
- Nutrient value depends on compost type

Green Manure or Cover Crops

- Grow your own OM
- Legumes will provide N
- Cover crop during the winter
- Early planting is best
- Soil incorporation takes work
- EB 1824 Cover crops for home gardens

Cover Crops

Relay planted legume

Fall-planted Cereal & legume

Short-term Grass-legume pasture

Common Winter Cover Crops

Cereal Rye

Annual Ryegrass

Hairy Vetch

Crimson Clover

Benefits of Early Planting

Cereal Rye-Hairy Vetch

Planted September 20

Planted October 4

Photos October 24, 2005

Incorporating Cover Crops into the Soil

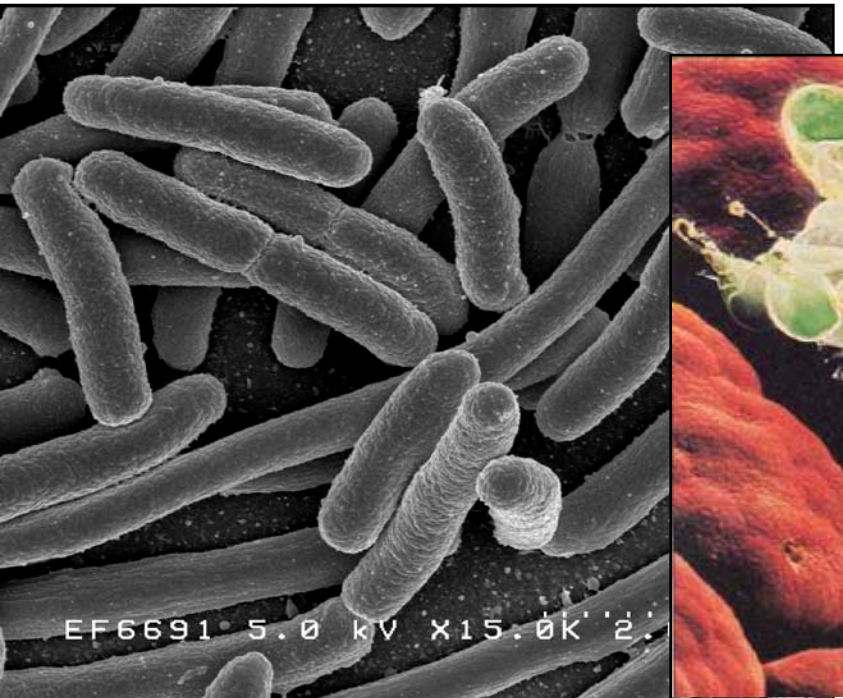
- Turn cover crops under before they go to seed
- Wait 2 to 3 weeks before planting garden crops
- If cover crop is tall and hard to turn under, mow it first to break up stems

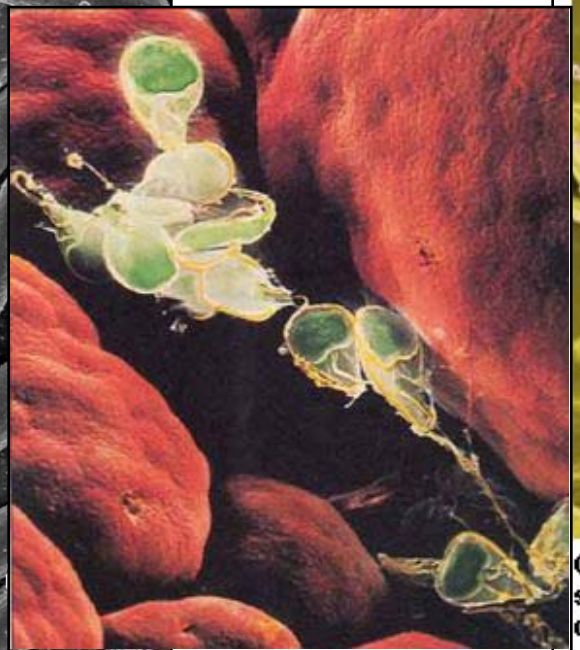
One-Minute Drill

What information does C:N ratio tell us about an organic amendment?

Manure and Pathogens

- Fresh manure can contain Salmonella, E. coli O157:H7, etc.
- We must use manure properly to avoid spreading diseases

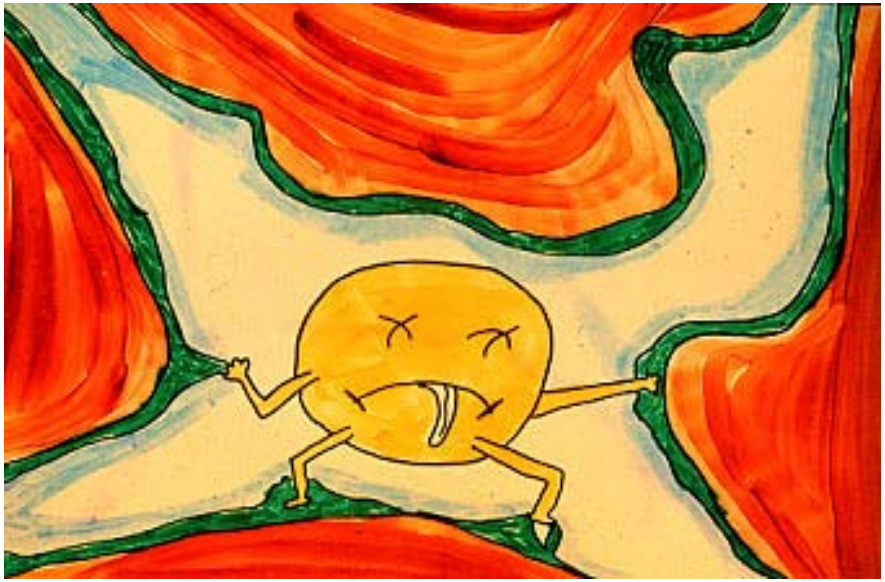




Color-enhanced scanning electron micrograph showing *Salmonella typhimurium* (red) invading cultured human cells Kevin Sorenson, Snow College

Using Animal Manure Safely

- Vegetables eaten fresh have greatest risk.



- Pathogens die off in the environment.

How Can We Use Manure Safely?

- Composting
  - o Exceed 131ºF for specified time
  - o Difficult to do in home compost piles
- Waiting periods
  - o 120 days when using fresh manure (maybe longer?)
- Till manure into soil before planting
- Don’t use dog and cat manure

Biosolids
(Wastewater Solids)

- Recycles nutrients
- Good source of N, P, and micronutrients
- Use only Class A (pathogen-free) biosolids around the home.
- Don’t over-apply

Types of Biosolids

Cake: Hot stuff, but generally not available to public

Blend (such as Tagro products): Class A cake + wood product, supplies OM and nutrients

Heat-dried product: Use like fertilizer

Compost (biosolids + yard debris or wood waste): Use like other compost.

Man - despite his artistic pretensions, his sophistication, and his many accomplishments - owes his existence to a six inch layer of topsoil and the fact that it rains.

- *Author Unknown*

References

- Soil Management for Small Farms *(EB1895, WSU)*
- Fertilizing with Manure *(PNW 533, WSU)*
- Soil Sampling for Home Gardens *(EC 628, OSU)*
- Soil Test Interpretation Guide *(EC 1478, OSU)*
- Using Cover Crops in Oregon *(EM 8704, OSU)*
- Cover Crops for Home Gardens in Western Washington and Oregon *(EB 1824)*
- Fertilizing your garden *(EC 1503, OSU)*

Soils Web Address: *www.soils1.org*

- **Gardening** button:
  - Soil sampling and texture videos
  - Backyard composting
  - Link to soil biology primer
- **Sustainable Ag** button:
  - Cover crops
  - Fertilizing with manure
  - Soil management on small farms
- **Soils and Soil Testing** button