Note

- This slideshow contains three presentations:
  - Intro to soil health science
  - How to protect soil health in the garden
  - How to teach soil health in the classroom or garden

WEST MULTNOMAH
Soil & Water Conservation District

Soil Health Workshop for School and Community Gardens

August 17, 2016

Scott Gall, Laura Taylor, Rebecca Heuer

Please complete the first side of your evaluation form

Overview

- Soil health basics with hands-on demos
- Building soil health in the garden
- Teaching soil health

Relax!
These materials will be available online.
https://wmswcd.org/projects/soil-health-workshop/

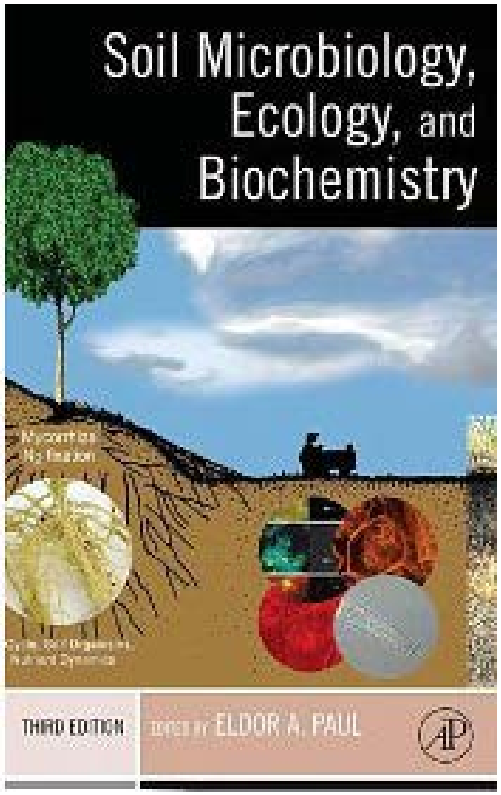
Soil Health for School Gardens: Intro to the Science

Scott Gall
WMSWCD Rural Conservationist

What is “soil health”? From the textbook:

The capacity of a soil to function within ecosystem boundaries to sustain biological productivity, maintain environmental quality, and promote plant and animal health.

Soil quality (Paul et al. 2007)



What is “soil health”?

From the farm:

- High performing and productive.
- Reduce production costs and increase profit.
- Protects natural resources.
- Increase efficiencies.

(NRCS)

What is “soil health”?

For the rest of us:

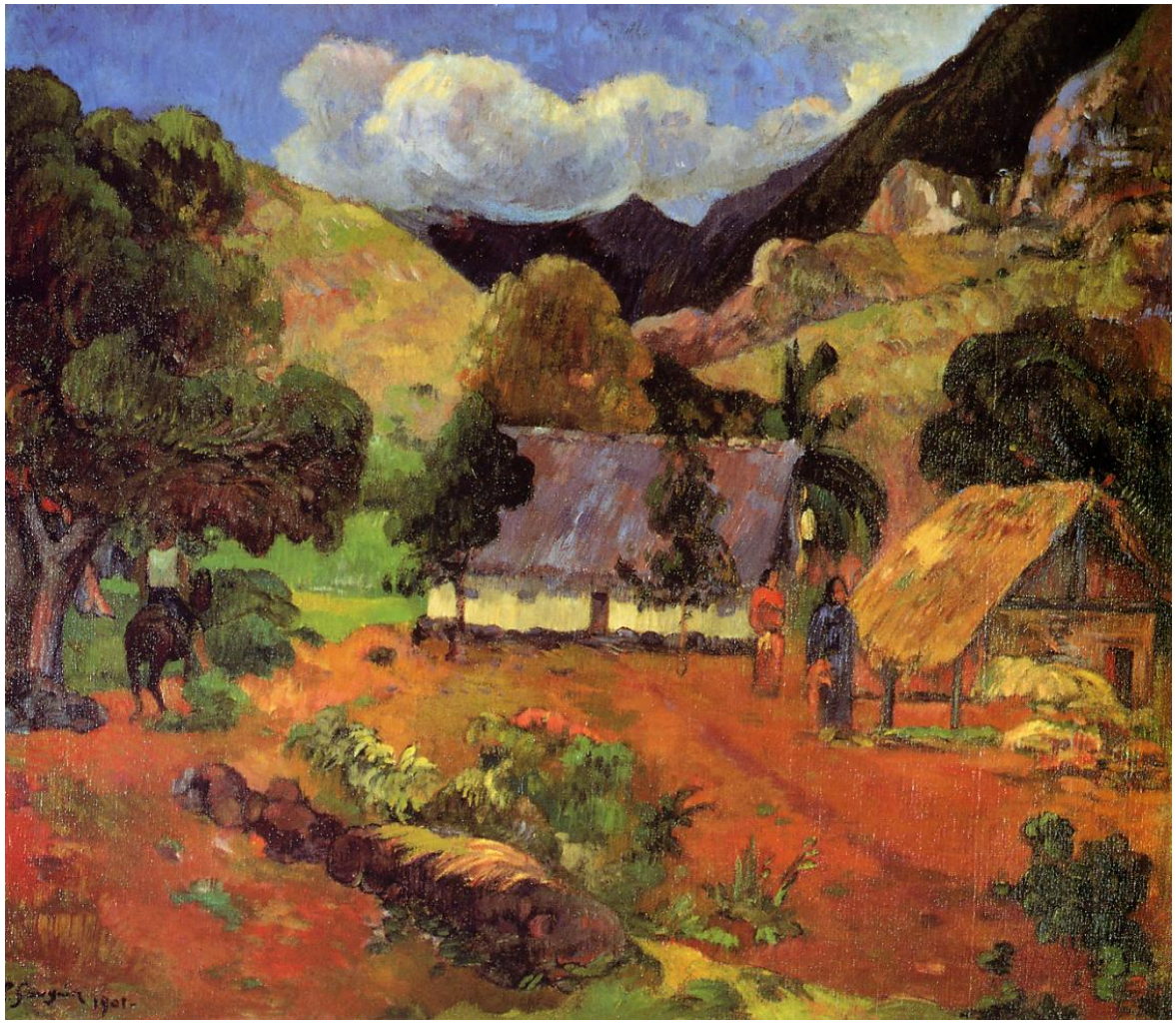
The ability of a soil to help you achieve your goals without spending too much money or messing up the environment.

Making sense of soil

- Physical
- Chemical
- Biological

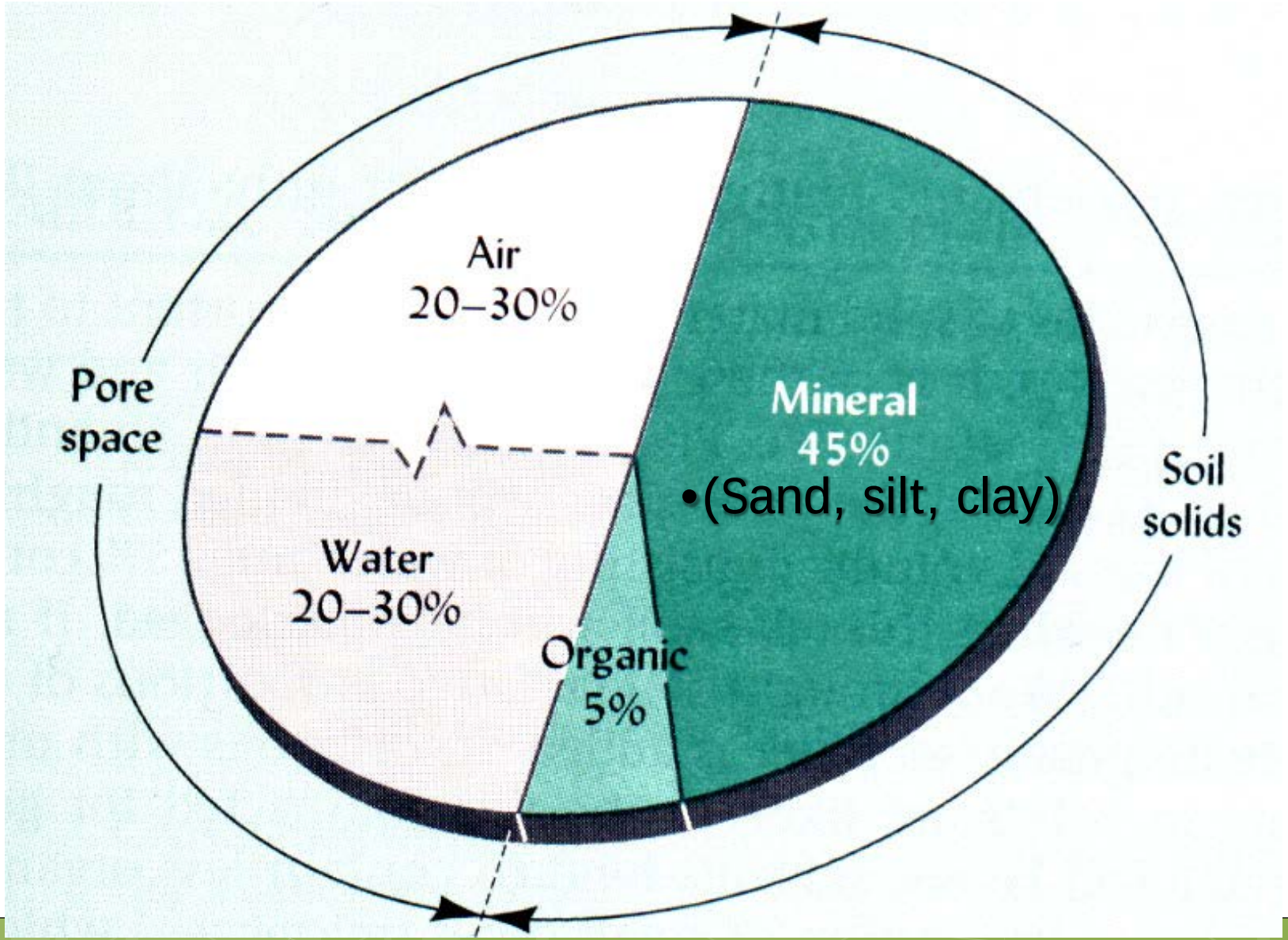
A system of soil health

Physical soil health



Gaugin, *Landscape with Three Figures*

The four components of soil:



Clay is a secondary mineral

- formed at normal surface temperatures and normal surface pressures
- The product of dissolution and recrystallization

Sand

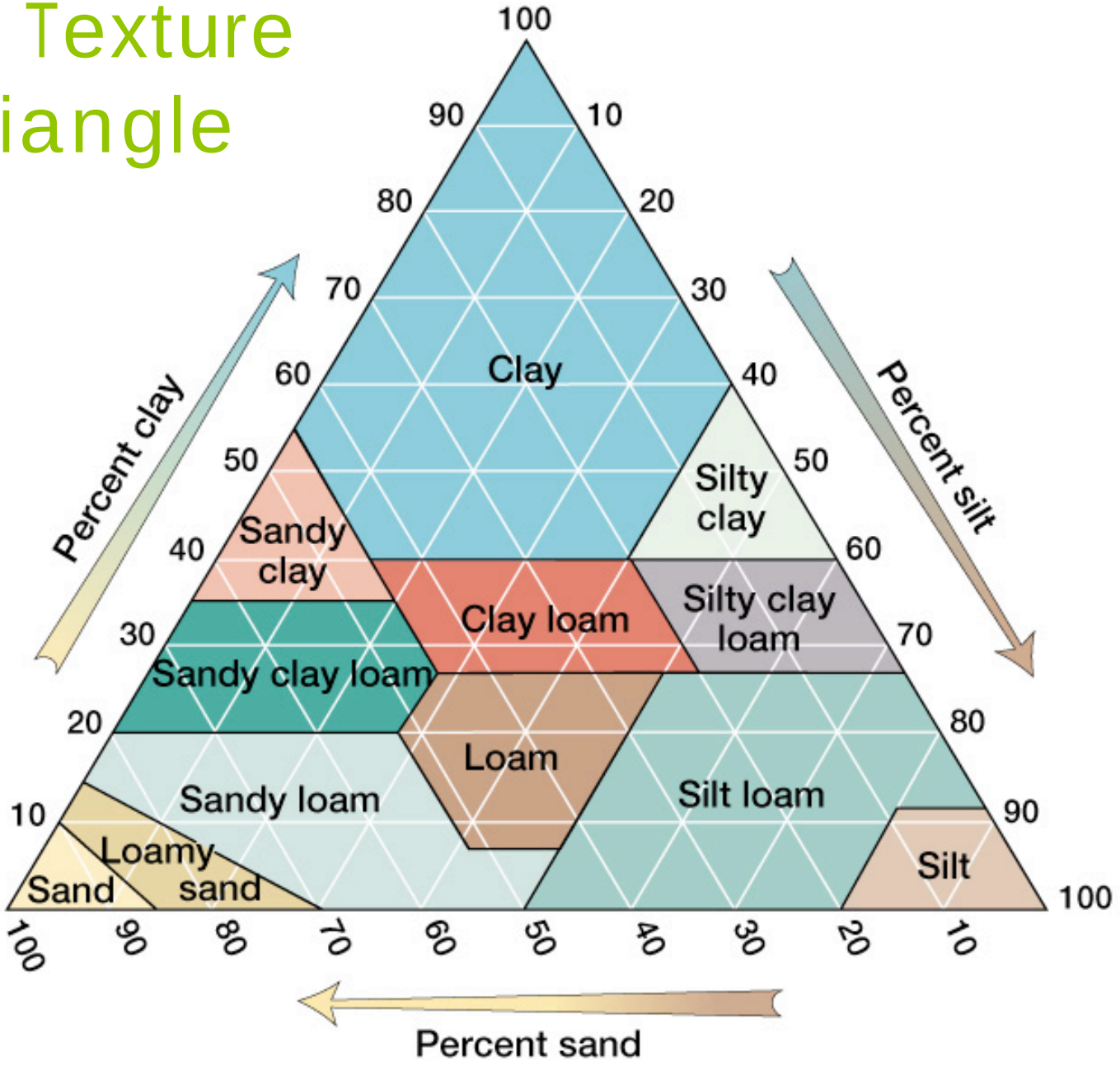
Silt

Clay

Physical soil health – relative particle & biology sizes

Component	Size (um)	X1000
Clay	1	Coarse sand grain
Silt	10	Blueberry
Bacteria	25	Ping pong ball
Amoeba	100	Saucer
Nematodes	150 x 2500	6” x 10’ pipe
Sand	500	Beach ball
Earthworm	3,000 (diameter)	Light rail train

Soil Texture Triangle

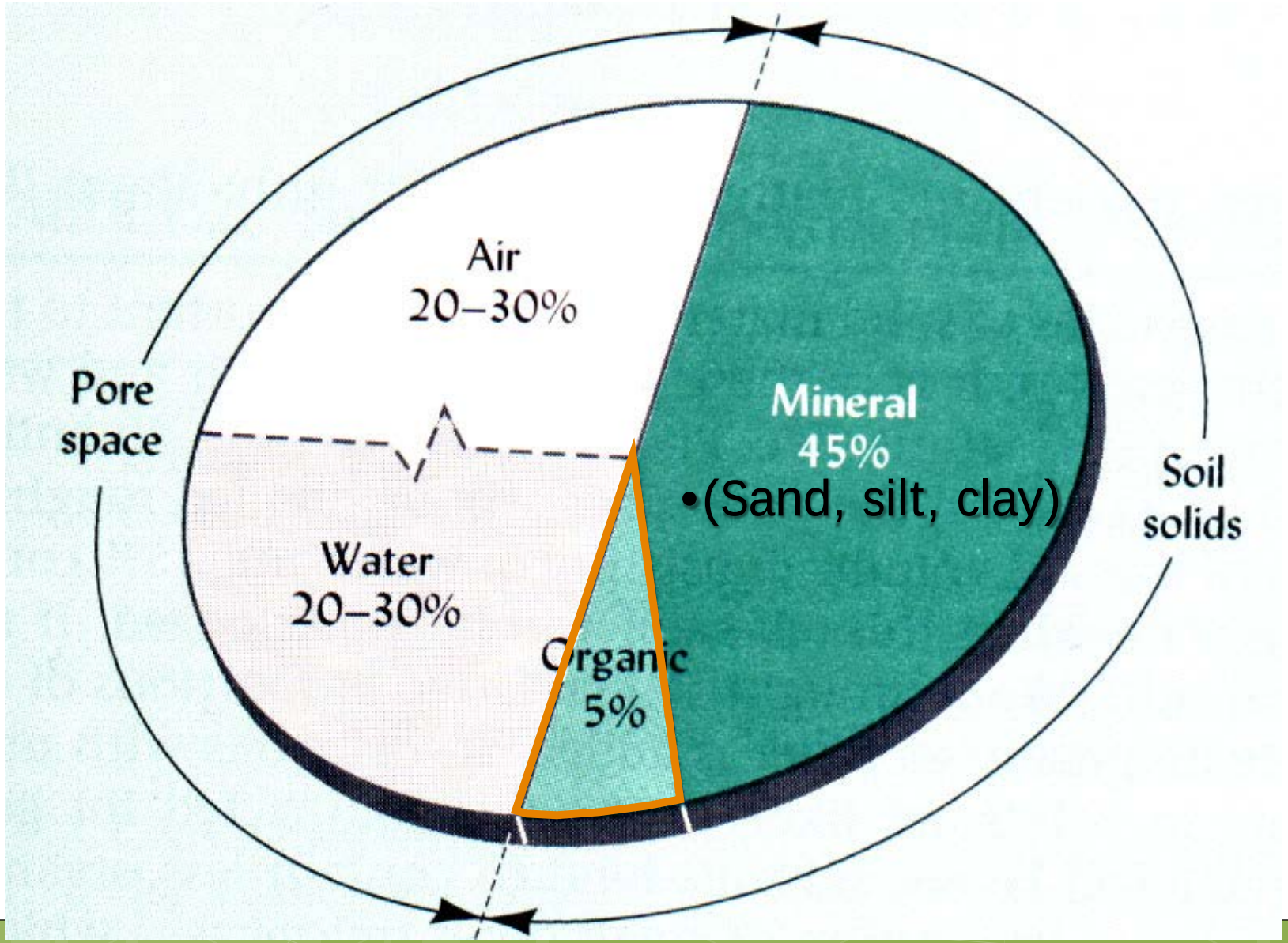


Soil Texture Demonstrations

Soil Health – Physical properties

- Improving soil health, often with the addition of Organic Matter:
  - Improve soil drainage and water infiltration / absorption
  - Improve aggregate stability (resistance to disturbance and compaction)

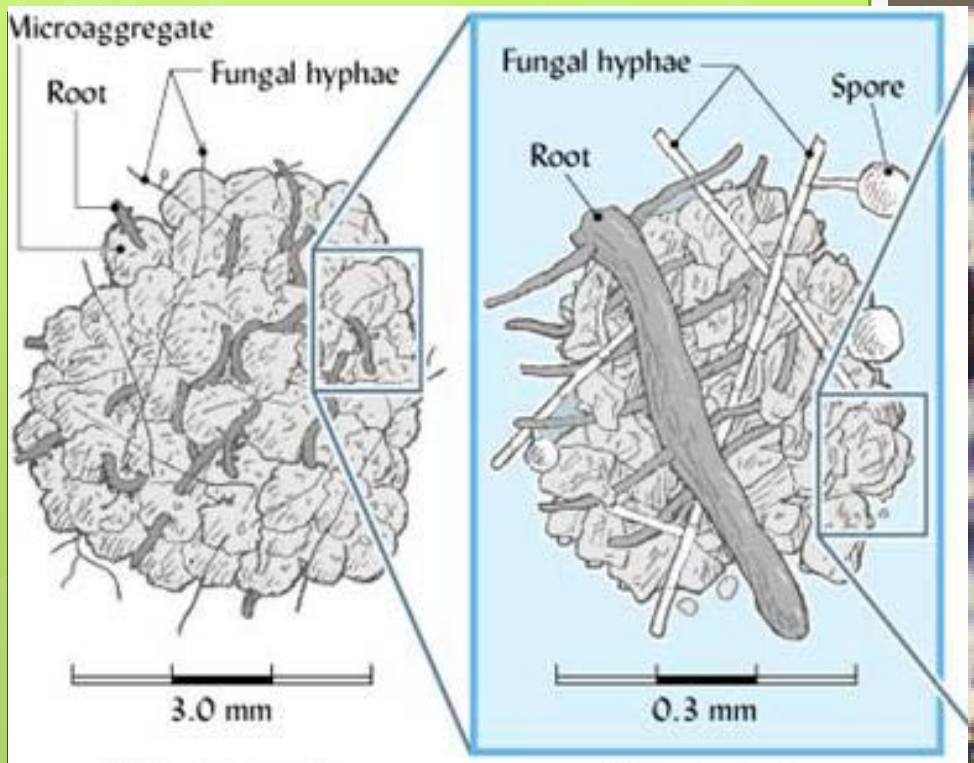
What is Organic Matter?

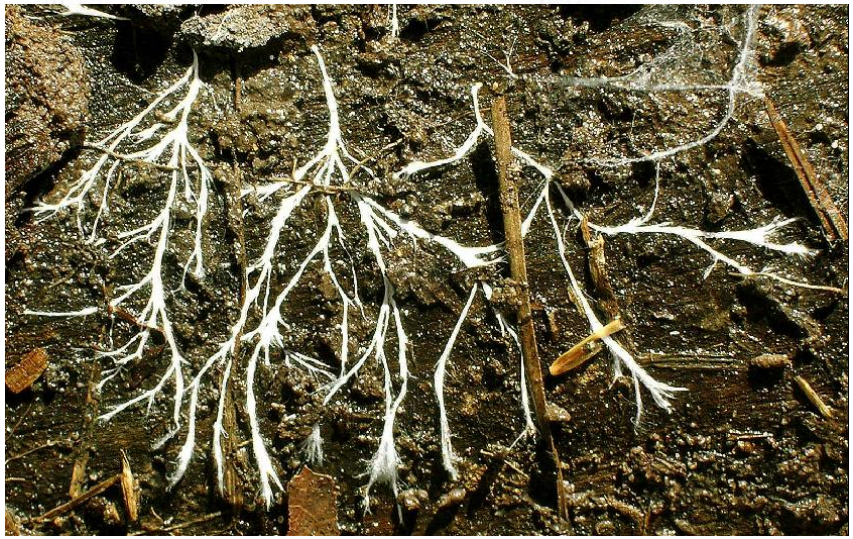


Physical soil health - stability

- Aggregate stability is good:
  - Equipment support
  - Water infiltration
  - Air infiltration
  - Root growth

Let's get a closer look...

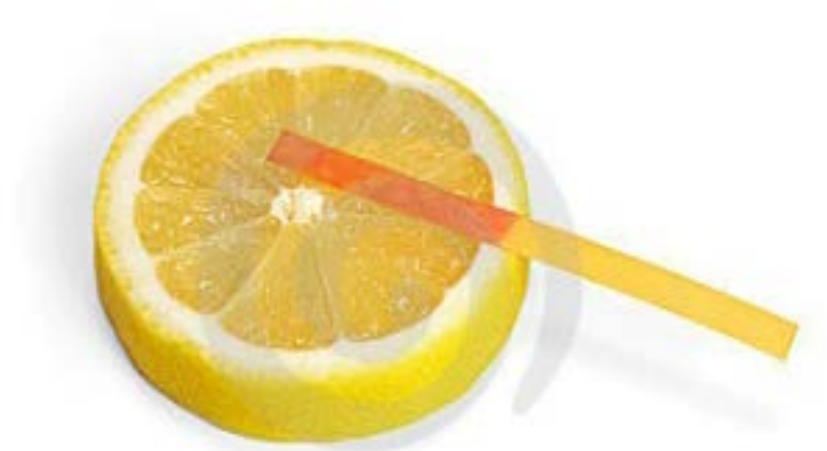

Microaggregate
Root
Fungal hyphae
3.0 mm
Fungal hyphae
Spore
Root
0.3 mm



Chemical soil health

Milton Avery

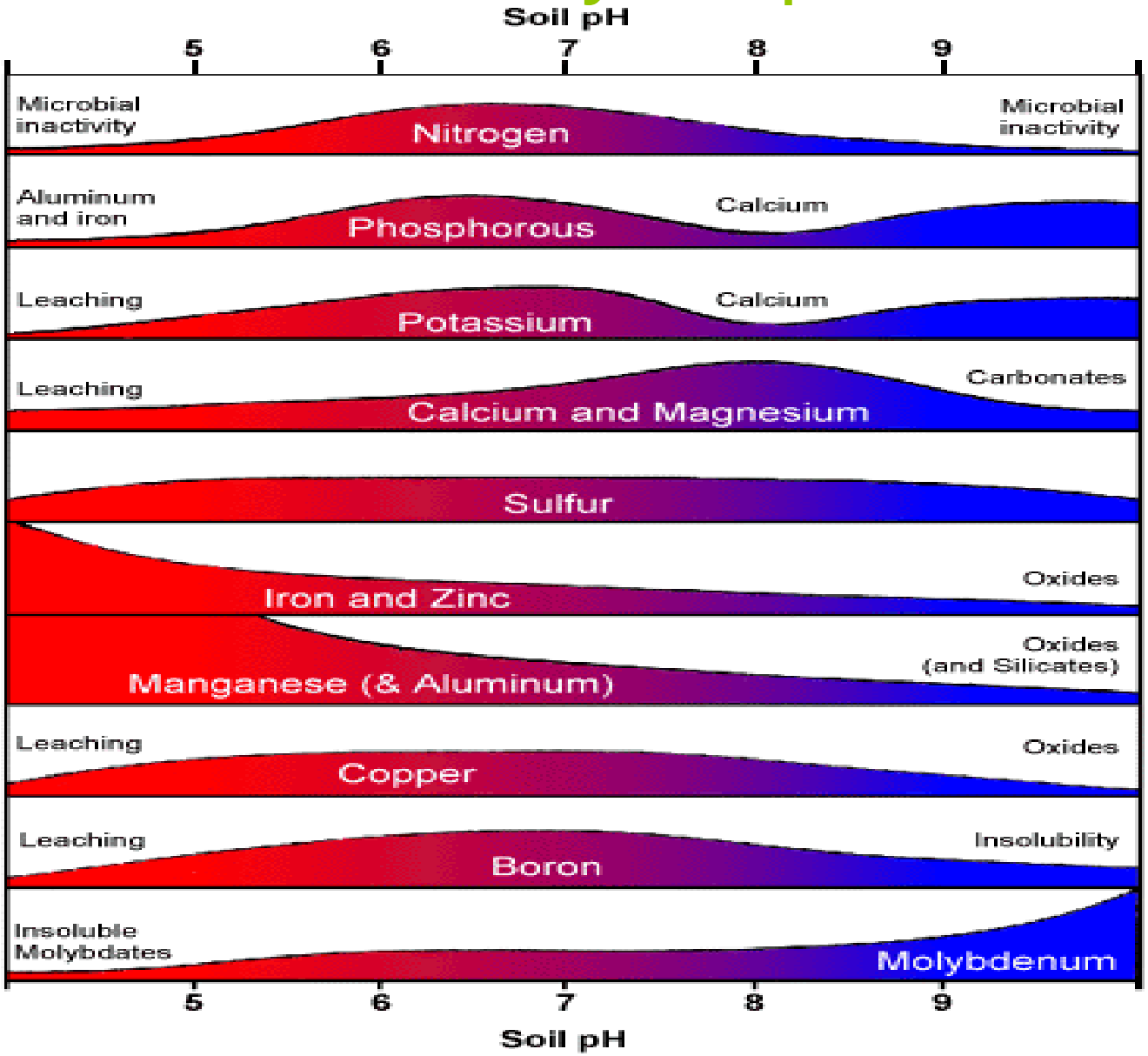
Chemical soil health: pH



As in life, moderate pH is good:

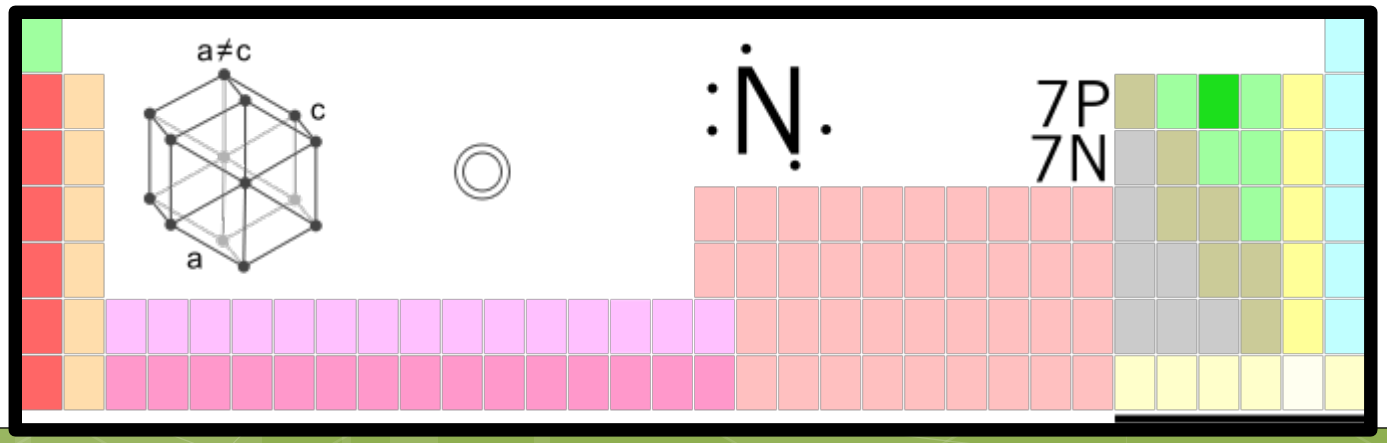
- Nutrient availability.
- Microbial growth.
- Pesticide effectiveness.
- Aluminum toxicity.
- Heavy metal mobility.

Nutrient availability vs. pH



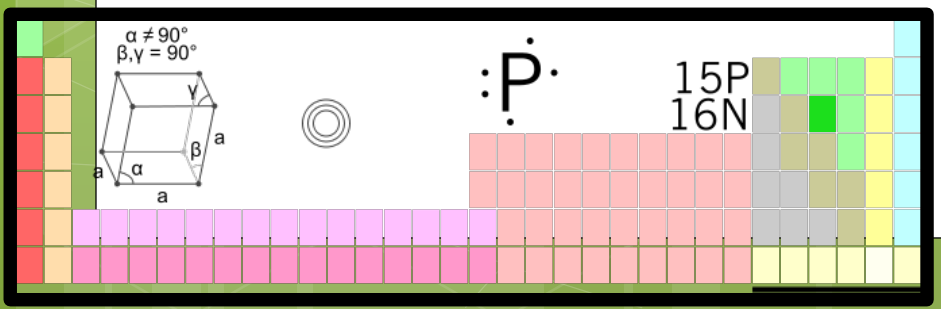
What's in soil? Nitrogen

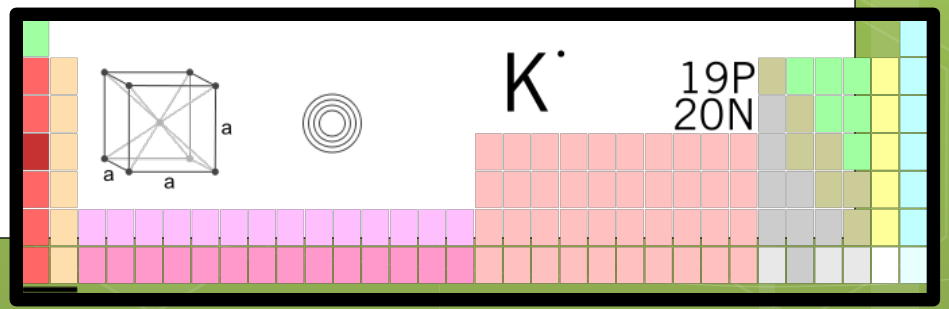
- The most commonly limiting nutrient.
- Cycle is complicated, but:
  - Unmanured McBee silty clay loam = 4200 lb/ac.
  - Manured McBee = 6400 lb/ac.
- Most of N is in old organic matter (humus) with a half-life of hundreds or thousands of years. (Soil testing for N usually not effective)



What's in soil? Phosphorus and Potassium

- Phosphorus (P): reported on soil tests as mg/kg P. Fertilizer is sold as P_2O_5.
- Potassium (K): reported on soil tests as mg/kg K. Fertilizer is sold as K_2O.
- Soil tests for P and K are "indices." There is much more P and somewhat more K in the soil than the soil tests indicate.





Humus versus hummus

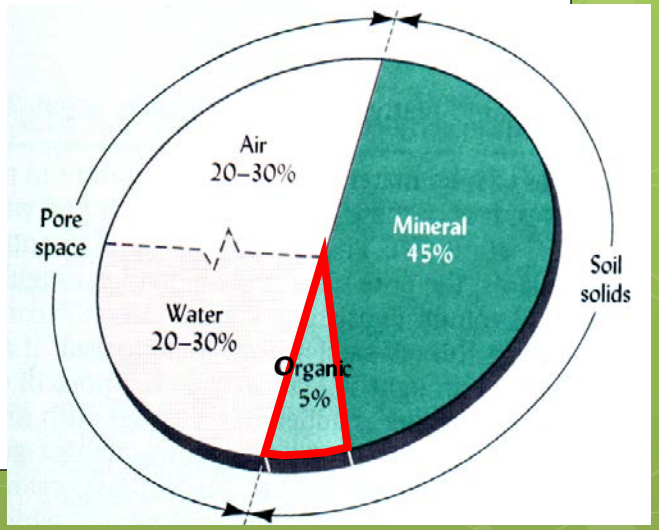
- Hans Jenny: “Humus is imperfectly understood.”
- Very complex, very long organic compounds that are resistant to decay.
- C:N is approximately 10:1.
- James Rice: “It is very possible that no two humus molecules are or have ever been alike.” Just like snowflakes or people.

Functions of Organic Matter

1. **Carbon and energy** - for soil organisms

2. **Provides nutrient storage!** – negative charge – twice that of clay!

3. **Structure** - Stabilizes soil structure, making soil easily managed – **SOIL GLUE!**



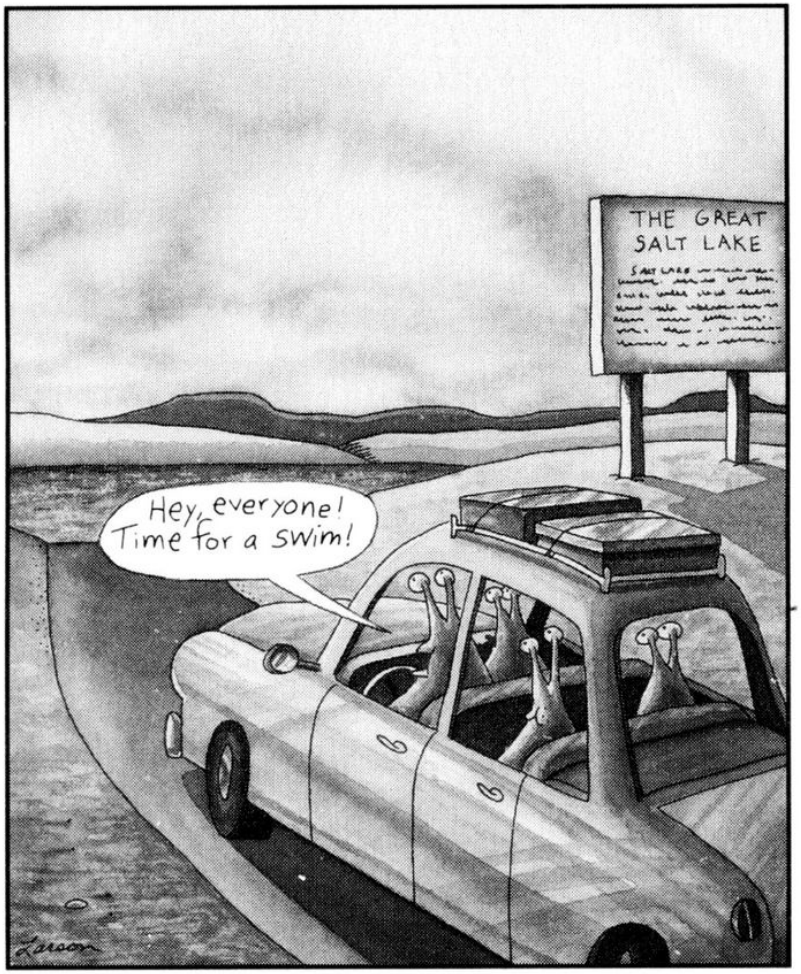
Biological soil health

Soil IS Habitat

Schiros, *Roots*

Soil health and biology

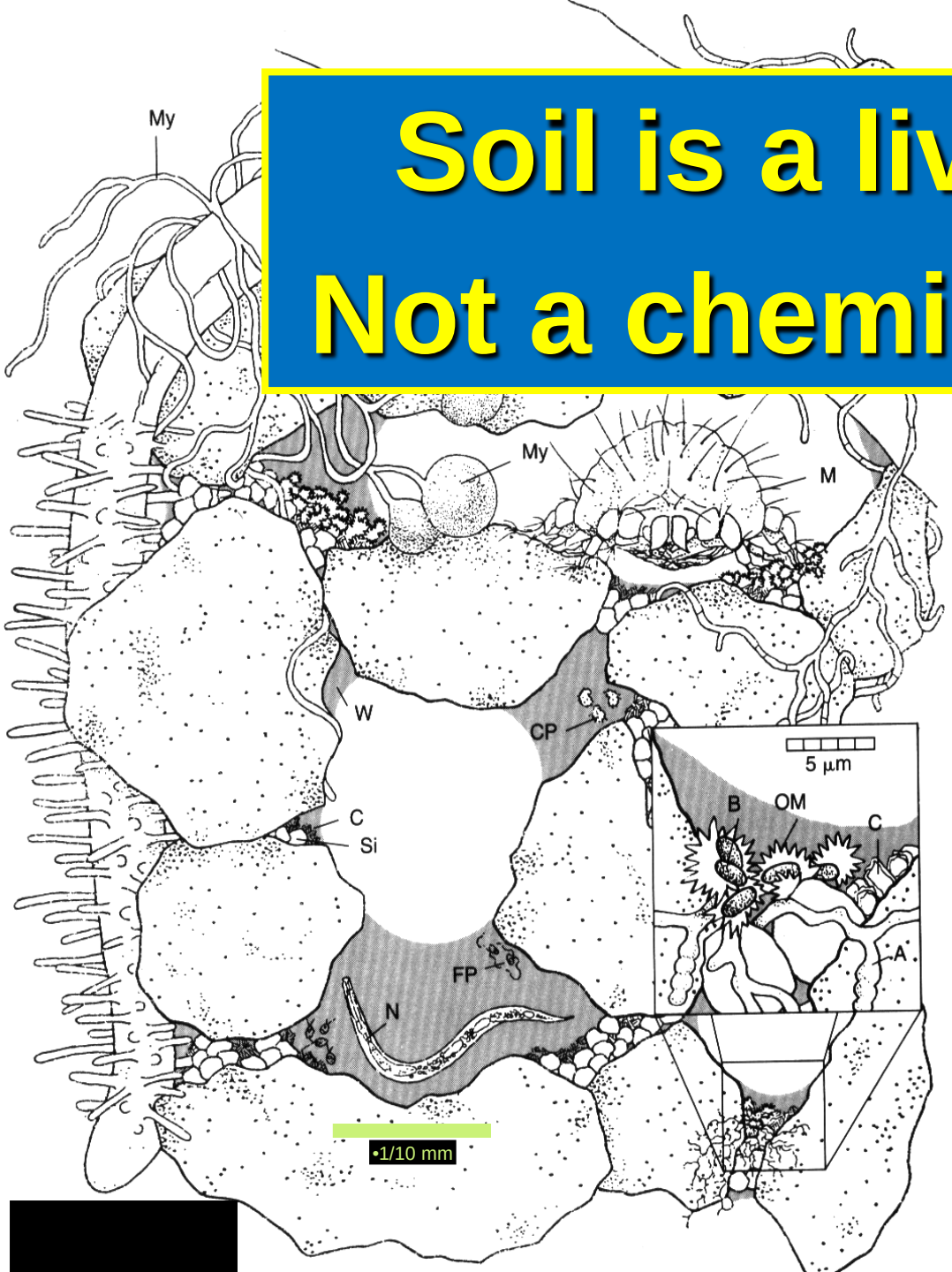
- One gram of soil contains:
  - One billion bacteria.
  - Miles of fungal hyphae.
  - And maybe a slug egg or two.



Slug vacation disasters

Soil is a living thing!

Not a chemical sponge!

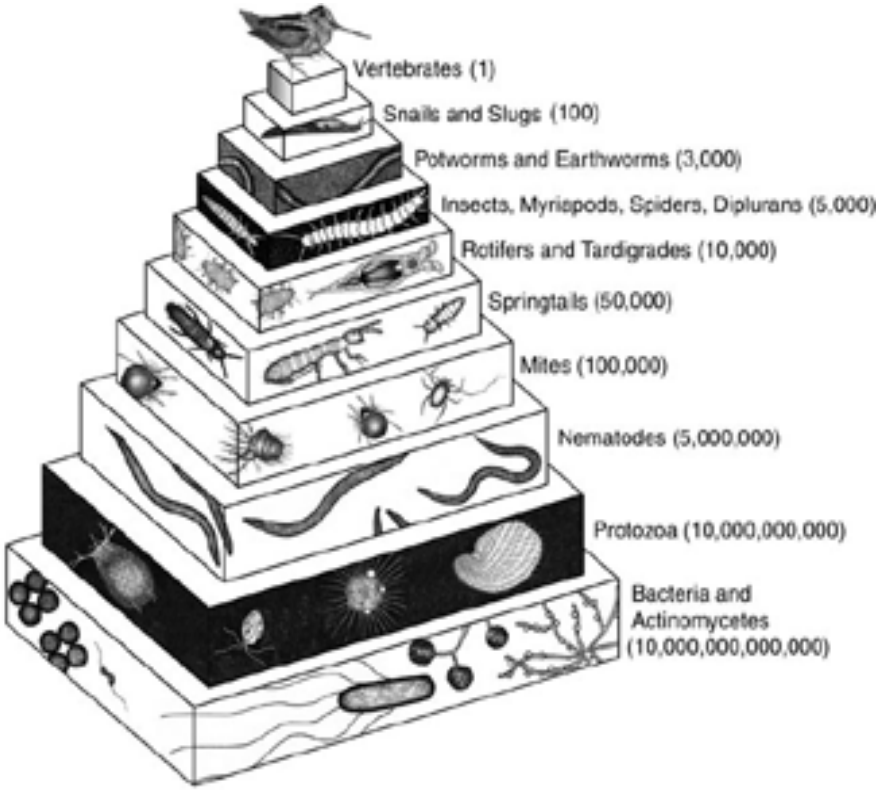


- **B – Bacteria**
- **A – Actinomycetes**
- **My – Mycorrhizae**
- **H – Saprophitic fungus**
- **N – Nematode**
- **CP – Ciliate protozoa**
- **FP – Flagellate protozoa**
- **M – Mite**

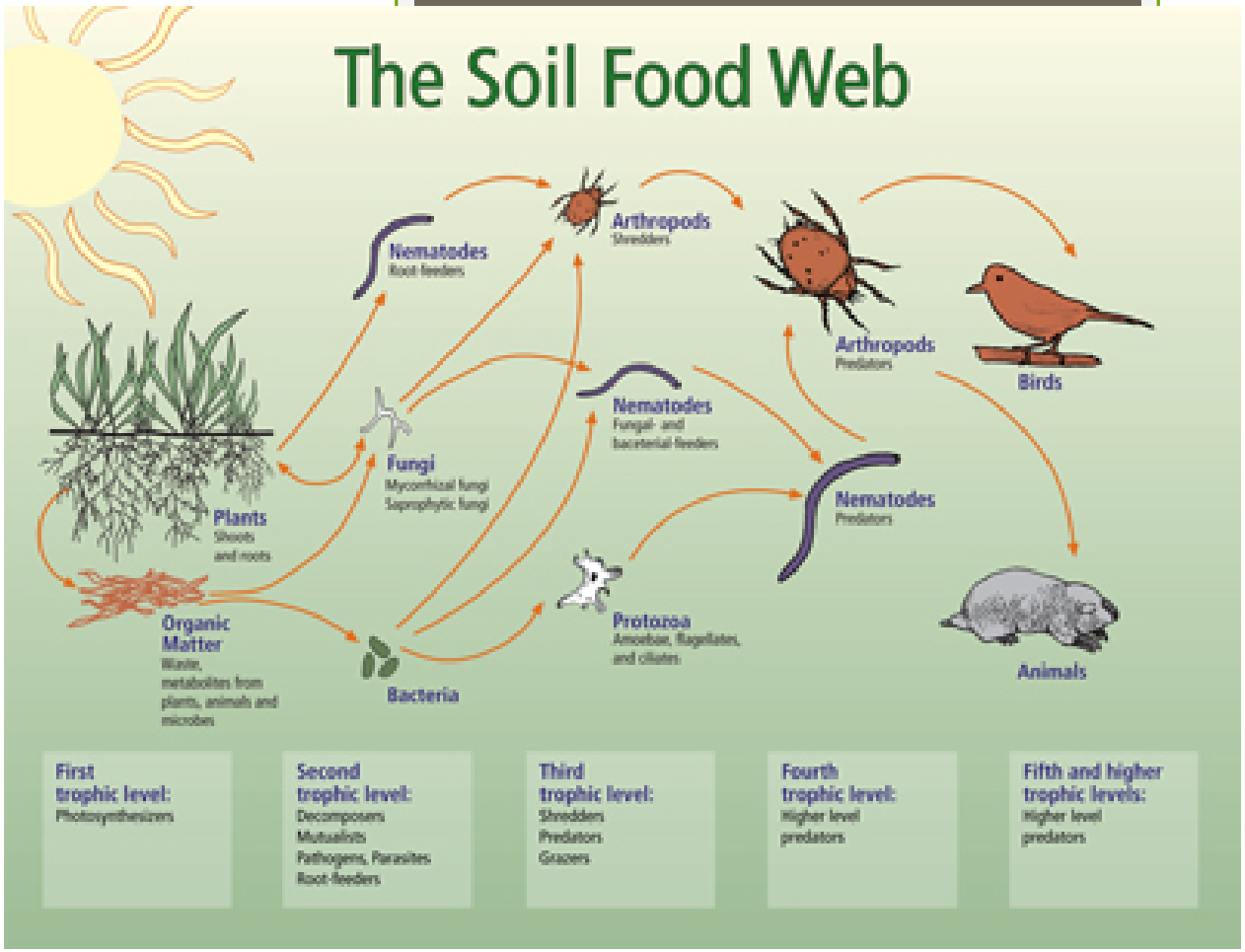
- **< 1mm**

The Soil Team

- Ecosystem engineers: earthworms and ants.
- Litter transformers: collembolas and mites.
- Micro-food webs: bacteria, fungi, nematodes, protozoa.



A great soil food web illustration



Available from NRCS with a soil food web glossary at http://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/soils/health/biology/?cid=nrcs142p2_053868 (all links on our website and in your materials!)

Earthworms

- Some species accidentally introduced by European settlers.
- Break down organic matter and create pores.
- Worm castings are incredibly rich in microbial nutrients.
- Can turn over 30 tons of soil per acre in a year!

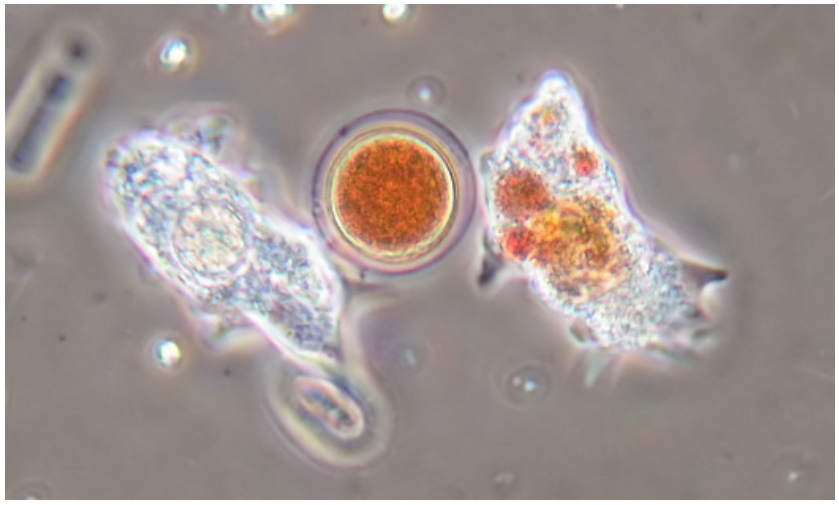
Nematodes

- Approximately 80% of the animals on earth are nematodes!
- Different species eat:
  - Insects
  - Plants
  - Organic matter
  - Microbes

Microarthropods

- Collembolas and mites.
- Can be >100,000 per square yard.
- Eat litter, fungi, nematodes.
- Are eaten by spiders, beetles.

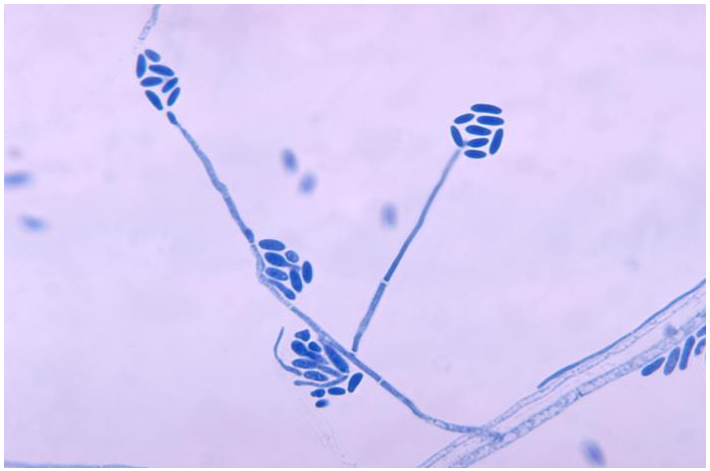
Protozoa



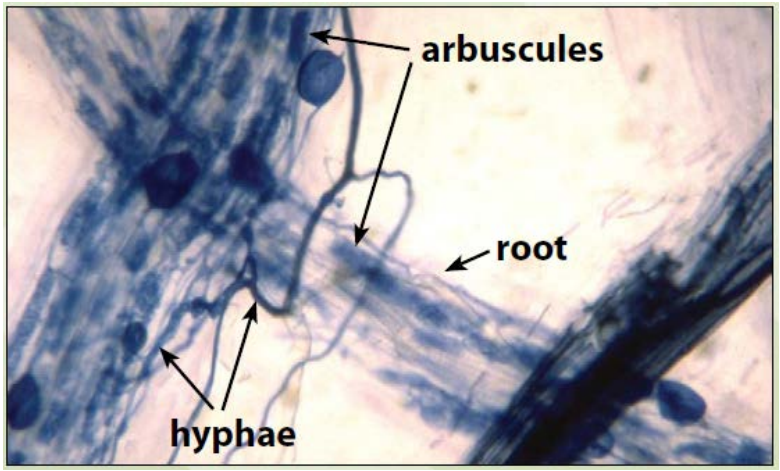
- Amoebae, flaggelates, ciliates.
- Generally graze on bacteria.
- Can consume one or more “crops” of bacteria each year.
- Release nitrogen, other minerals, and may release root stimulating compounds.

Fungi

- Grow through the soil with hyphae.
- Very efficient at decomposing complex organic matter (lignin).
- Fungi : bacteria ratio:
  - Conifer forest > 10:1
  - Cropland < 1:1
  - Most productive cropland ~ 1:1



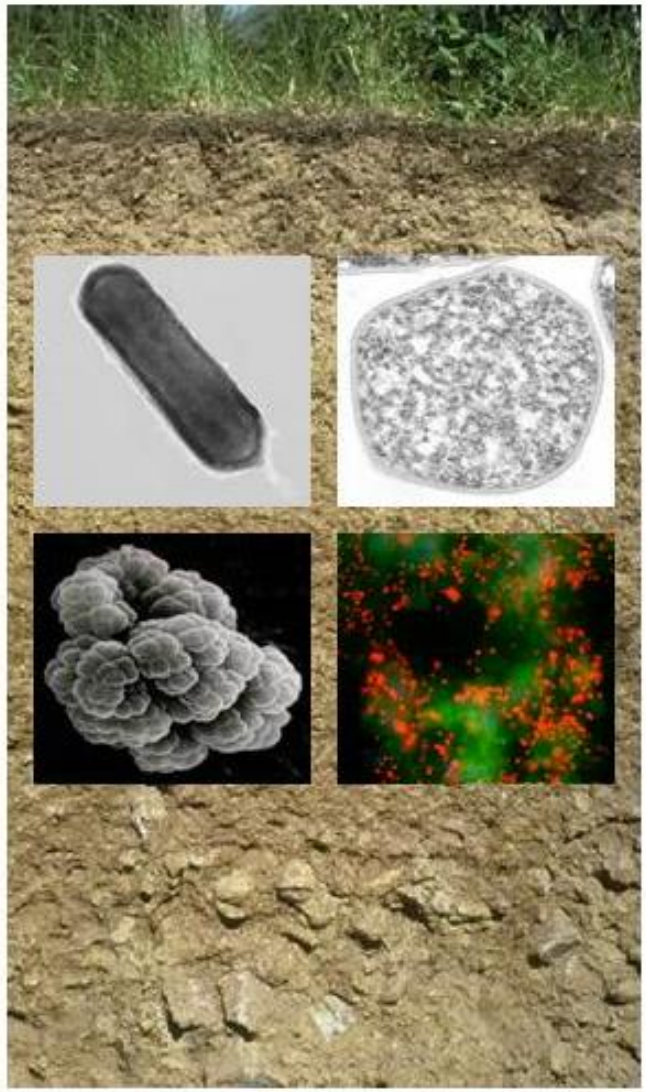
Mycorrhiza



- Fungi-plant symbiosis
- Vesicular-arbuscular found on >70% of plants.
- Ectomycorrhizae more common on trees, especially boreal.
- Mustards and buckwheats: no.
- Adding mycorrhizae? Mixed results.

Bacteria and Archaea

- Prokaryote carbon = plant carbon.
- Prokaryote nitrogen = 10x plant nitrogen.
- Influenced greatly by soil environment (temperature, moisture, tillage, oxygen).
- Often live on clay particles or inside aggregates.



Soil Compaction & Infiltration Demonstration

- Head outside

Break between presentations

Soil Health for School Gardens: How to Protect and Improve it

Laura Taylor
WMSWCD Conservation Technician
& Education Coordinator

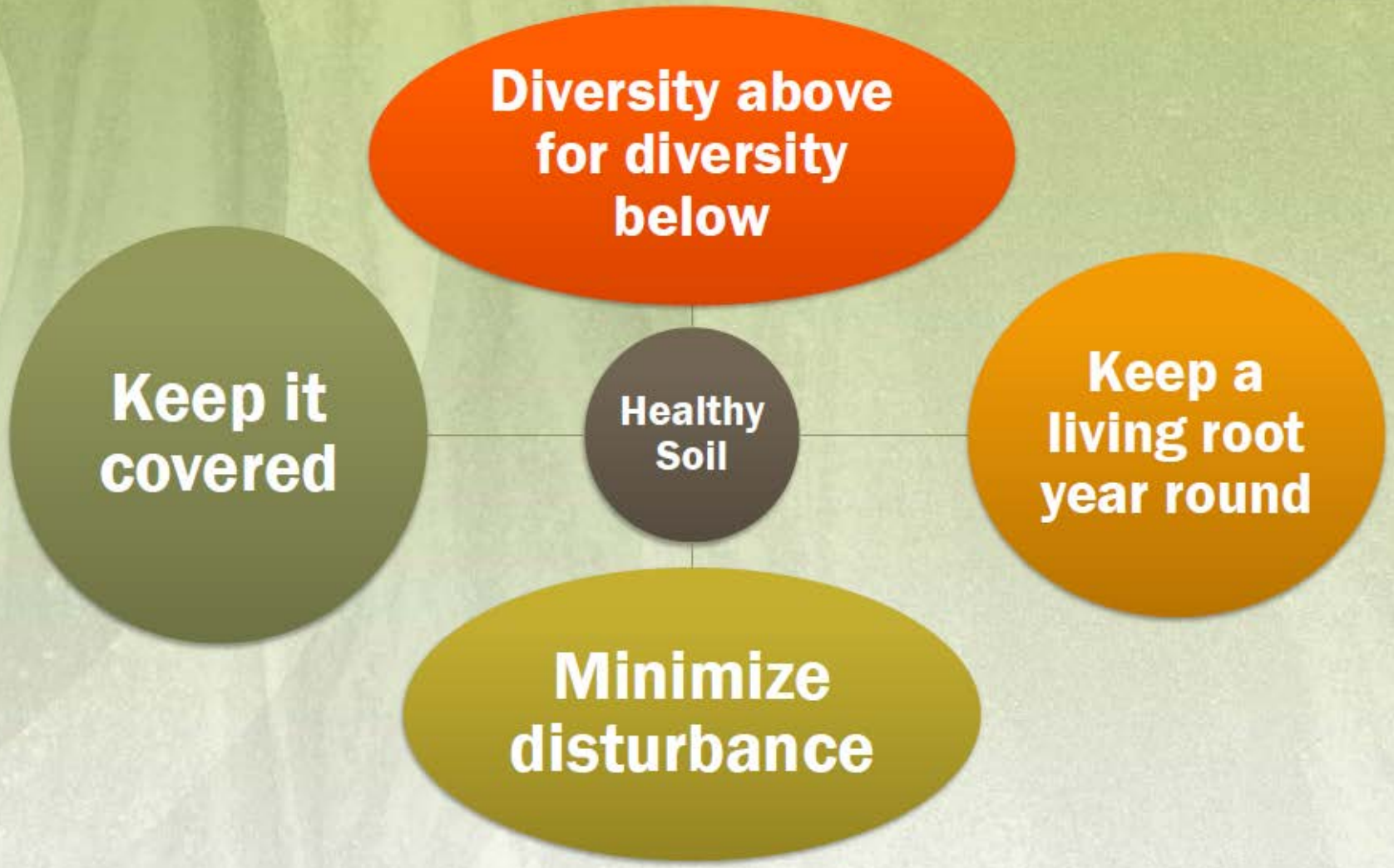
Building soil health

Jean Francois Millet , *Two Men Turning the Soil*

Why Build Soil Health?

- Healthier plants
- Increased plant nutrients
- Less watering
- Less weeding
- Less erosion
- Improved water infiltration
- Build carbon in the soil
  - Reduce greenhouse gasses in the atmosphere

NRCS Soil Health Principles



Cover Crops

Benefits:

- Add & conserve nitrogen
- Add organic matter
- Reduce soil erosion
- Weed suppression
- Improve soil structure
- Better water infiltration & storage capacity
- Improved soil biology
- Benefit pollinators

Cover Crops

How to:

- Plant in off-season
- Let it grow
- Cut ~ 1-2 weeks before planting
  - Leave as mulch or turn into soil
- Or pull up and compost
- Plant your veggies

Warning:

- Don't let it go to seed
- Avoid weedy species

Cover Crops

Recommendations:

<u>Winter</u> (plant in Sept)

- Winter wheat, barley
- Fava beans
- Common vetch
- Phacelia

<u>Summer</u> (plant mid spring)

- Buckwheat
- Sunflower
- Millet

Available from most urban farm stores

Mulching and Composting

Benefits:

- Control weeds
- Reduce soil erosion
- Build organic mater in the soil
- Reduce soil temperature
- Improve moisture control
- Add nutrients (compost)
- Soil biology

Warning: avoid weed seeds! “Hay is for horses”

Mulching and Composting

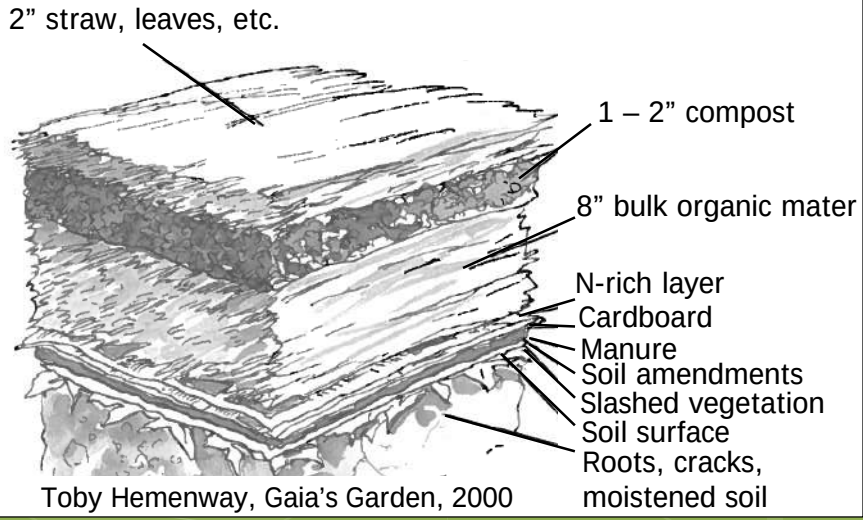
Keep it Covered

Grow your Own:

- Leaf litter
- Landscaping debris (trimmings)
- Food waste compost, worm bin

Other options:

- Chip Drop
- Sheet mulching



Toby Hemenway, Gaia’s Garden, 2000

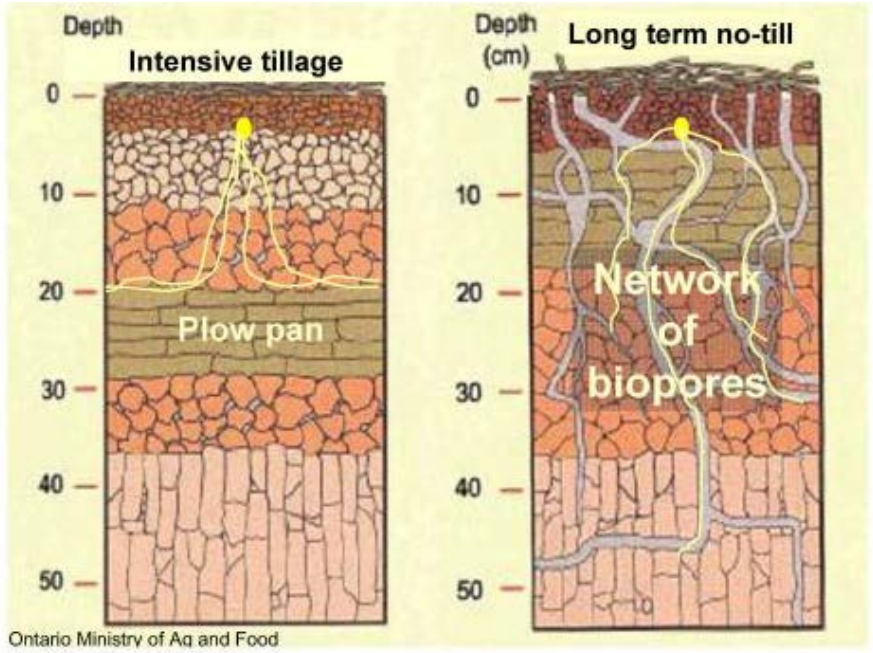
No or Low-Till Gardening

Staying on Paths

Minimize Disturbance

Benefits:

- Greater aggregate stability
- Increased water infiltration & retention
- Preserve organic mater
- Improve soil food web habitat



Organic Fertilizer

Diversity above & below

Recipe:

4 parts Seed meal (cotton, soy)

½ to 1 part Kelp meal

1 part Lime

1 part Bone meal

Benefits:

- More nutrients: Protects water quality
- Slow-release
- Improves soil biology
- Non-toxic

Photo by Matthew T. Stallbaumer complete organic fertilizer mix

Garden Symphylan

Resources

Books

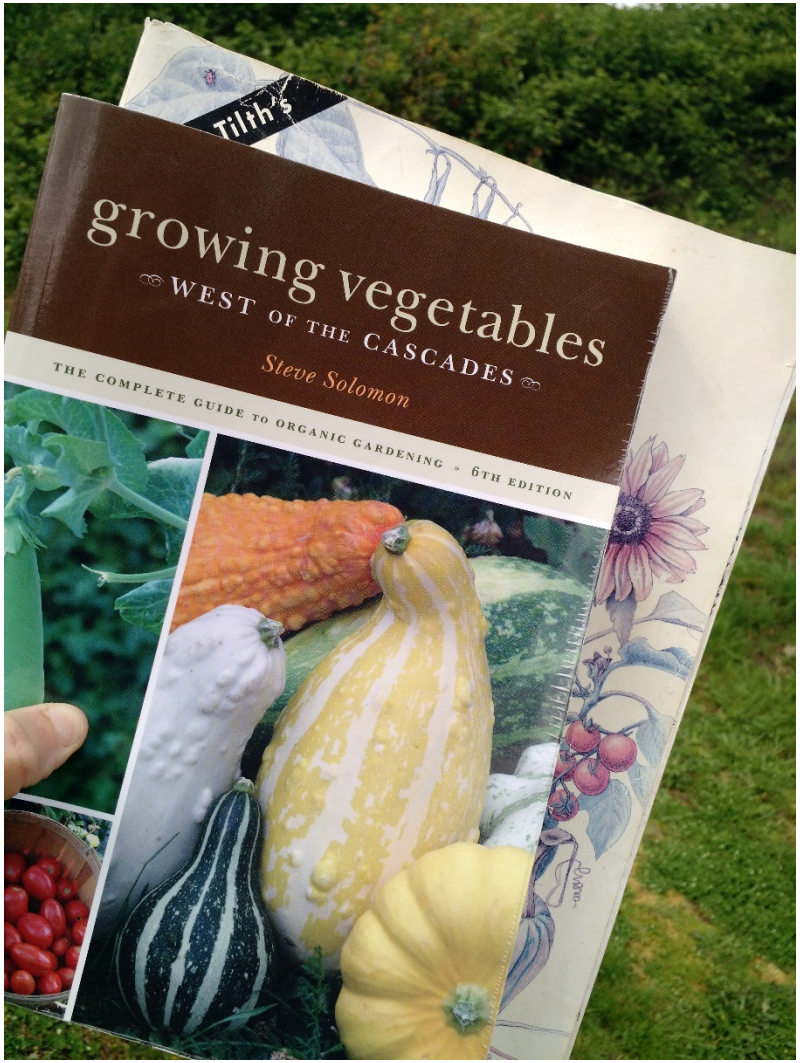
- Growing Vegetables West of the Cascades
  by Steve Solomon
- Maritime NW Garden Guide
  by Seattle Tilth

Materials

- www.Chipdrop.in for mulch
- Bike stores for cardboard

Web

- growgreatvegetables.com/
- Google group: Portland Farm & Garden Educators Network



Break between presentations

Soil Health for School Gardens: Teaching It

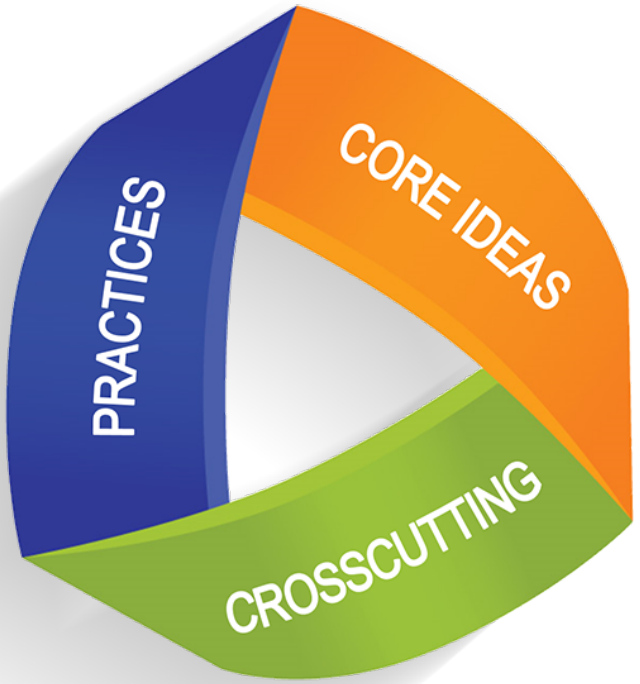
Rebecca Heuer
First Grade Teacher
Bilquist Elementary

Teaching Soil Health with Next Generation Science Standards

Practices

- Observations

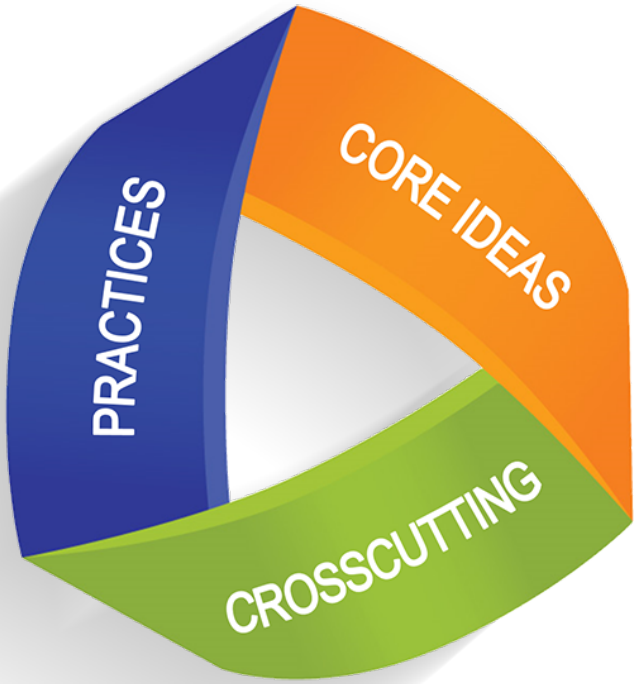
1. Asking questions, defining problems
2. Models
3. Investigations
4. Data
5. Math, computation
6. Explanations
7. Argument from evidence
8. Information



Teaching Soil Health with Next Generation Science Standards

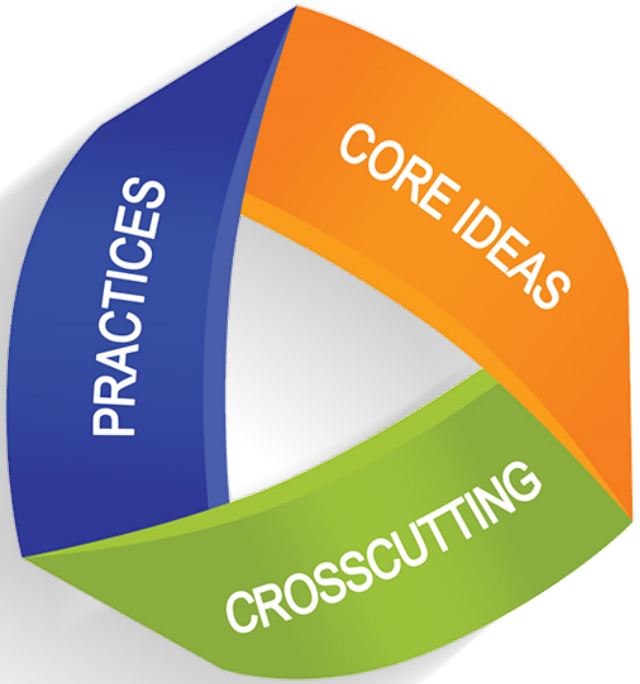
Crosscutting Concepts

1. Patterns
2. Cause and effect
3. Scale, proportion, and quantity
4. Systems
5. Energy and matter: flows, cycles, conservation
6. Structure and function
7. Stability and change



Teaching Soil Health with Next Generation Science Standards

Core Ideas applicable to Soil Health



Physical Science

PS 1: Matter and its interactions

PS 3: Energy

Life Science

LS 1: Molecules to organisms

LS 2: Ecosystems

LS 4: Biological evolution

Earth & Space Science

ESS 2: Earth's systems

ESS 3: Earth & human activity

Engineering & Technology

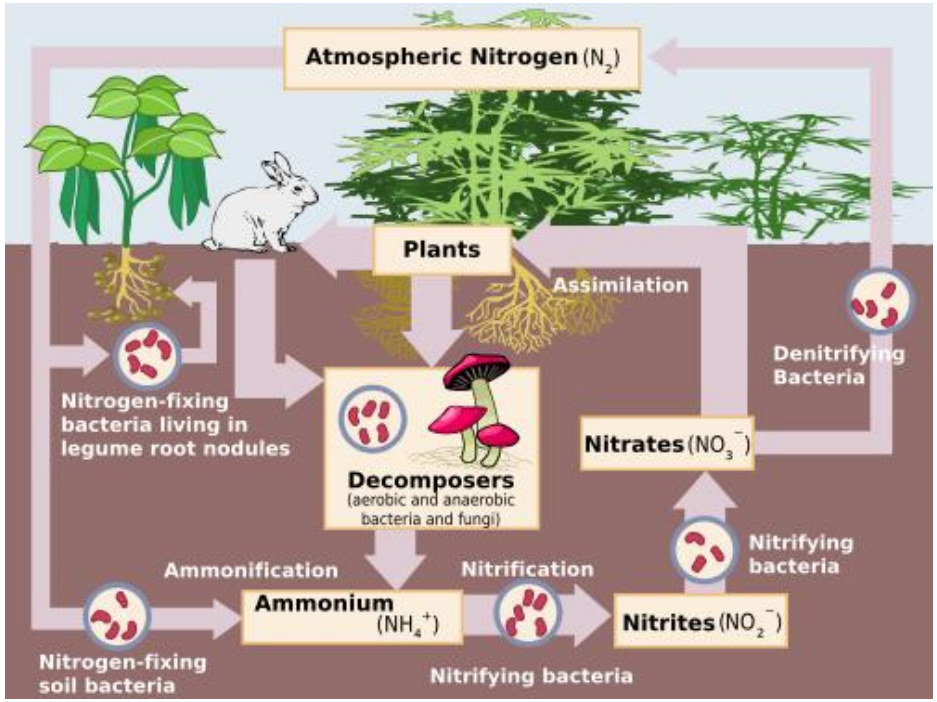
ETS 1: Engineering design

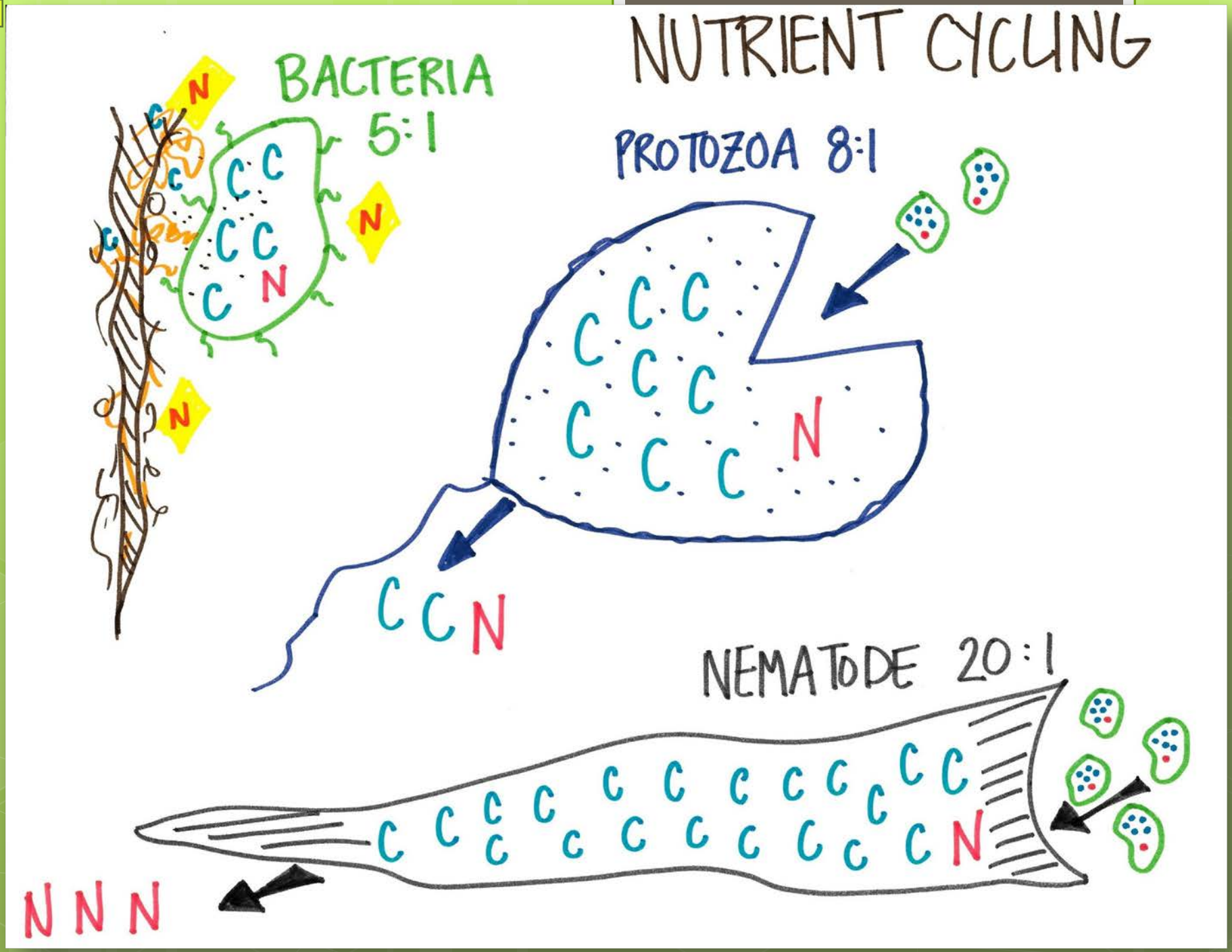
ETS 2: Links among engineering technology, science & society

Teach... Nutrient Cycles

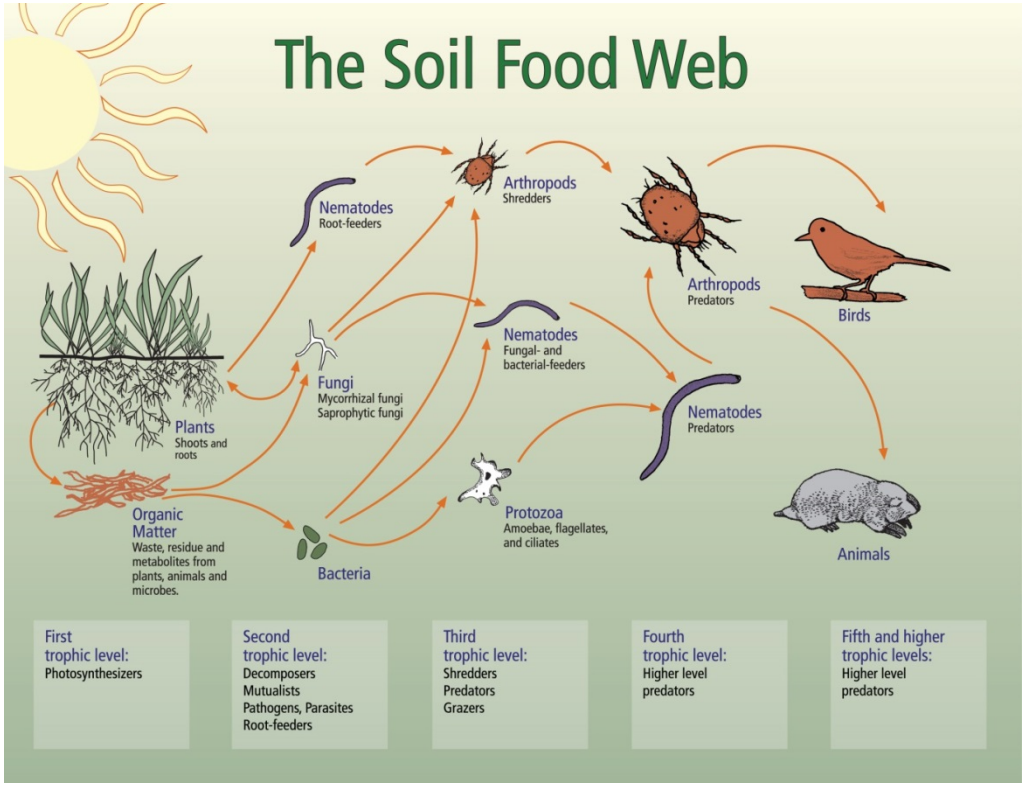
NGSS elements supported:

- Developing & using models
- Using mathematics
- Systems and system models
- Mater flows, cycles, conservation
- Mater & its interactions
- Molecule to organism: structure & processes
- Ecosystems: interactions, energy, dynamics
- Earth & human activity

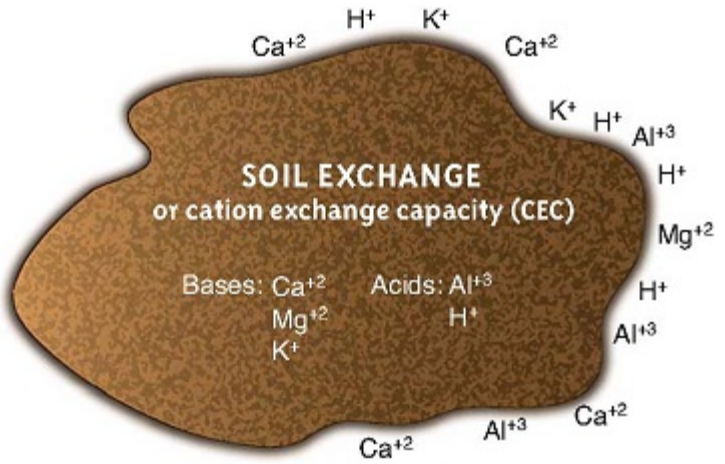


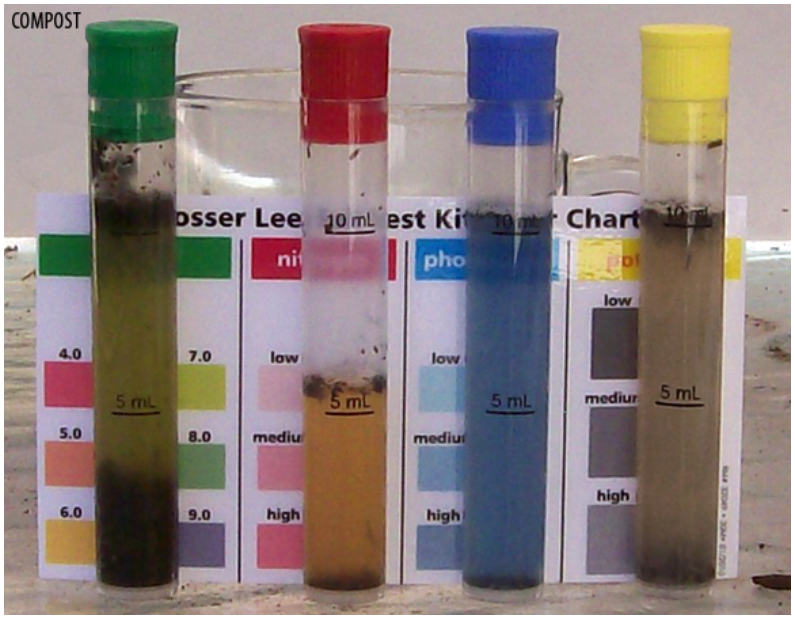

NUTRIENT CYCLING
BACTERIA
5:1
PROTOZOA 8:1
NEMATODE 20:1
N N N

Teach... Soil biology

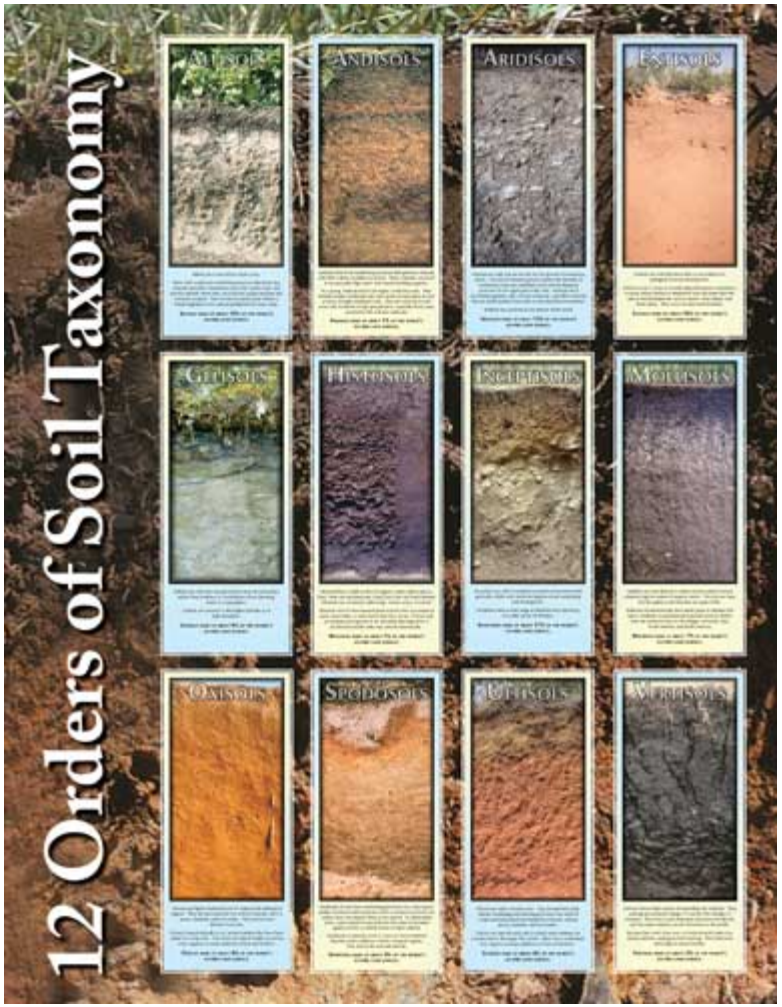


Teach...
Soil chemistry



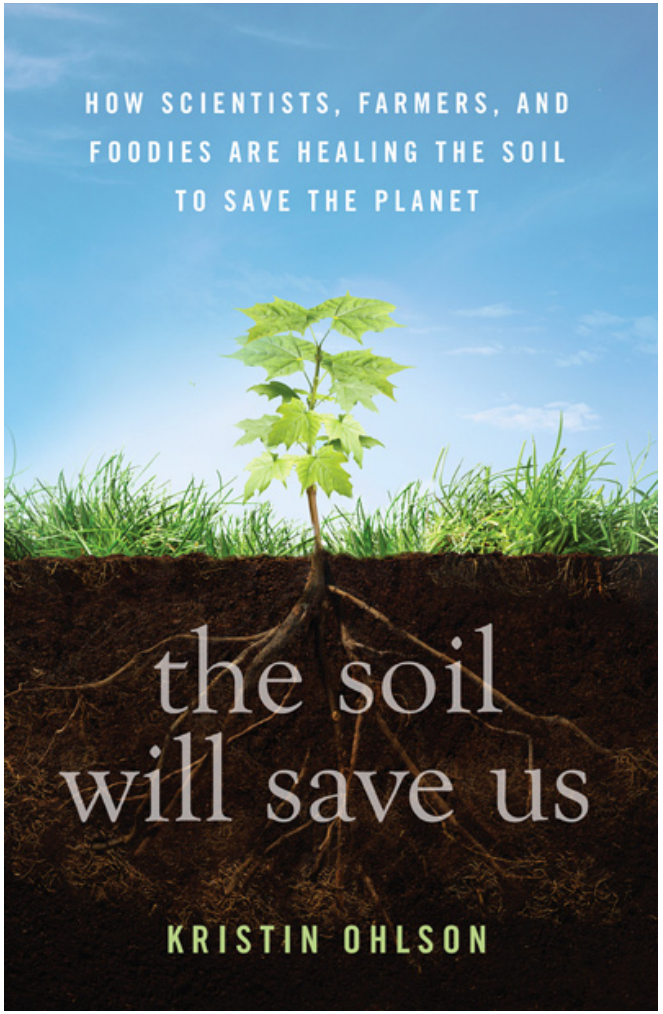


Teach... Physical properties of soil



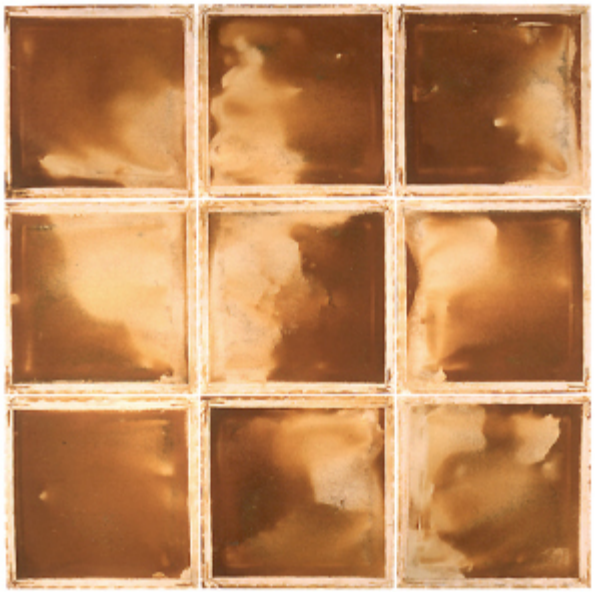
Connect to…
Social sciences

Connect to…
Global Climate Change



- 80 billion tons of carbon lost from the soil due to poor ag practices so far.
  - 30% of annual CO_2 emissions
- Good soil health practices have the capacity to offset all annual human-caused CO_2 emissions on < 11% of world cropland!
  - We can even reduce our "legacy load" – the carbon already in the atmosphere

Connect to…
Arts



Questions?

Please complete your evaluation form and return it to the registration table

Laura Taylor, Education Coordinator

West Multnomah Soil & Water Conservation District

503-238-4775 x112 **Laura@wmswcd.org**

www.wmswcd.org

Thanks

Tualatin Soil & Water Conservation District

GRAY FAMILY FOUNDATION