SOIL SCIENCE

TERMS

Fauna- animal life
Biology- the science of life and living matter

Learning Objectives

- Understand how soils form
- Understand soil characteristics and how they effect crop growth
- Learn why and how to take soil samples, what to test for and what to do with the results
- Learn how to manage for healthy soil ecosystems, increased fertility, and sustainable crop production

How is soil formed?

The formation of soil happens over a very long period of time. It can take 1000 years or more. Soil is formed from the weathering of rocks and minerals. The surface rocks break down into smaller pieces through a process of weathering and is then mixed with moss and organic matter. Over time this creates a thin layer of soil. Plants help the development of the soil. How? The plants attract animals, and when the animals die, their bodies decay. Decaying matter makes the soil thick and rich. This continues until the soil is fully formed. The soil then supports many different plants

How Soils Form

Time
Parent Material
Biotic factors
Topography
Climate

Photo credit http://www.eoearth.org/article/Soil_forming_factors

Soil Forming Factors

Weathering is the breakdown of rock into smaller and smaller pieces. Two types of weathering are recognized.

- **Mechanical breakdown** is due to physical factors i.e. temperature, freezing and thawing patterns
- **Chemical breakdown** results from chemical reactions i.e. gypsum and limestone dissolve in water.

Five Factors that affect Weathering and How Soils are Formed

- **Time-** How long the soil has been forming
- **Parent Material-** rock, alluvium
- **Biotic factors-** plants, animals, microorganisms
- **Topography-** slop position, aspect shape and amount
- **Climate-** temperature, moisture, seasonal distribution

See Video on these factors http://youtu.be/bTzslvAD1Es

Soil Toposequence: Moving from the ridge top to valley bottom, soil characteristics vary greatly.

The soil forming process is know as Pedogenesis and is a dynamic process that continues to evolve.

Soil Horizons

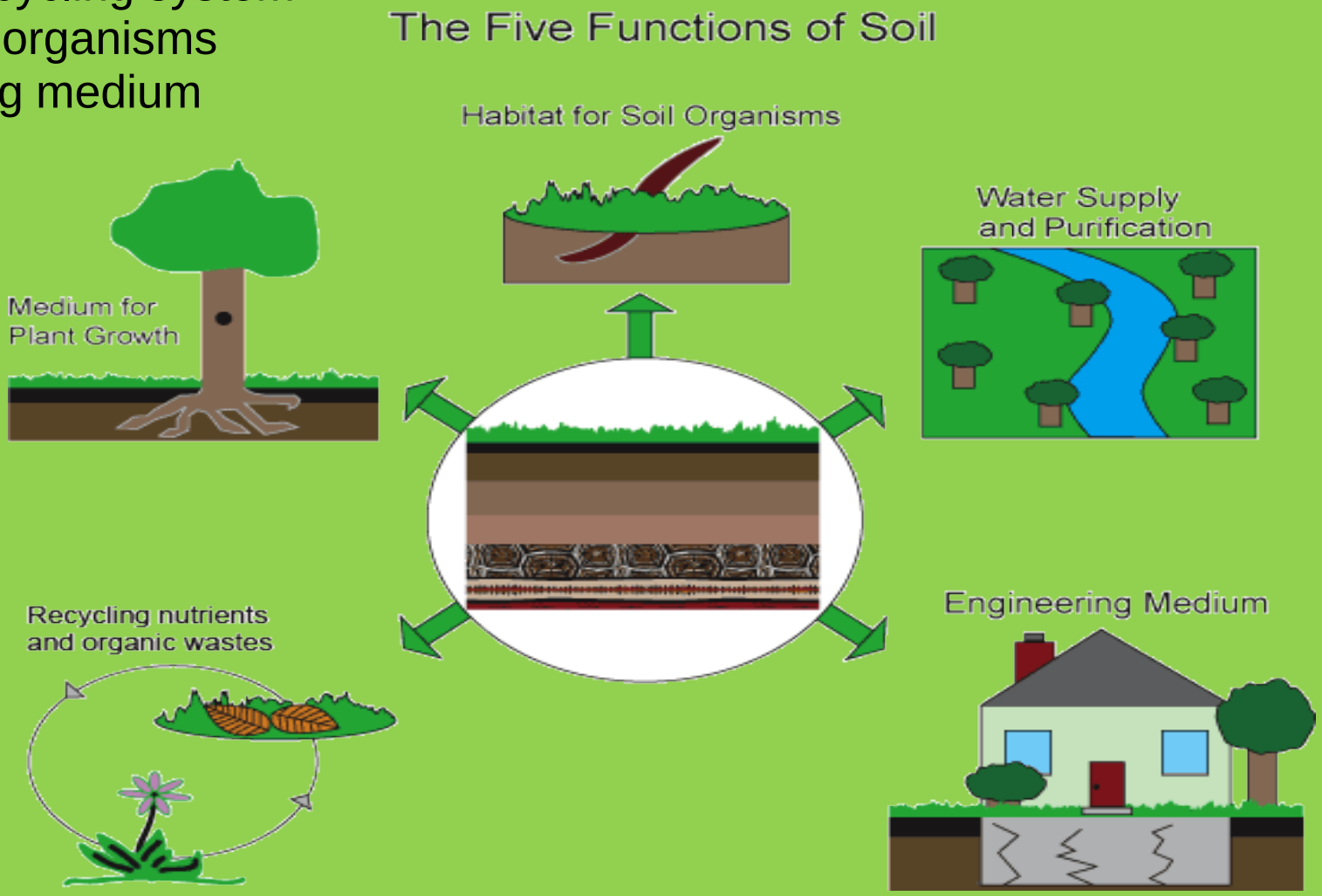
Soil consists of one or more distinct layers called horizons. Horizons are referred to as O,A,E,B,C and R depending on their position and nature.

VIDEO http://www.youtube.com/watch?v=YQhyMsisRD8

SING ABOUT IT: https://www.youtube.com/watch?v=gx2wVHeiTKE

Functions of Soil

1. Support growth of higher plants
2. Primary factor in controlling water
3. Natures recycling system
4. Habitat for organisms
5. Engineering medium

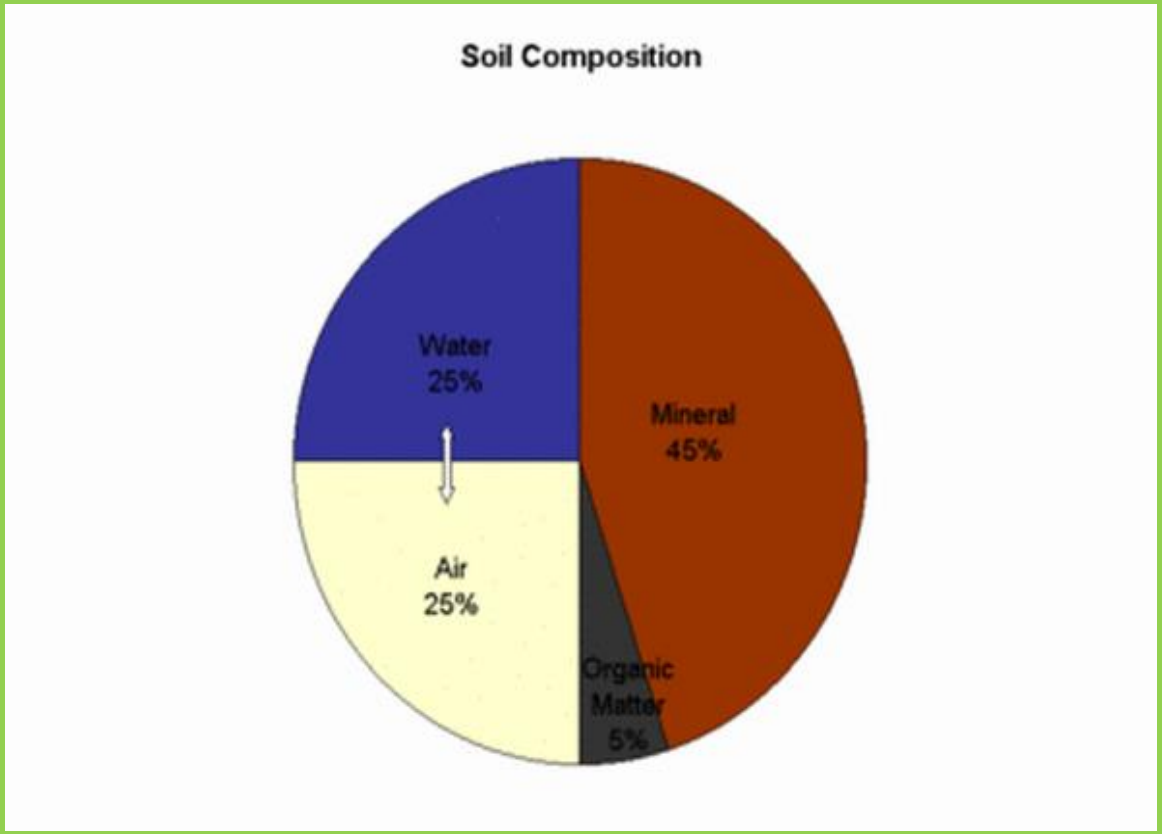


Ideal Soil Composition

Minerals 40 -50%
- Gravel, cobbles, stone
- Sand
- Silt
- Clay

Pore Space 50%
- Air
- Water

Biological 0-10%
- Flora and Fauna
- Live and dead (organic matter)
- Macro and Microscopic



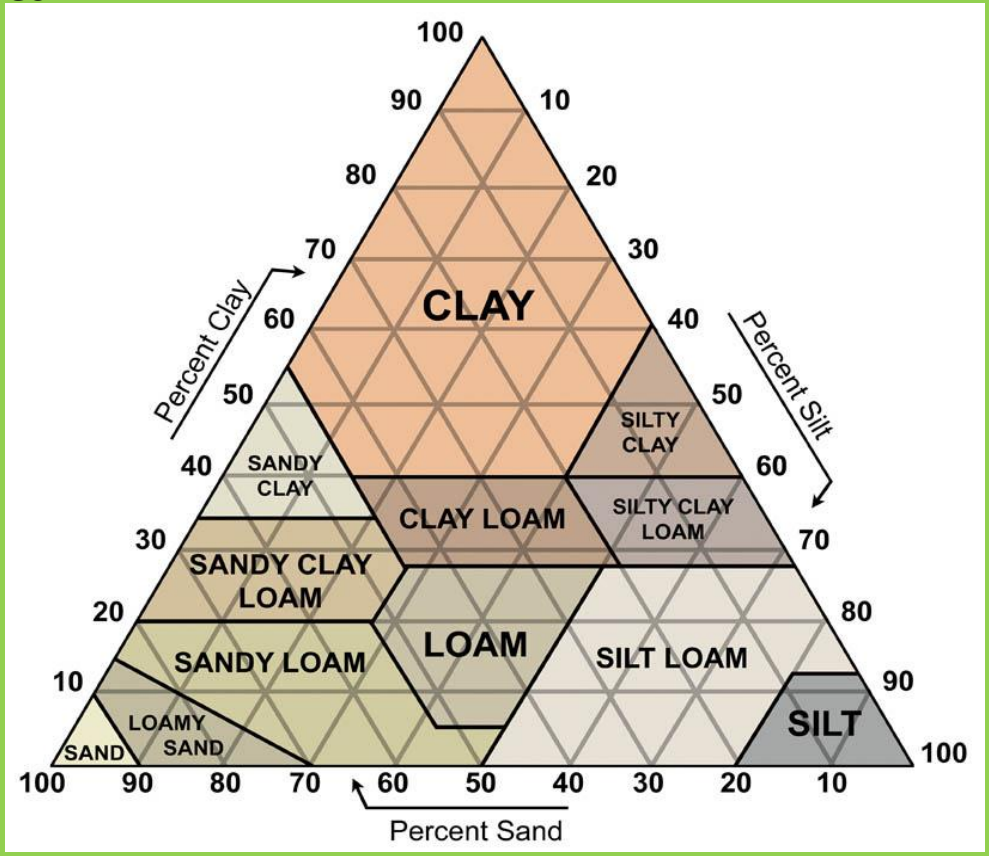
Soil Properties

1. Texture
2. Structure
3. Pores
4. Bulk Density
5. Organic Matter
6. Color
7. Soil Depth
8. Soil Temperature
9. Drainage
10. Odor
11. Permeability
12. Available Water Capacity(AWC)

1. Soil Texture: refers to the mineral part of soil. It tells how much sand, silt or clay is in the soil. Soil texture can be described by the percentage of each as seen in the texture triangle. There are 12 soil texture types.

12 Texture Types

Clay	C
Sandy Clay	SC
Silty Clay	SIC
Clay Loam	CL
Sandy Clay Loam	SCL
Silty Clay Loam	SICL
Sandy Loam	SL
Loam	L
Silt Loam	SIL
Loamy Sand	LS
Sand	S
Silt	SI



Silt - floury when dry, greasy when wet

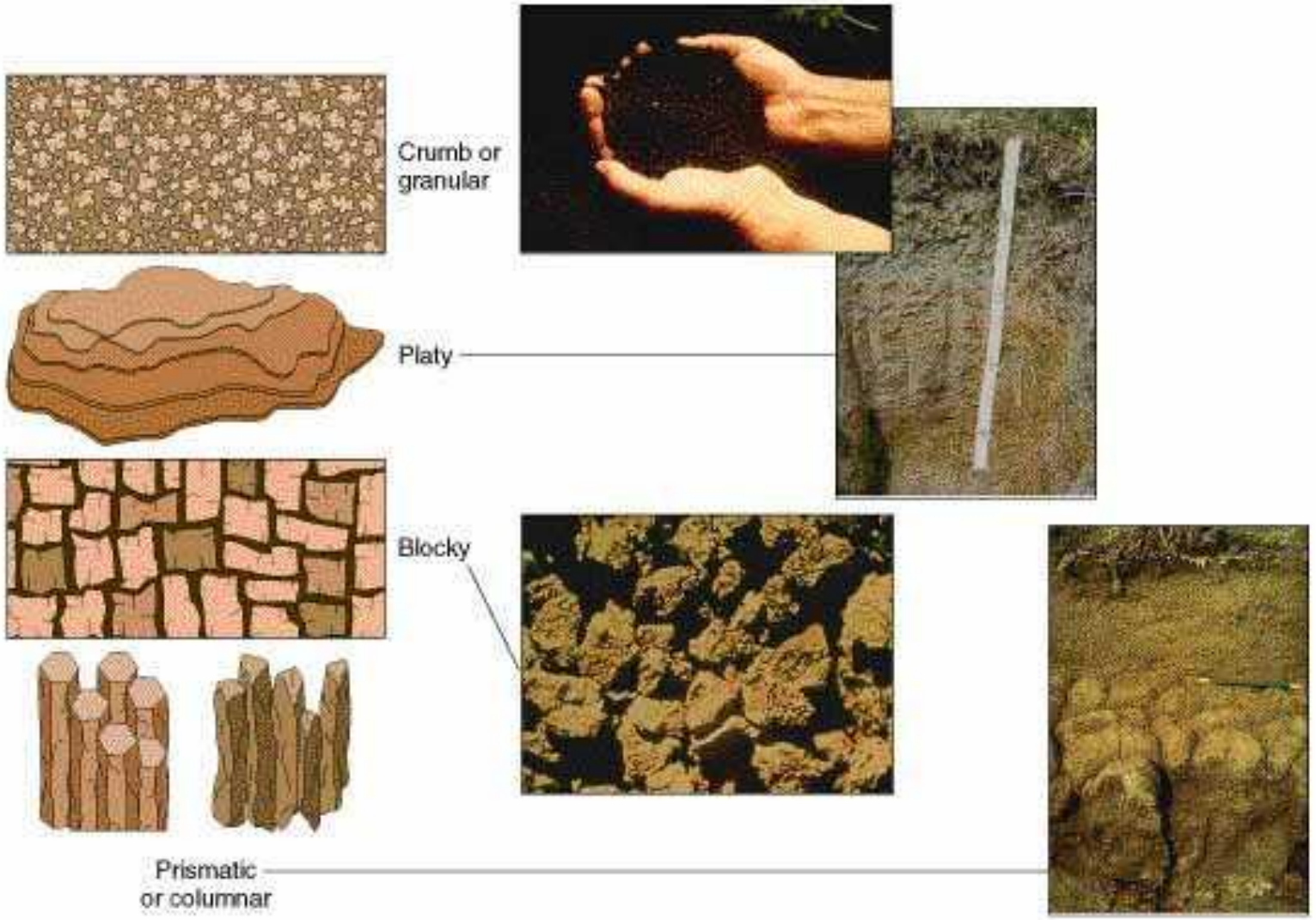
Sandy soils- gritty; low water and nutrient holding capacity; droughty

Clay soils- microscopic layers ; high water and nutrient holding capacity, but low permeability; poor tilth.

SING ABOUT IT AGAIN: https://www.youtube.com/watch?v=gx2wVHeiTKE

Soil Properties

2. Structure in soil refers to the arrangement of soil particles and pores into aggregates. Structure affects permeability.



Soil Properties

3. Pores

Pores are the holes or voids between soil particles. They are important because air and water move through and are stored in pores. Air and microbes can not live with out air and are essential to healthy soil.

4. Bulk Density

Bulk Density of a soil is the dry weight of a given volume of soil divided by the volume. It is expressed in grams per cubic centimeter. Soil bulk density values range from .5 - .3 but most are between 0.8 and 1.8. Anything denser than 1.8 is root limiting. Compacted soils have a higher bulk density.

5. Organic Matter

Organic matter consists of dead plant parts and animal parts and microbial waste products in various stages of decomposition. Eventually breaking down to humus. Organic matter makes up a minor part of soil but has a very significant impact on soul structure, water holding capacity and Cation Exchange Capacity(CEC).

- Organic matter acts like glue to hold soil aggregates together. This will hold upon
- wetting.
- Organic matter helps bind water to soil to keep it from being lost through percolation
- Especially important in sandy soil.
- Humus can have a CEC of 100-300meq/100g(highest CEC in clay is 160meq/100g)

6. Color

Color in soil is measured by the Munsell Color Notation Book. Greens, blues and grays indicate wetness. Bright colors indicate good drainage. Dark colors usually indicate organic matter.

7. Soil Depth

It is important to know the depth of the soil. The depth determines how far the roots can grow and how much water the soil can hold. Depth is measured to the shallowest root limiting layer. Some things that control depth include; bedrock, Natural or tillage hardpans, contrasting textures and water table.

8. Soil Temperature

Soil temperature is important to gardeners as many seeds need a minimum temperature for germination. Soil temperatures are influenced by; air temperature, topography, Plant cover shades the soil, darker colored soils absorb more heat, mulching reduces heat.

9. Drainage

Soil drainage is classified into 7 categories(from the US Department of Agriculture Soil Survey Manual) from Excessively drained to Very poorly drained as a way of expressing frequency and duration of periods in which soil is saturated in excess of field capacity. Excess water in the root zone can kill plants or keep them from taking.

Soil Properties

10. Odor

Odor is an indicator of wetness. When soils are waterlogged, bacteria will get their oxygen from sulfur. This will release hydrogen sulfide gas.

11. Permeability

Permeability is the rate at which water moves down through the soil. It is usually measured in inches per hour. Texture and Structure affect permeability. Soil texture not only affects how fast water moves but also affects the pattern. Water will move almost straight down in sandy soil where as it will have more lateral movement in heavy clay soils.

12. Available Water Capacity (AWC)

AWC refers to how much water a soil can hold against the flow of gravity. AWC is Influenced by texture, salts, Organic matter, Compaction, soil depth, and coarse Fragments.

Soil Testing and Assessment

Important elements to test when assessing the quality of your soil:

- minor and trace minerals
- CEC (cation exchange ratio)
- pH
- soil biotic community
- Quantity of Organic Matter

Conventional farming testing focuses on **Mineral Analysis** where as the organic farmer emphasizes **Soil Biotic Communities** and **Organic Matter.**

Soil Testing

https://www.youtube.com/watch?v=8Qx070sHGgo

https://www.youtube.com/watch?v=HHCVIfu1j_U

https://www.youtube.com/watch?v=BLXJR4HrtHc

Important Information gained from Soil Tests

Minerals and Trace Minerals

The presence and quantity of Minerals and Trace minerals in your soil are measured and reported on soil tests . The availability of these minerals to your plants , and ultimately to us, are the basis of nutrition.
Organic farmer s are equally , if not more, concerned about the soils ability to breakdown these minerals into plant soluble form which is accomplished by the microbiology present in the soil.
Minerals are categorized into two groups , major and minor elements. Though needed in much less quantities the minor elements are very important and should always be included in a soil test.

Minerals are nutrition:

http://www.traceminerals.com/research/soilsea

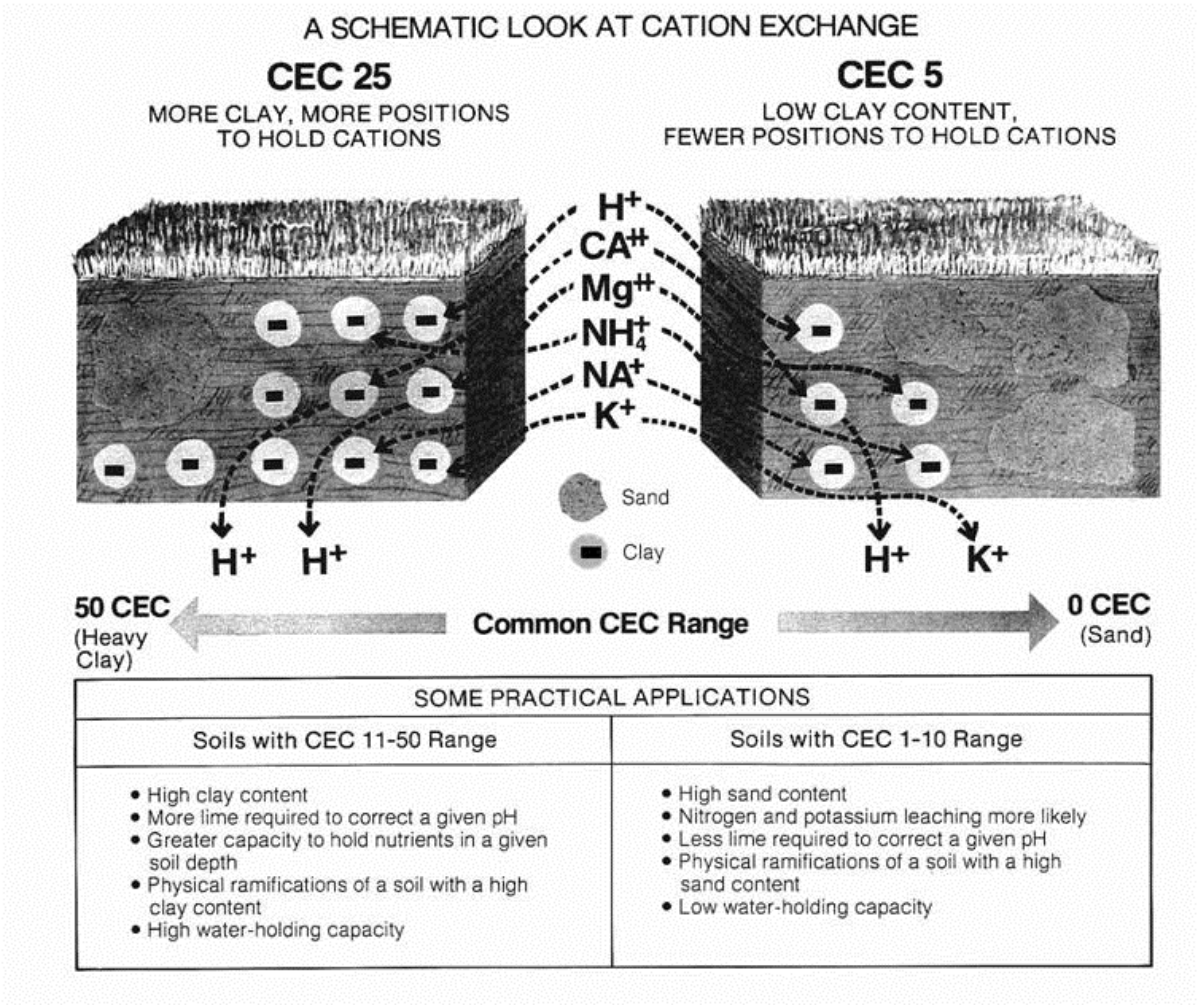
A soil test result:

http://www.soilminerals.com/samplereportI.htm

Important Information gained from Soil Tests

Cation Exchange Capacity

Cation exchange capacity refers to the capacity of negatively charged humus (see slide 13) and clay particles(colliods) to hold cations(Calcium, Magnesium, Potassium- also sodium and amonia).



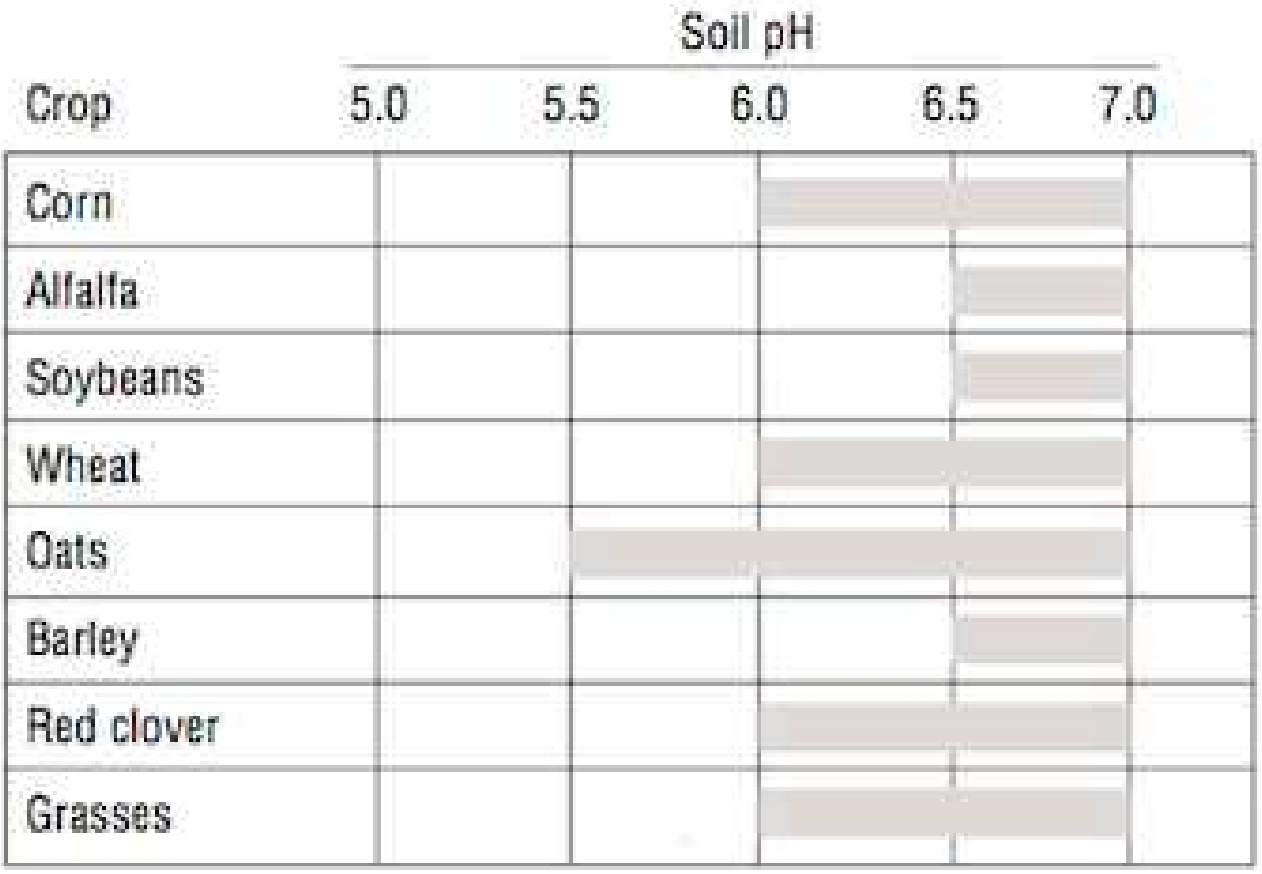
Video Explanation
https://www.youtube.com/watch?v=eHev2Ovrm6M

CEC is measured on soil tests and is important information as to the nutrient holding ability of your soil.

Important Information gained from Soil Tests

Desirable Ph Levels

Figure 1. Favorable pH ranges for common crops.



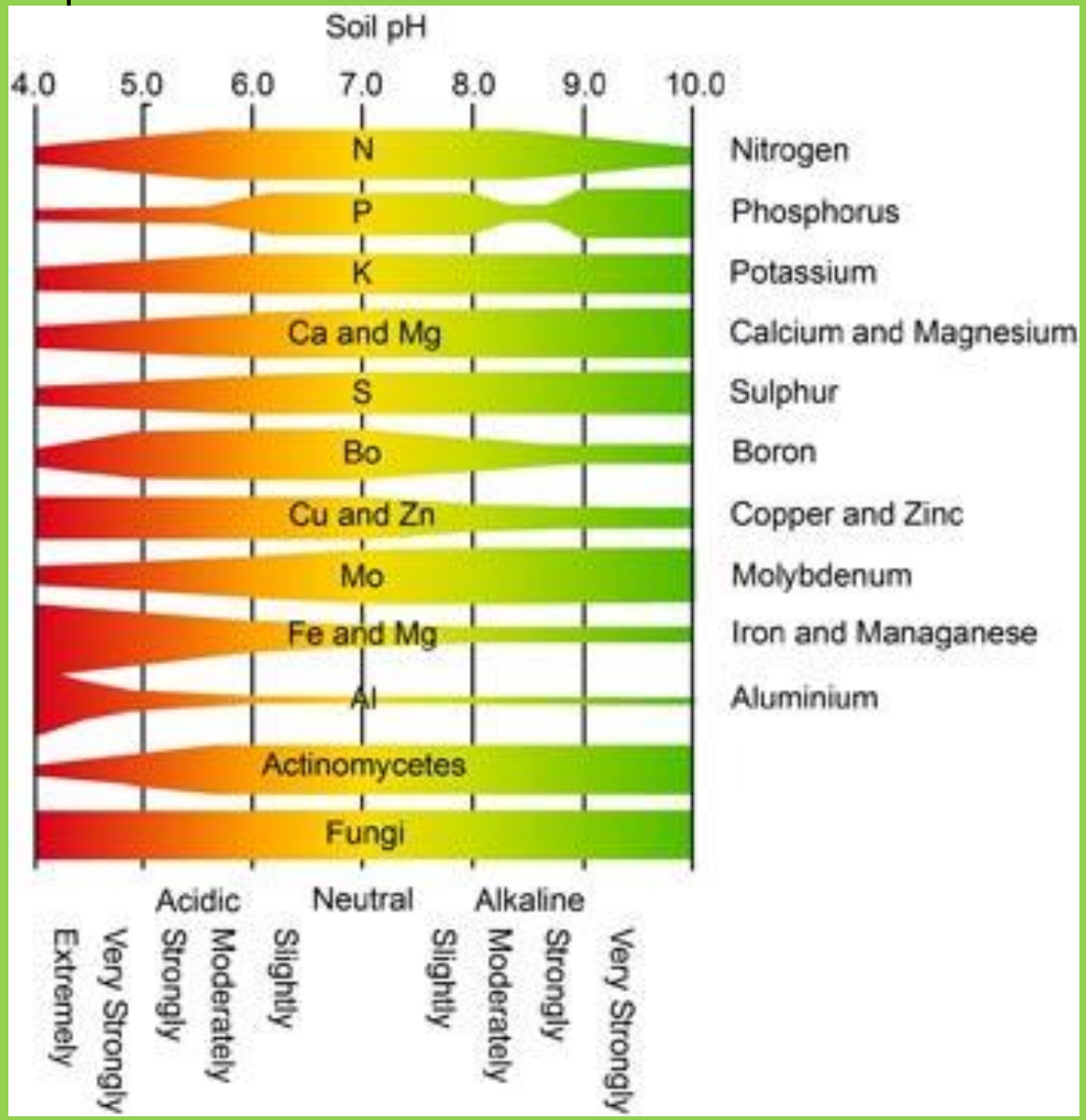
Videos about Ph Level:

http://youtu.be/s_6suv7Nd48

http://youtu.be/7b88FtQC9kc

Important Information gained from Soil Tests

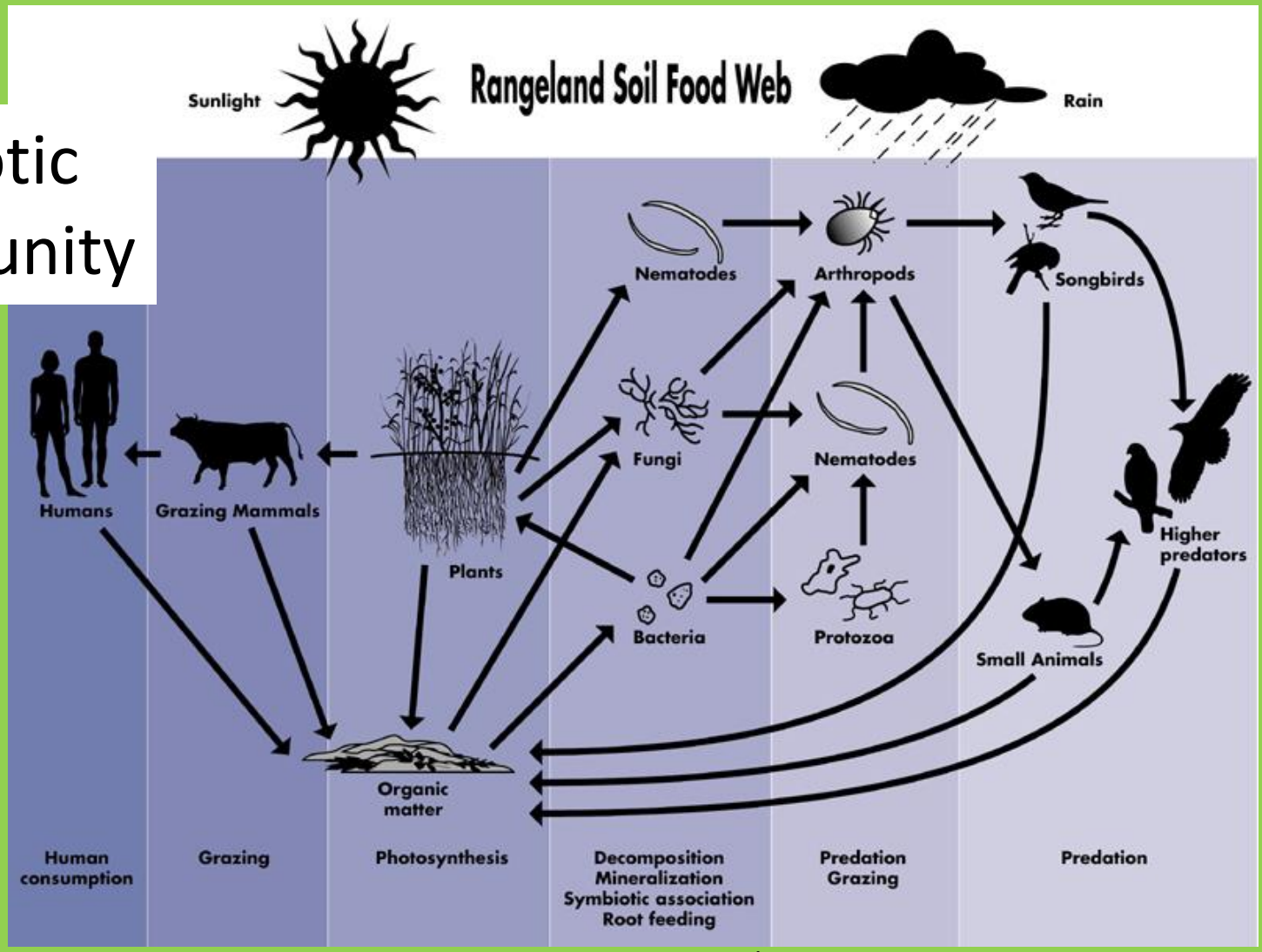
PH and its relation to CEC –(if your bases are balanced, pH will take care of itself)



Soil Ph Video
https://www.youtube.com/watch?v=7b88FtQC9kc

Important Information gained from Soil Tests

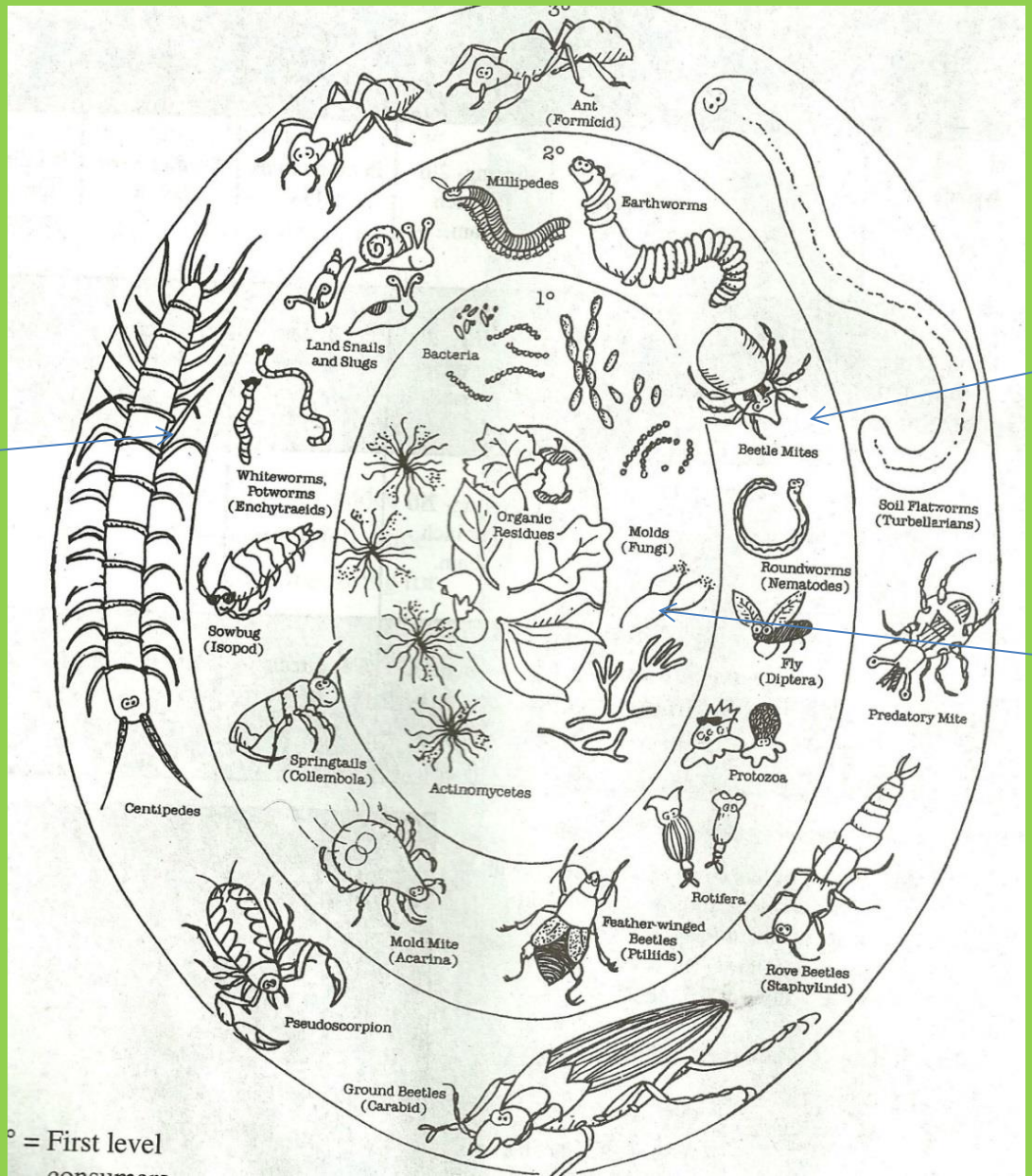
Soil Biotic Community



We know that an acre of soil can support or produce 2000 lbs of beef (cow / calf pair), 5 sheep, and lots of chickens, for example, but we rarely consider the extent of the soil fauna living underground: 1 acre of topsoil contains approximately 900 pounds of earthworms,2,400 pounds of fungi, 1,500 pounds of bacteria, 133 pounds of Protozoa, 890 pounds of arthropods and algae, and small mammals.

The Soil Food Web/Biotic Community

Decomposers 3 levels of consumers (organisms that feed on each other and the organic matter).



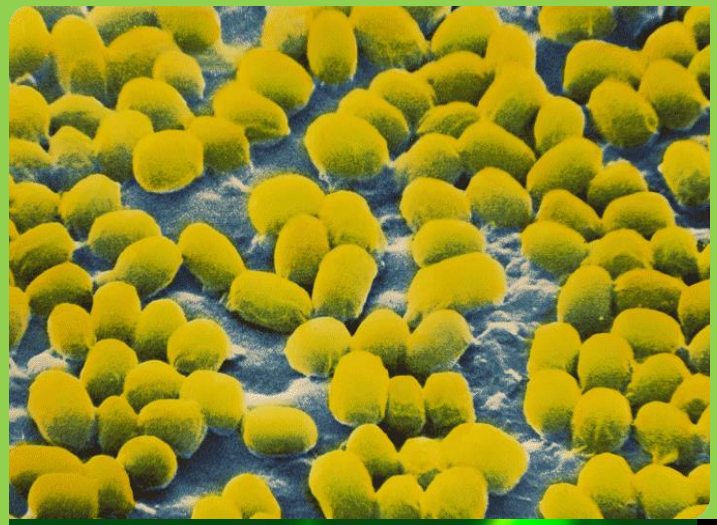
3rd Level
Macro
organisms

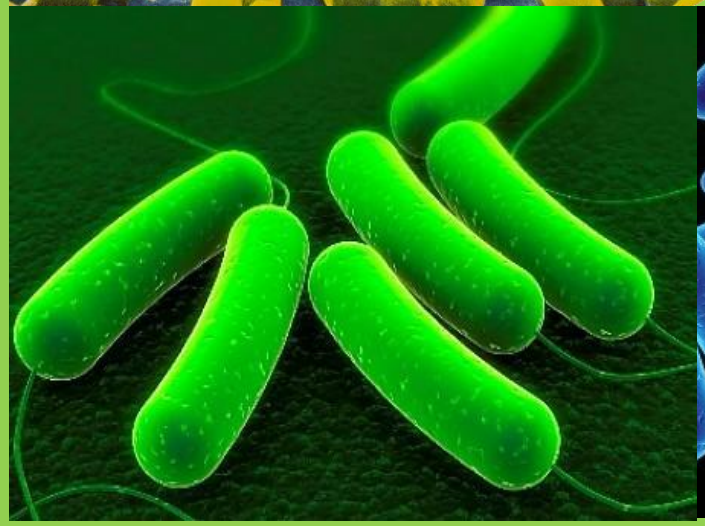
2nd Level
Meso organisms

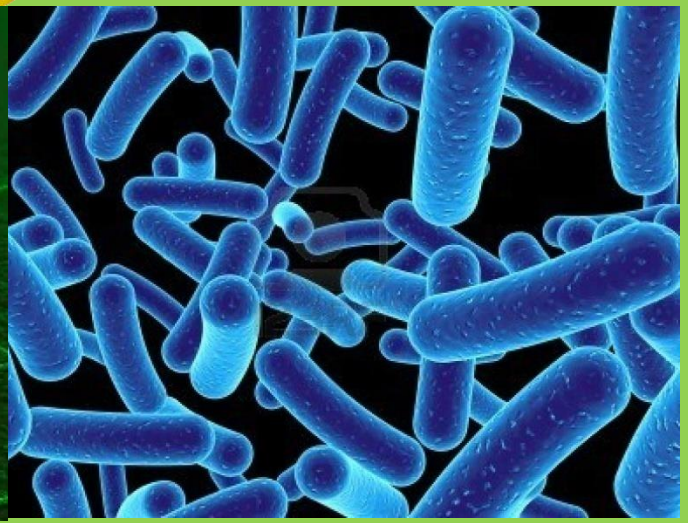
1st Level
Micro organisms

Micro- Biology in Soil

Bacteria – make plant growth hormones, make nutrients and minerals available to plants, fix atmospheric nitrogen, fight root diseases, and detoxify soils.







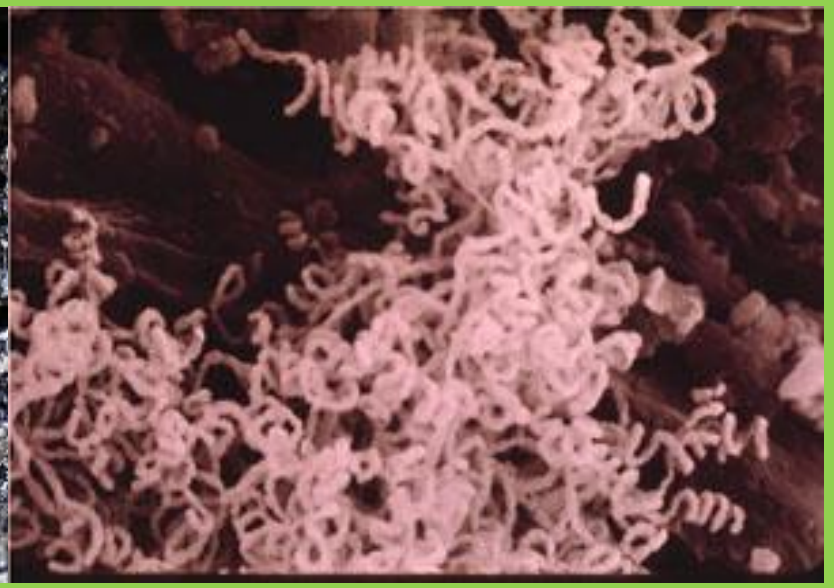
Micro- Biology in Soil

Fungi – break down OM and release nutrients available to plants, produce plant hormones and antibiotics, mycorrhizal associations.

Fungal hyphae in healthy compost

Micro- Biology in Soil

Actinomycetes – threadlike bacteria that look like fungi: decompose OM, produce root disease-fighting antibiotics, and produce a sweet, “earthy” smell.

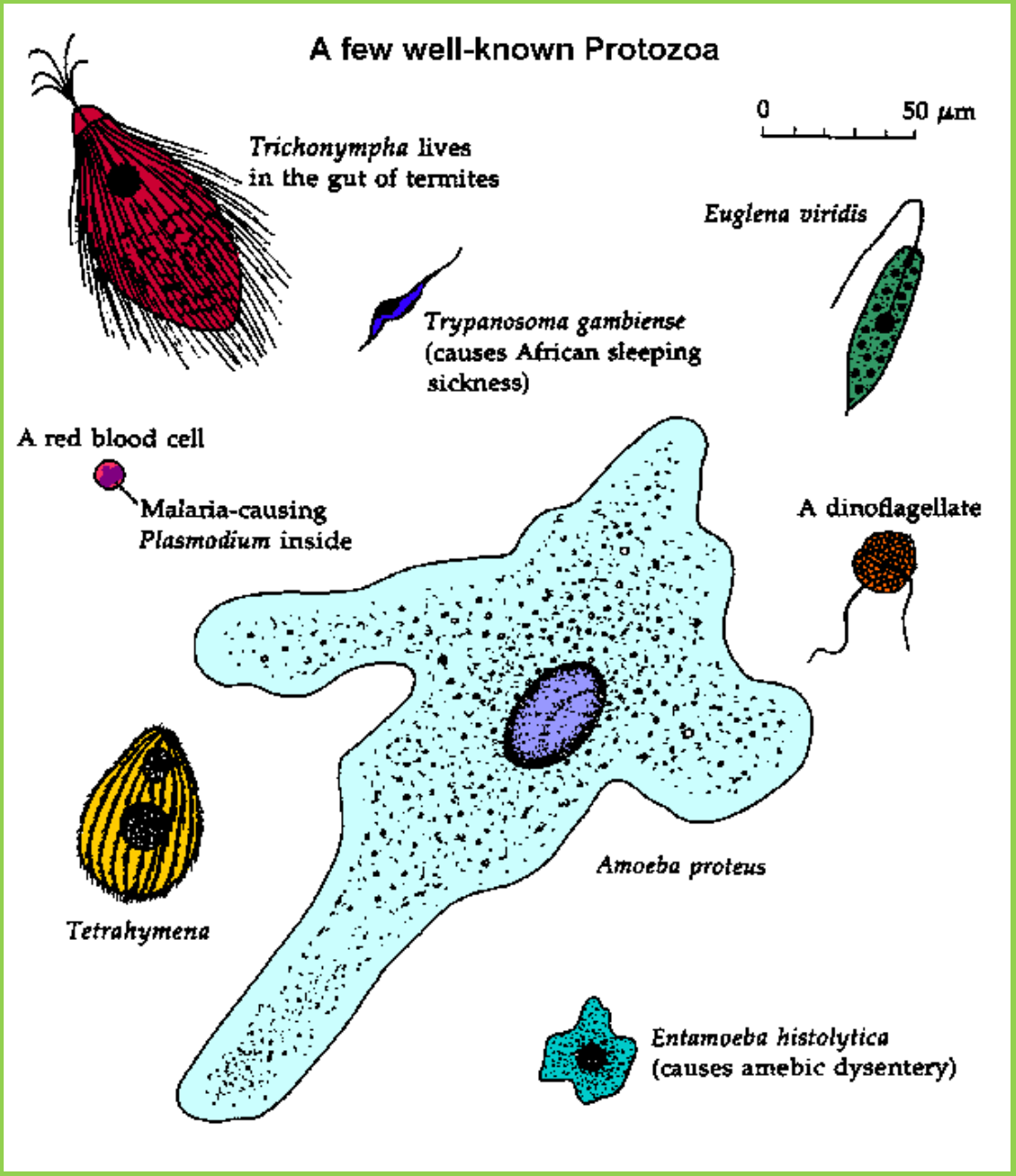


Meso- Fauna

Algae – located in the upper ½ inch of soil .Algae will fix nitrogen and enhance soil structure by producing biologic glues.

Meso- Fauna

Protozoa – free-living organisms that swim in soil water, eating bacteria and speeding up the nutrient cycle.



Meso- Fauna

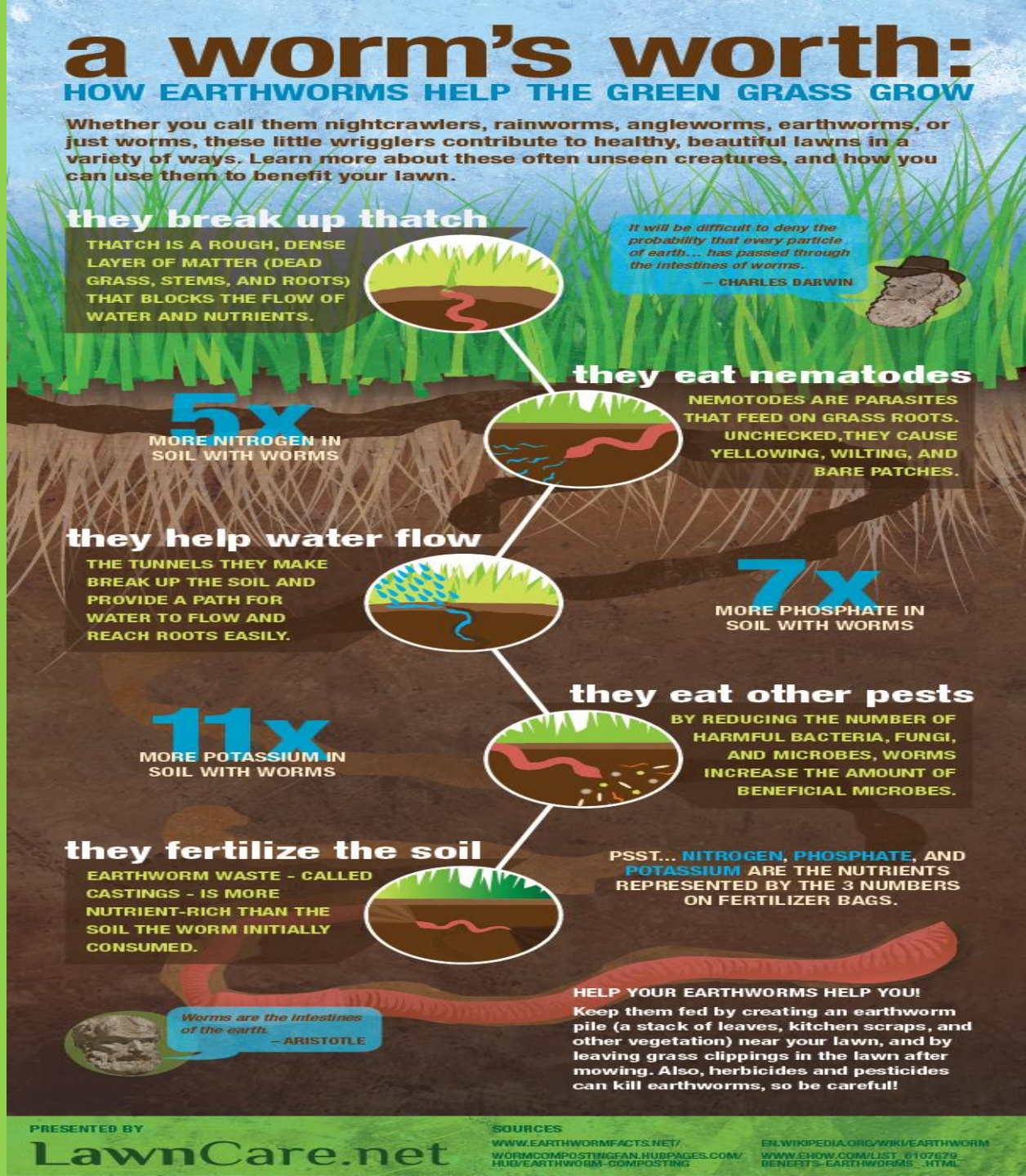
Nematodes – eat decaying plant litter, bacteria, algae, protozoa, and other nematodes – only a few species harmful to plants.

Mega- Fauna

Arthropods – sow bugs, centipedes, slugs, snails, and springtails: primary decomposers

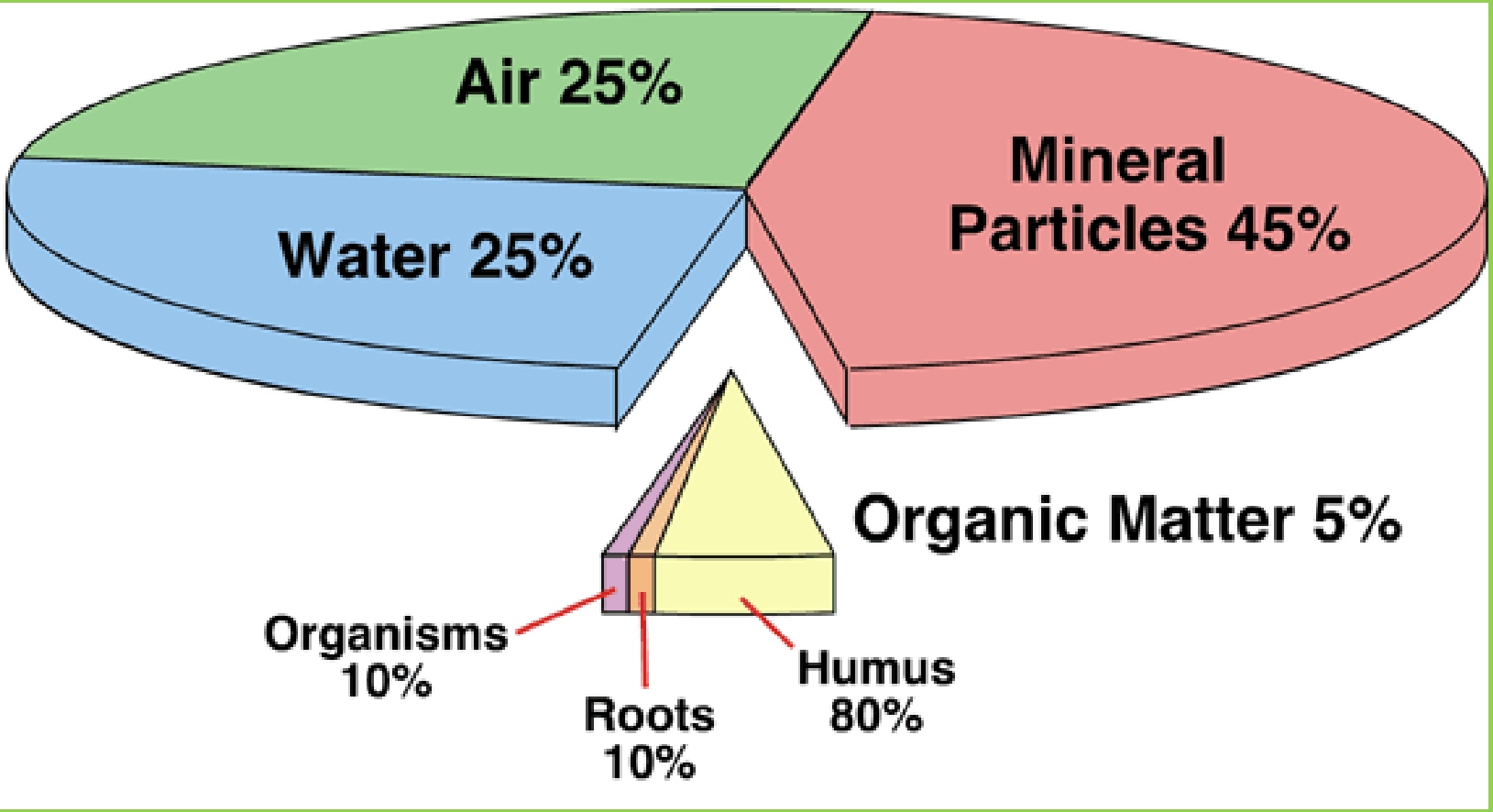
Mega- Fauna

Earthworms – air & water penetration, high-nutrient castings, secretion of plant growth stimulant, natural soil tiller.



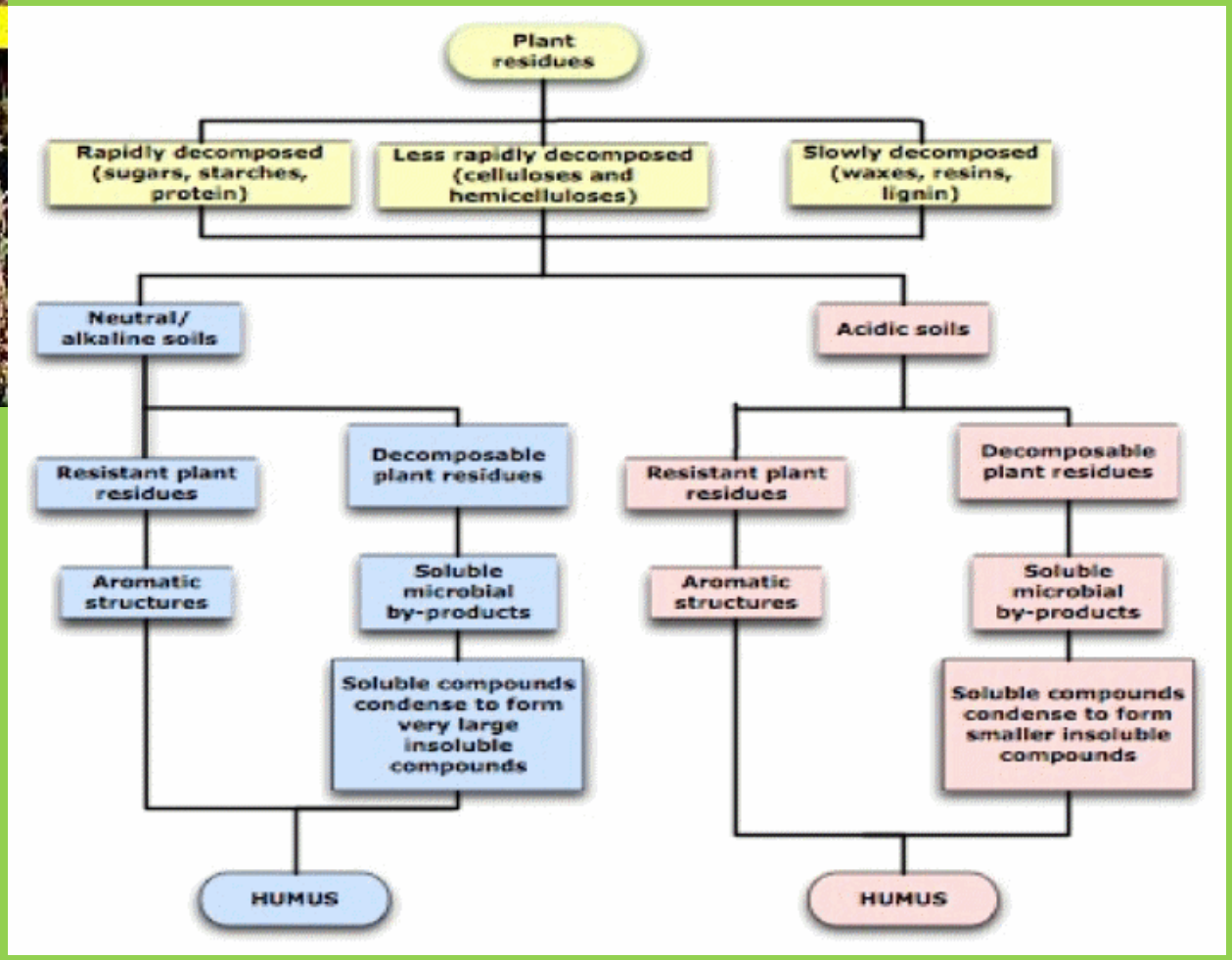
Soil Organic Matter

The key to managing a healthy soil community is to build organic matter. A soil test will let you know what percent of your soil is organic matter. This diagram is an ideal situation.



Humus

What is HUMUS?
https://www.youtube.com/watch?v=8Q1VnwcpW7E



http://www.bioag.com/humicfaqresources/faqforhumicacids.html

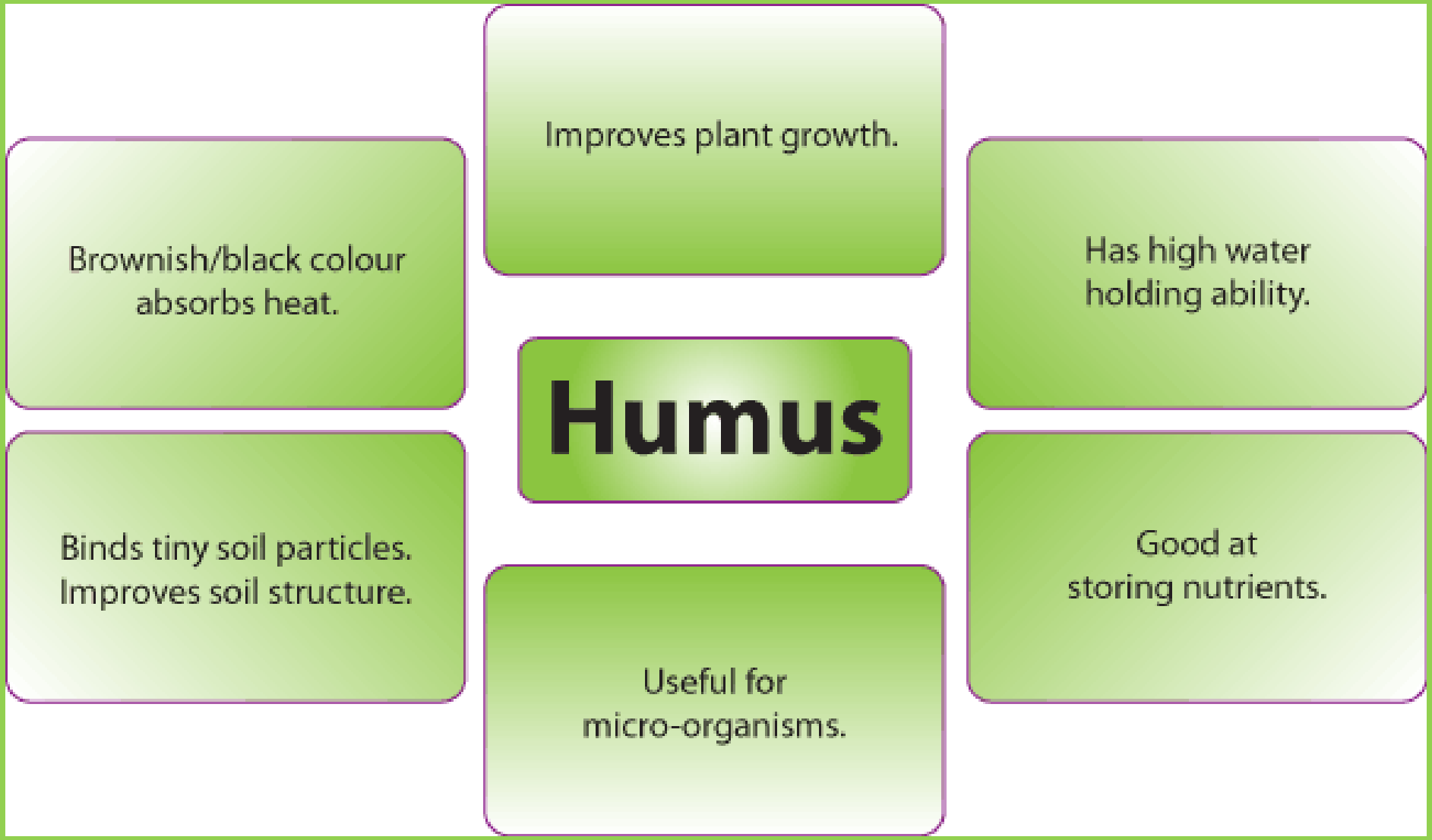
Humic Acid (organic compounds containing displaceable hydrogen), A natural Chelator.

http://www.teravita.com/Humates/Chapter2.htm

Humate (the salt of a humic acid, where hydrogen has been displaced by cations such as potassium, calcium, and magnesium)

Soil Organic Matter(SOM) , Matters!

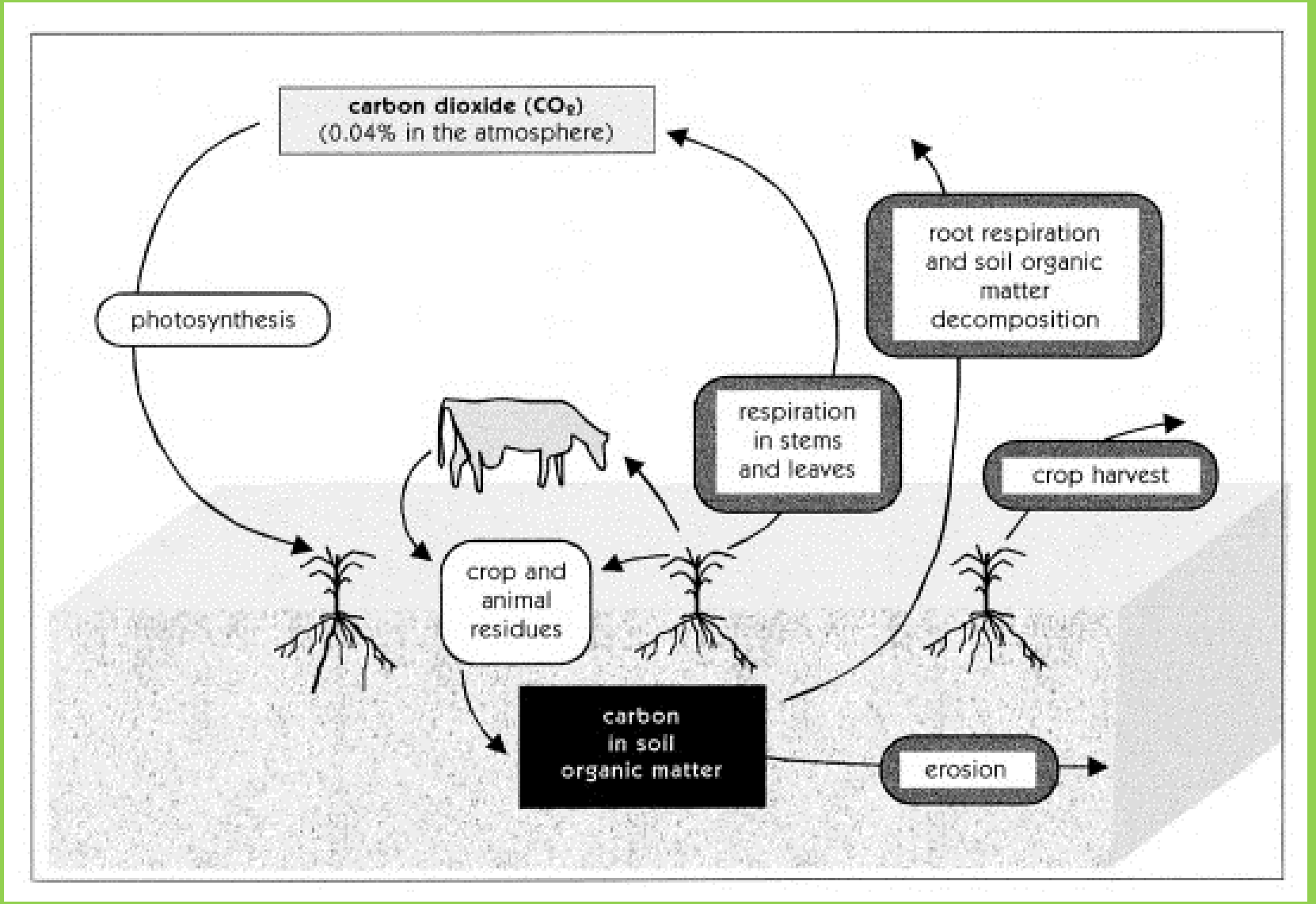
- Building Humus-Creating an environment for the biotic community
- Carbon Cycle – sinking Co2
- SOM and Managing the Nitrogen Cycle
- The key to Air and Water quality



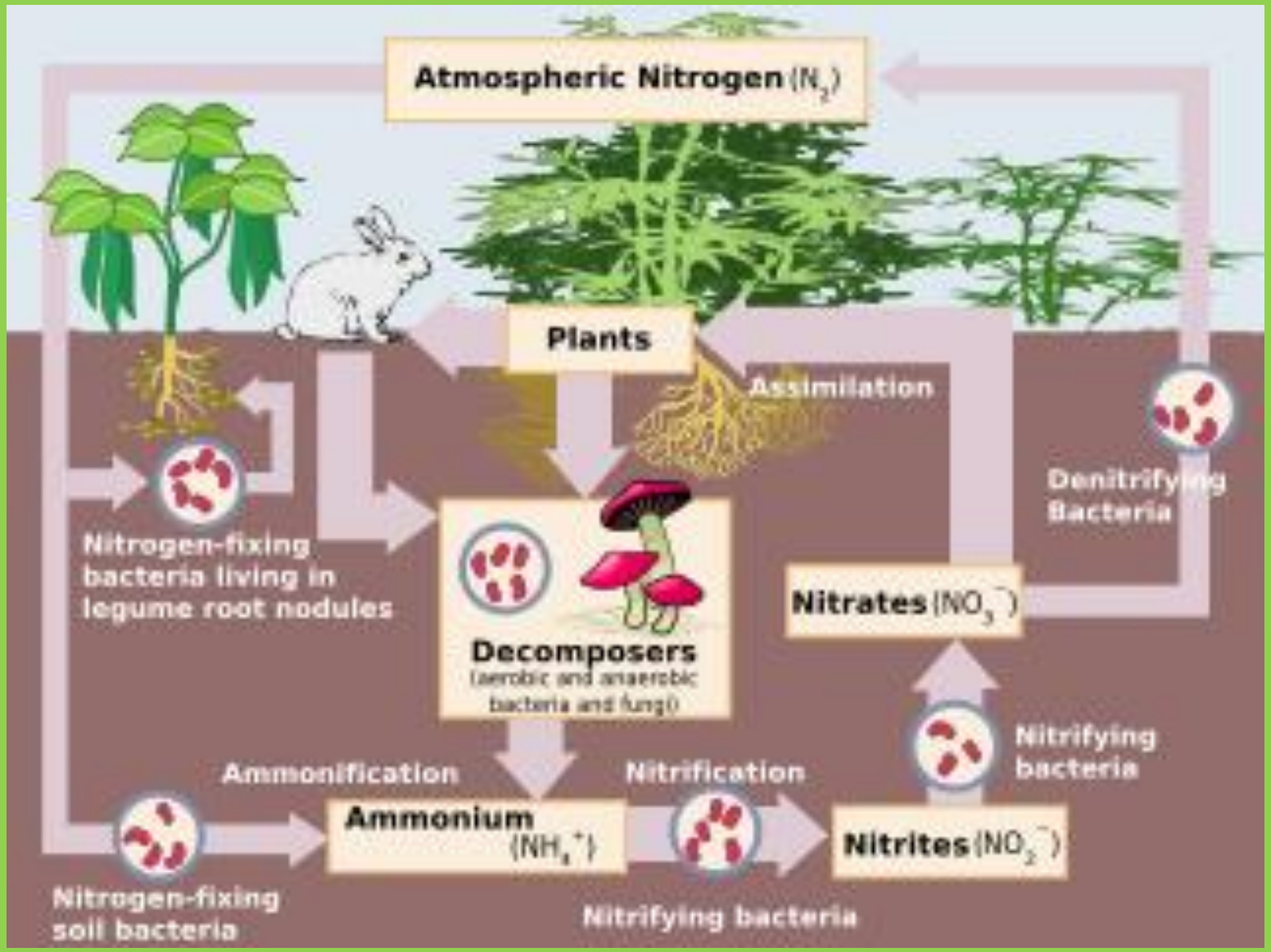
Humus is also a major contributor in sinking carbon emissions.

Soil Organic Matter and Sinking CO2

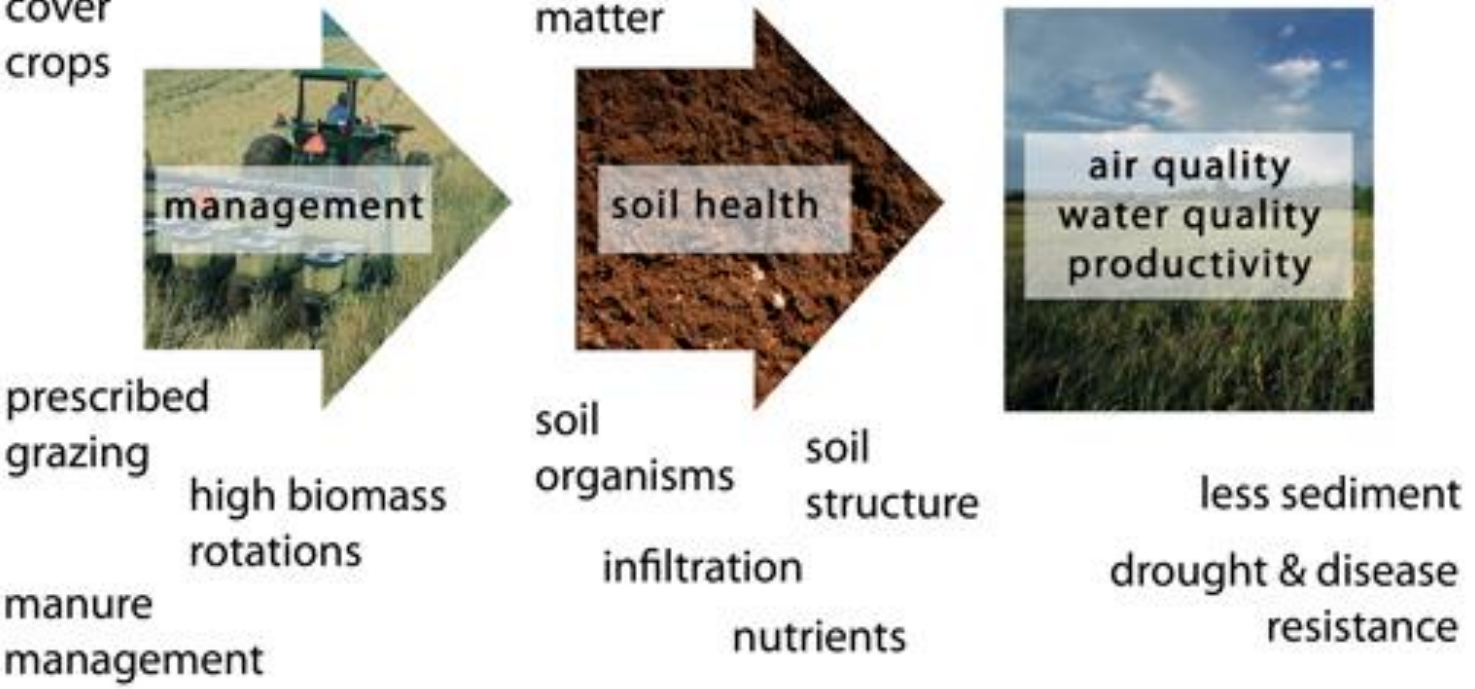
Carbon Cycle: role of C (CO2) and how to manage it.



SOM and Managing the Nitrogen Cycle



Managing soil organic matter is the key to air and water quality.



Building Organic Matter

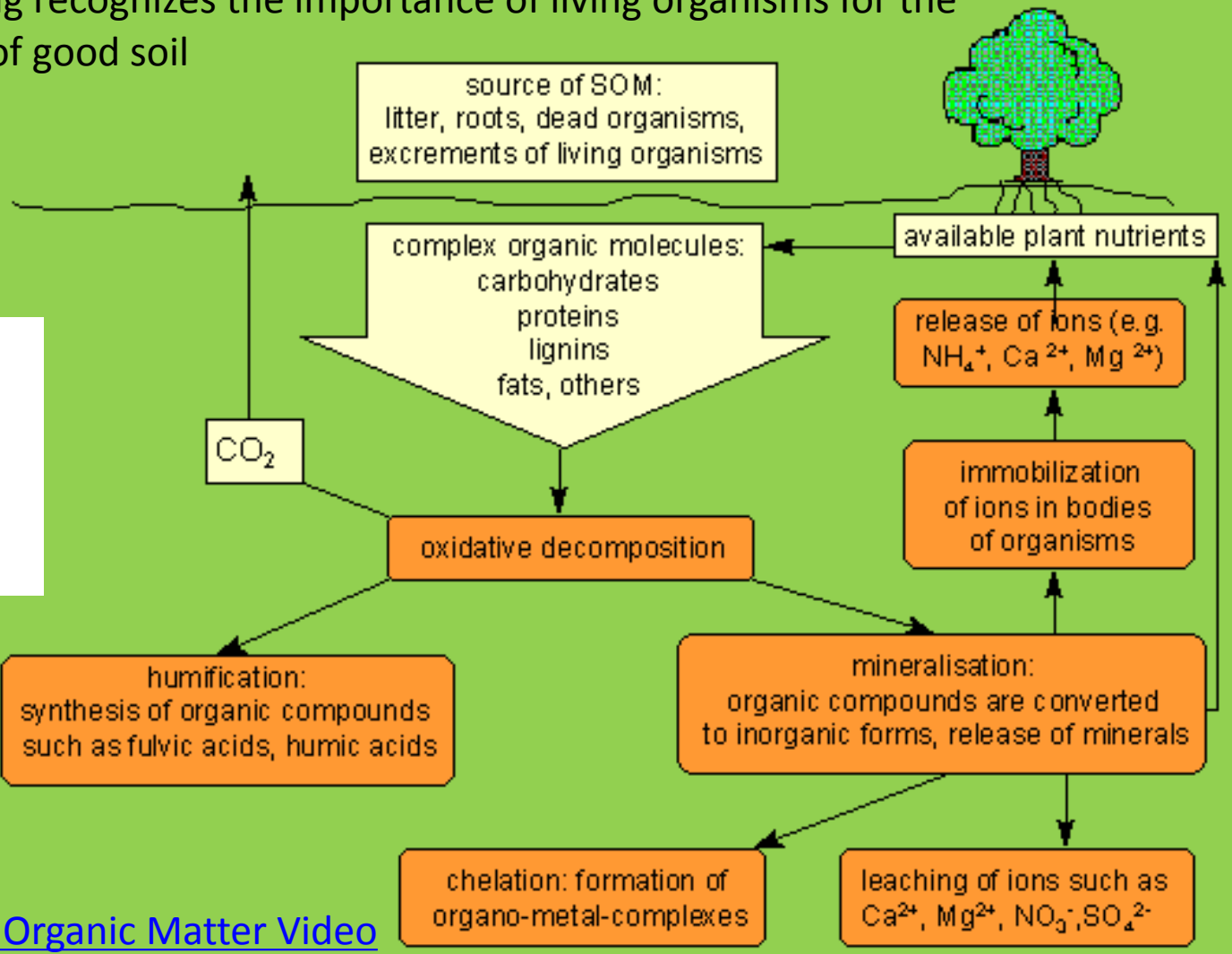
- Compost*/Compost Teas*
- Cover cropping/Green Manures*
- Crop Rotation*
- Minimum Tillage*

* See SARE power point module on this topic for a complete lesson.

Comparing Organic and Commercial Farming

Organic farming recognizes the importance of living organisms for the development of good soil

Organic Farming depends on organic matter in the soil for soil health and nutrition.



[Importance of Soil Organic Matter Video](https://www.youtube.com/watch?v=z5zDD2q7PE8)
https://www.youtube.com/watch?v=z5zDD2q7PE8

Commercial farming uses harsh pesticides and fertilizers to create synthetically "good" soil. However, it is unnatural , harmful to the environment and unsustainable.

Assessment/Review

- How is soil formed?
- What are some important soil characteristics?
- Explain cation exchange capacity and how to improve it.
- Describe a cropping system that improves soil organic matter and enhances the soil biotic community.

Resources

- USDA.gov
  - http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/edu/
- Encyclopedia of the Earth
  - http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/edu/
- Beginning Farmers.org
  - http://www.beginningfarmers.org/the-nitrogen-cycle-agricultural-science-basics/
- Mosesorganic.org
- S.A.R.E.- previous grant projects