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Why Compost?

The Benefits of Organic Matter in Home Garden Soil

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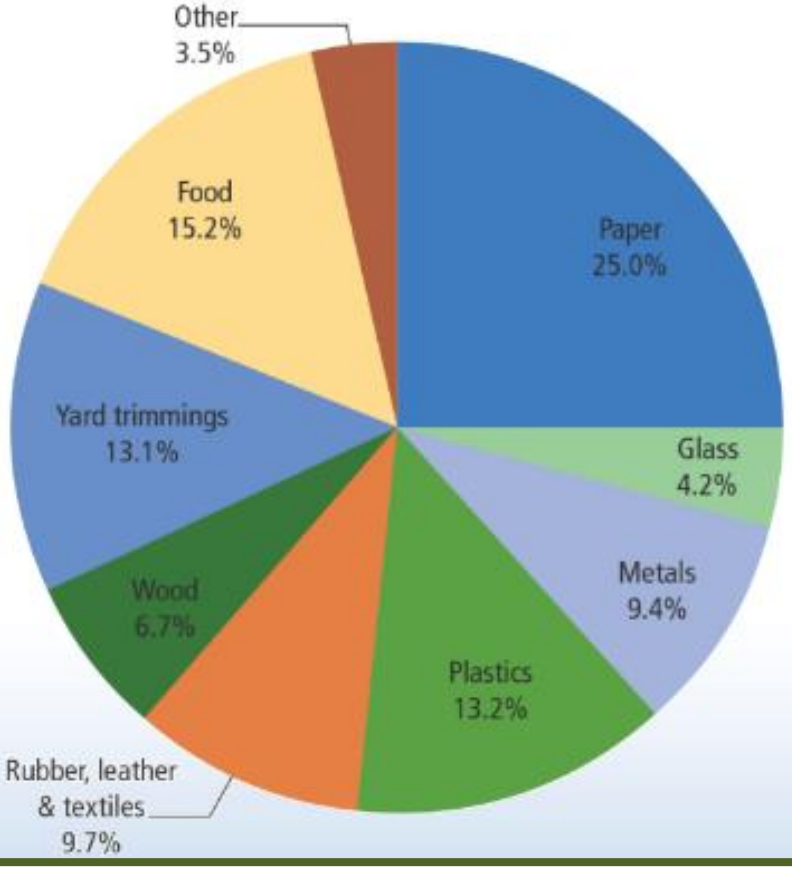
CCEDC Community Horticulture Resource Educator

Agenda

- Why Compost?
- How to Compost
- Soil
- The Value of Organic Matter in Soil
- pH Effect on Availability of Nutrients in Soil

US Waste Facts

Total MSW* Generation (by material), 2017: **267.8 Million Tons** *Municipal Solid Waste



The EPA estimates that 75% of the American waste stream can be recyclable and/or compostable.

The ultimate benefits from recycling and composting are cleaner land, air, & water and a more sustainable environment.

35% was Recycled or Composted

Equivalent to removing 39 million cars from the road for a year

Figure 5. Total MSW Recycling (by material), 2017
67.2 Million Tons

Only 8% of plastic tonnage was recycled.

Figure 6. Total MSW Composting (by material), 2017
27.0 Million Tons

Only 6% of food waste tonnage was composted.

Landfills

Minimal Change in last Decade

Table 2. Generation, Recycling, Composting, Combustion with Energy Recovery and Landfilling of MSW, 1960 to 2017 (in millions of tons)

Activity	1960	1970	1980	1990	2000	2005	2010	2015	2016	2017
Generation	88.1	121.1	151.6	208.3	243.5	253.7	251.1	262.1	266.8	267.8
Recycling	5.6	8.0	14.5	29.0	53.0	59.2	65.3	67.6	68.6	67.2
Composting*	neg.	neg.	neg.	4.2	16.5	20.6	20.2	23.4	25.1	27.0
Combustion with energy recovery†	0.0	0.5	2.8	29.8	33.7	31.7	29.3	33.5	33.9	34.0
Landfilling and other disposal‡	82.5	112.6	134.3	145.3	140.3	142.2	136.3	137.6	139.2	139.6
	94%	**93%**	**88%**	**70%**	**58%**	**56%**	**54%**	**52%**	**52%**	**52%**

Why Compost?

Composting lowers MSW volumes

Organic Matter improves soil

- Better soil grows heathier plants
- Healthier plants resist diseases

Organic Matter helps soil retain water and improves drainage

Organic Matter has many other uses in gardens and on lawns.

2. Composting Basics

- What is it?
- The Biology
- Materials
- Variables

Composting Basics

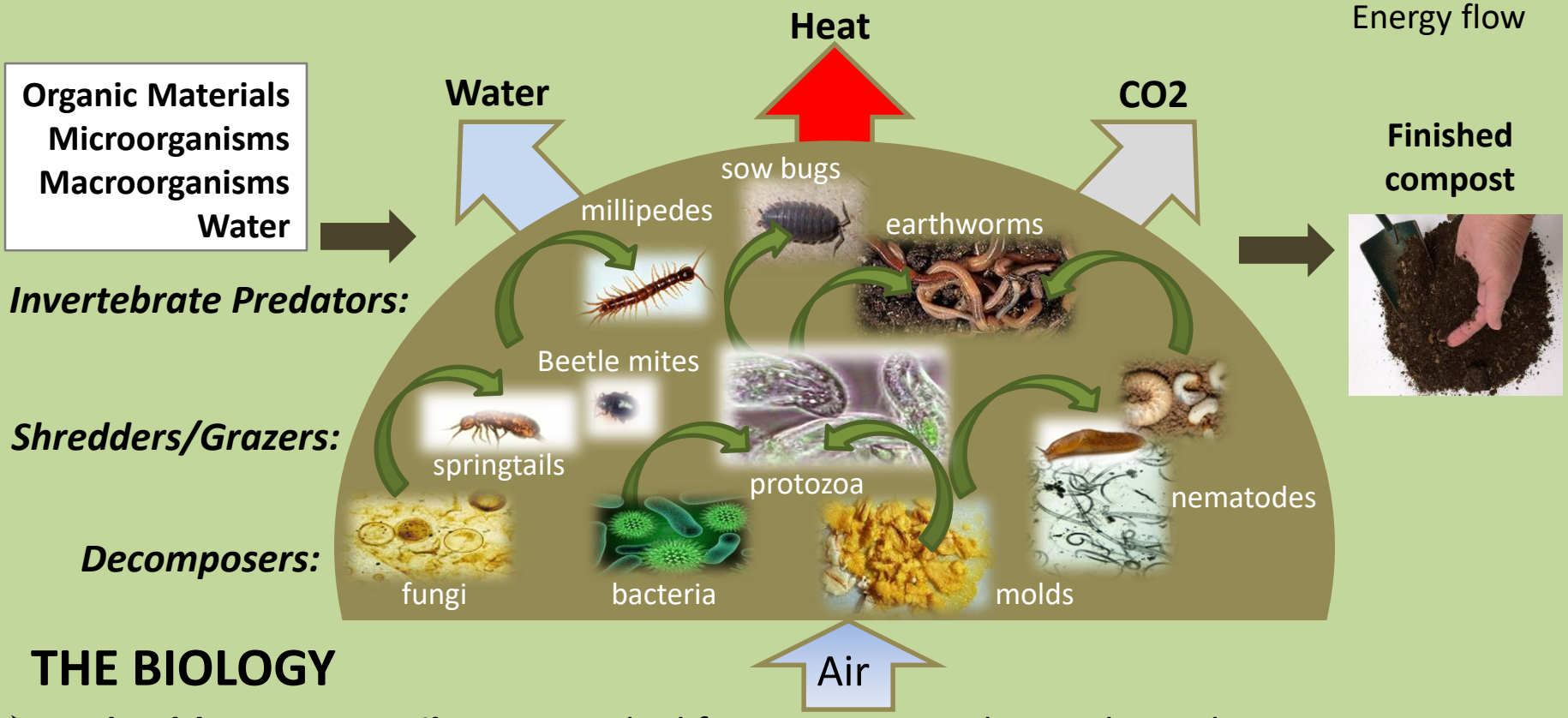
What is Home Composting?

Composting is the aerobic (oxygen requiring) decomposition of organic materials by macro/microorganisms under controlled condition

Compost = Managed Decomposition

Home Composting is small-scale, primarily including garden and yard trimmings and leaves, kitchen scraps, wood shavings, cardboard and paper.

Composting Basics: Inside the Compost Pile



THE BIOLOGY

- ***A healthy compost pile*** is a microbial farm teeming with interdependent organisms.
- **Decomposer** microorganisms such as fungi, bacteria, and mold start the process.
- ***Shredders and grazer*** macroorganisms such as protozoa and nematodes join the mix.
- ***Invertebrate predators*** such as sow bugs & earthworms eat decomposers & shredders.
- ***The end result*** is 'Black Gold' – rich organic matter!

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Composting Basics

Browns = Carbon Dry Materials

Organic Materials (Feedstock)

Greens = Nitrogen Wet Materials

Composting Basics

Materials: Carbon:Nitrogen (C:N) Ratio

Woodchips (400:1)
Cardboard (350:1)
Sawdust (325:1)
Newspaper (175:1)
Pine needles (80:1)
Straw (75:1)
Corn stalks (75:1)
Leaves (60:1)
Fruit waste (35:1)
Peanut shells (35:1)
Garden waste (30:1)
Weeds (30:1)
Hay (25:1)
Vegetable Scraps (25:1)
Clover (23:1)
Coffee grounds (20:1)
Food waste (20:1)
Grass clippings (20:1)
Seaweed (19:1)
Manures (15:1)
Alfalfa (12:1)

Compost requires a 30:1 mixture of browns & greens.

Browns are high in Carbon
Used by shredders/decomposers for food

C:N ratio refers to the material composition, not volume.

Greens are high in Nitrogen
Used by shredders/decomposers for growth /reproduction

Composting Basics
Materials: Mixing by Volume

Woodchips (400:1)
Cardboard (350:1)
Sawdust (325:1)
Newspaper (175:1)
Pine needles (80:1)
Straw (75:1)
Corn stalks (75:1)
Leaves (60:1)
Fruit waste (35:1)
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Seaweed (19:1)
Manures (15:1)
Alfalfa (12:1)

Rule of Thumb

For the best C:N ratio (30:1), mix:

1 part Green ***2-3 parts Brown***

Composting Basics
Layering Greens and Browns

Layers of Greens

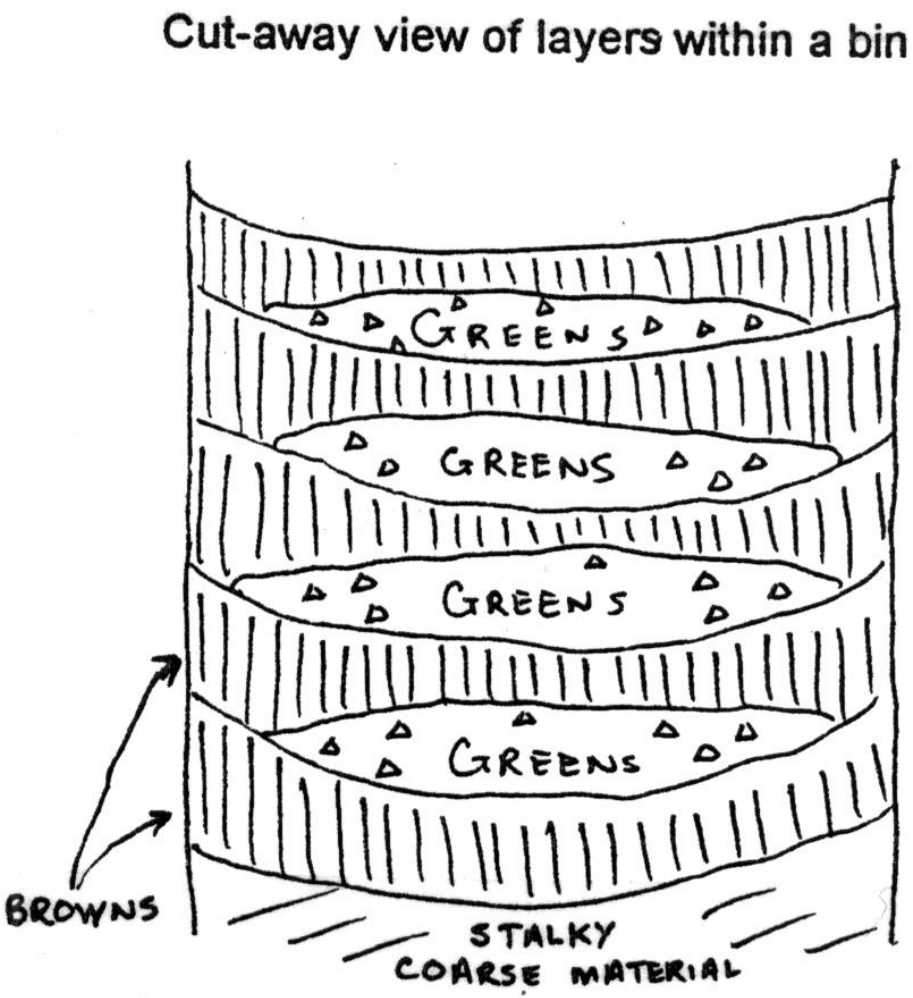
- Lawn & garden waste, food scraps

Layers of Browns around the Greens

- Allow air flow and aid drainage
- Are visual and physical barrier to pests

Bottom Layer

- Coarse materials to allow air in



Composting Basics

What not to Compost

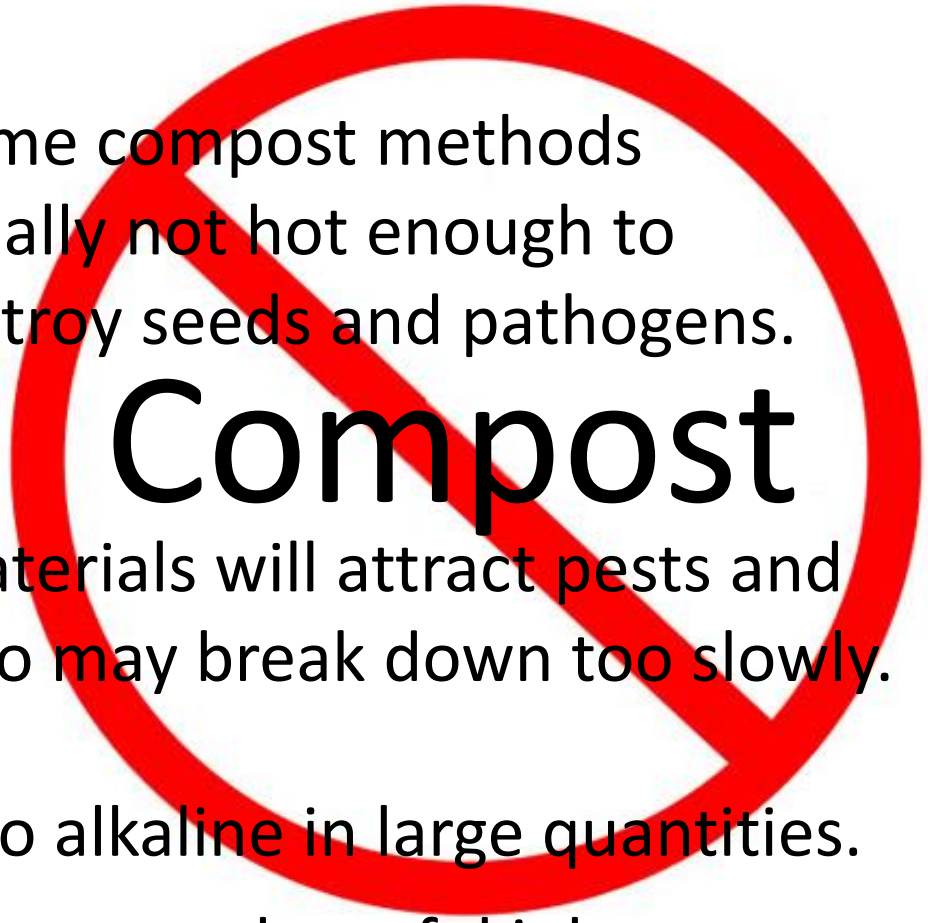
- Seedy Weeds
- Invasive plants
- Diseased plants
- Diseased potatoes or tomatoes
- Dog &cat manure
- Dairy products
- Grease and fats
- Meats and fish
- Bones
- Wood ash
- Coated or treated paper

Home compost methods usually not hot enough to destroy seeds and pathogens.

Materials will attract pests and also may break down too slowly.

Too alkaline in large quantities.

Some use harmful inks.



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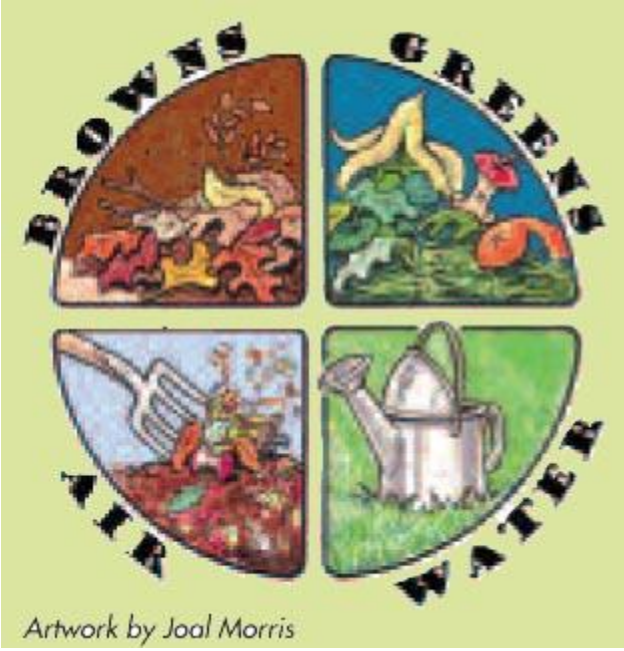
Composting Basics

The Variables

- Materials
- Oxygen
- Moisture
- Surface Area
- Temperature



Composting Basics

The Variables…Oxygen

- Air is needed for aerobic decomposition
- Frequencies of turning is governed primarily by moisture content and type of materials

Composting Basics

The Variables…Moisture

Organisms need moisture. Decomposition will slow with too much or too little moisture. The optimum moisture for compost is 40-60%, damp enough that a handful feels moist, dry enough that a squeeze produces no more than a drop of two of liquid.

Composting Basics

The Variable…Surface Area

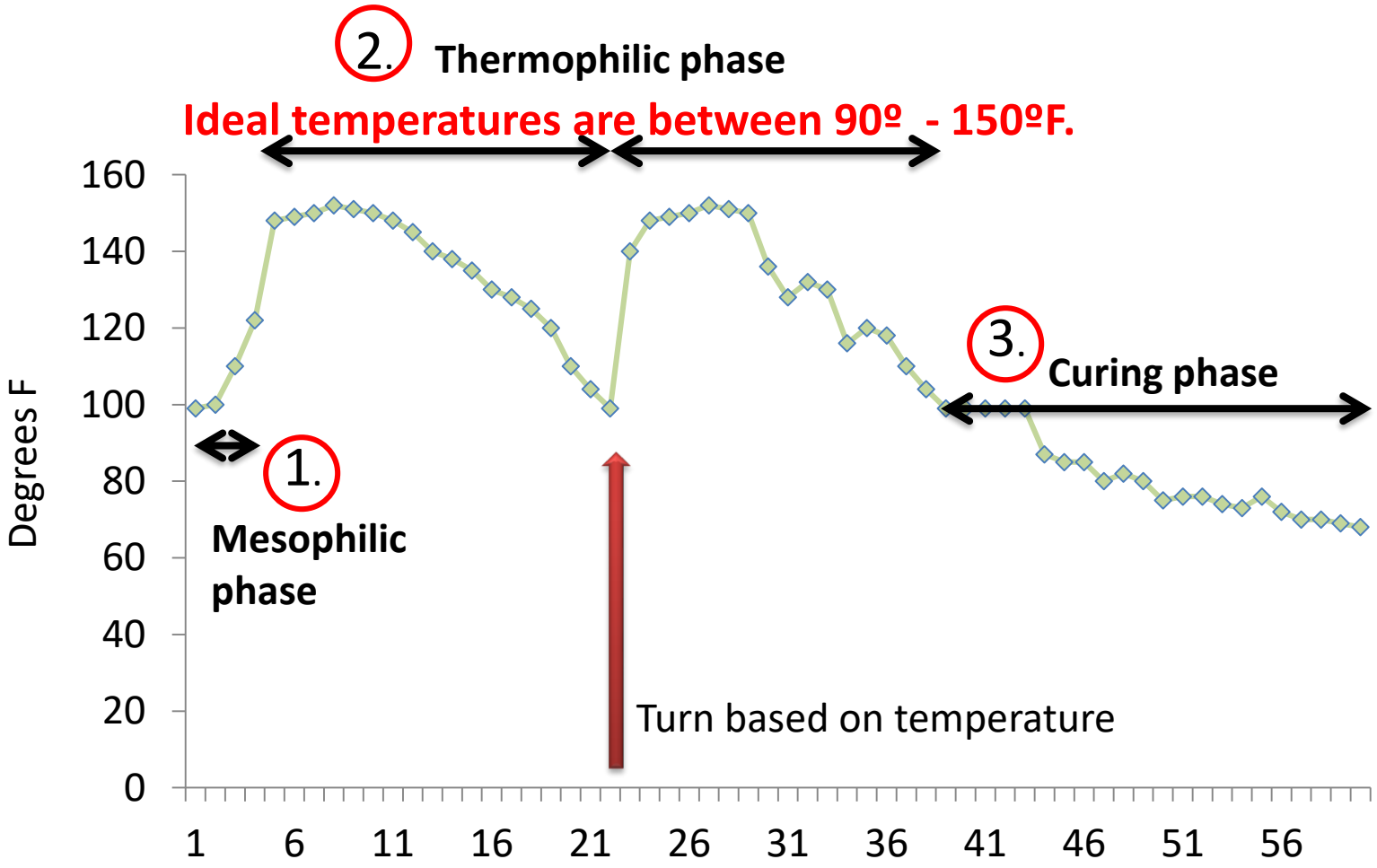
Woodchips

Sawdust

- Decomposition occurs on the surface of particles.
- Large particles (woodchips) = better aeration and less labor, but take longer to breakdown
- Small particles (sawdust) = more surface area, less space to circulate air and more labor to aerate

Composting Basics

The Variable…Temperature



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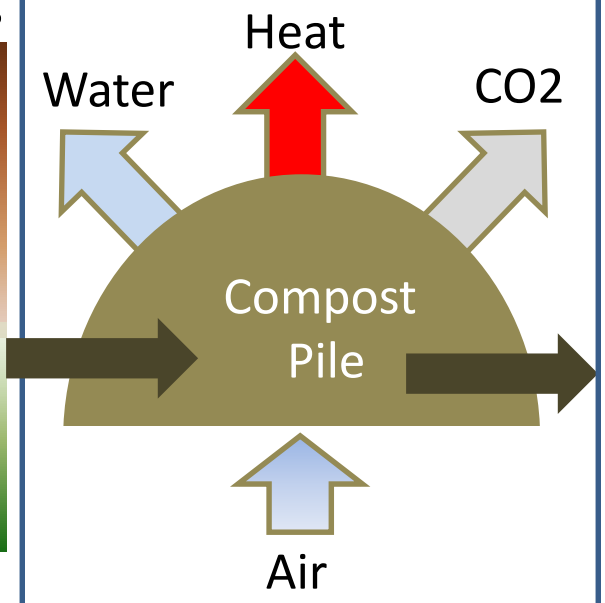
Composting Basics: Summary

Components | **Process** | **Results**

Organic Materials
- woodchip
- cardboard
- newspaper
- corn stalk
- leaves
- garden wastes
- vegetable scraps
- coffee grounds
- manures

Microorganisms
Macroorganisms
Water



Finished Compost

- ***Organic Materials****: add 1 part Green to 2-3 parts Brown.*
- ***Micro & Macroorganisms:*** *add soil, compost, or starters.*
- ***Water:*** *add as needed to make a handful feel moist.*
- ***Air:*** *add oxygen by turning the pile.*
- ***Shelter****: create a mass of at least 3'x3'x3'.*

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Home Composting Systems
On the Ground - 3 bin unit

More expensive to build, but is effective and long lasting.
Decomposes yard, garden waste and kitchen materials quickly.
Fill the first bin. Monitor temps. Turn before 155^{o} into the 2nd bin.
Repeat using the 3rd bin. Compost can be created in a month.

On the Ground – Tower Unit

Cost: $150-$200
Equipment: Turning tool or fork.
Speed: 6 months to a year
Useful for smaller yards, looks nicer than a compost pile.

Continuously add food scraps and cover with “Browns”.
Turn if desired. Add a second unit if first is full.
Remove decomposed material from the bottom.

Make Your Own!

Leaf Paper Bags

Garbage Pails

Wire Bins

Finished Compost Uses

- ***Soil Amendment:*** create healthy soil by incorporating ½ - 1” layer of compost into top 6-8” of soil
- ***Mulch:*** retain moisture & suppress disease by spreading 2-3” of compost without contacting plant stems or trunks

- ***Potting Mixture:*** improve potting medium by adding up to 50% compost
- ***Top-dressing:*** boost established lawns with ¼ inch of fine material

Compost Troubleshooting

Organic Materials

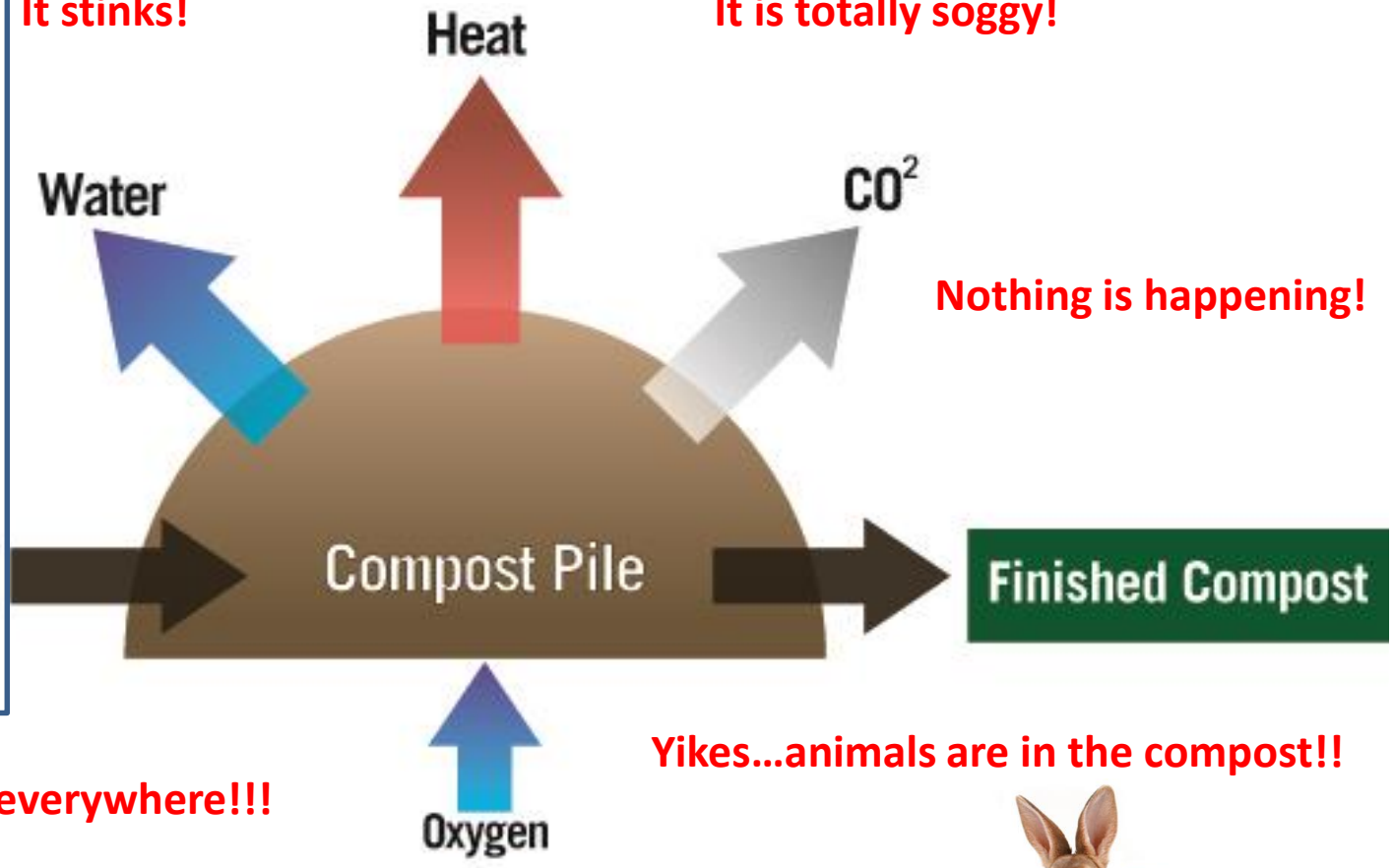
- woodchip
- cardboard
- newspaper
- corn stalk
- leaves
- garden wastes
- vegetable scraps
- coffee grounds
- manures

Microorganisms
Macroorganisms
Water

It is stone cold!

It stinks!

It is totally soggy!



Nothing is happening!

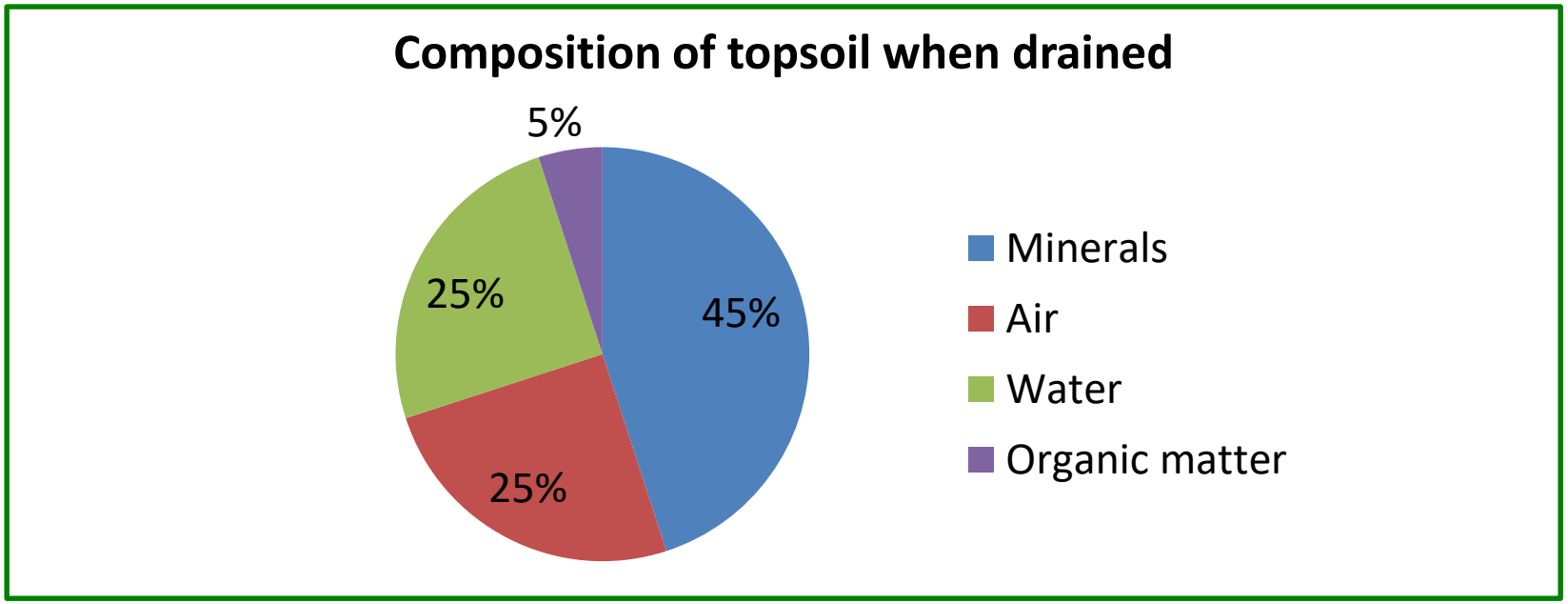
Bugs are everywhere!!!

Yikes…animals are in the compost!!

Troubleshooting

Problem	Issue	Resolution
Damp &/or warm only in middle	Pile could be too small or weather cold	Pile should be at least 3 cubic feet
Nothing is happening	1. Not enough nitrogen, oxygen, &/or water 2. Cold weather 3. Compost is finished	1. Add greens, aerate, &/or add water 2. Wait until spring 3. You're done!
Matted leaves/ grass clippings are not breaking down	Poor aeration or lack of moisture	Break up &/or shred the layers and turn pile
Smells like rotten eggs	1. Not enough oxygen 2. Pile is too wet &/or compacted	1. Aerate pile 2. Add dry materials
Smells like ammonia	Not enough brown/carbon	Add brown/carbon materials
Attracts rodents or other animals	1. Inappropriate materials 2. Kitchen scraps too close to surface	1. Bury kitchen scraps near the center 2. Switch to a rodent-proof closed bin.
Attracts insects	Normal composting	Not a problem
Attracts many ants	1. Pile too dry &/or not hot enough 2. Kitchen scraps too close to surface	1. Ensure right material mix & moist 2. Bury kitchen scraps near center

What is Soil?



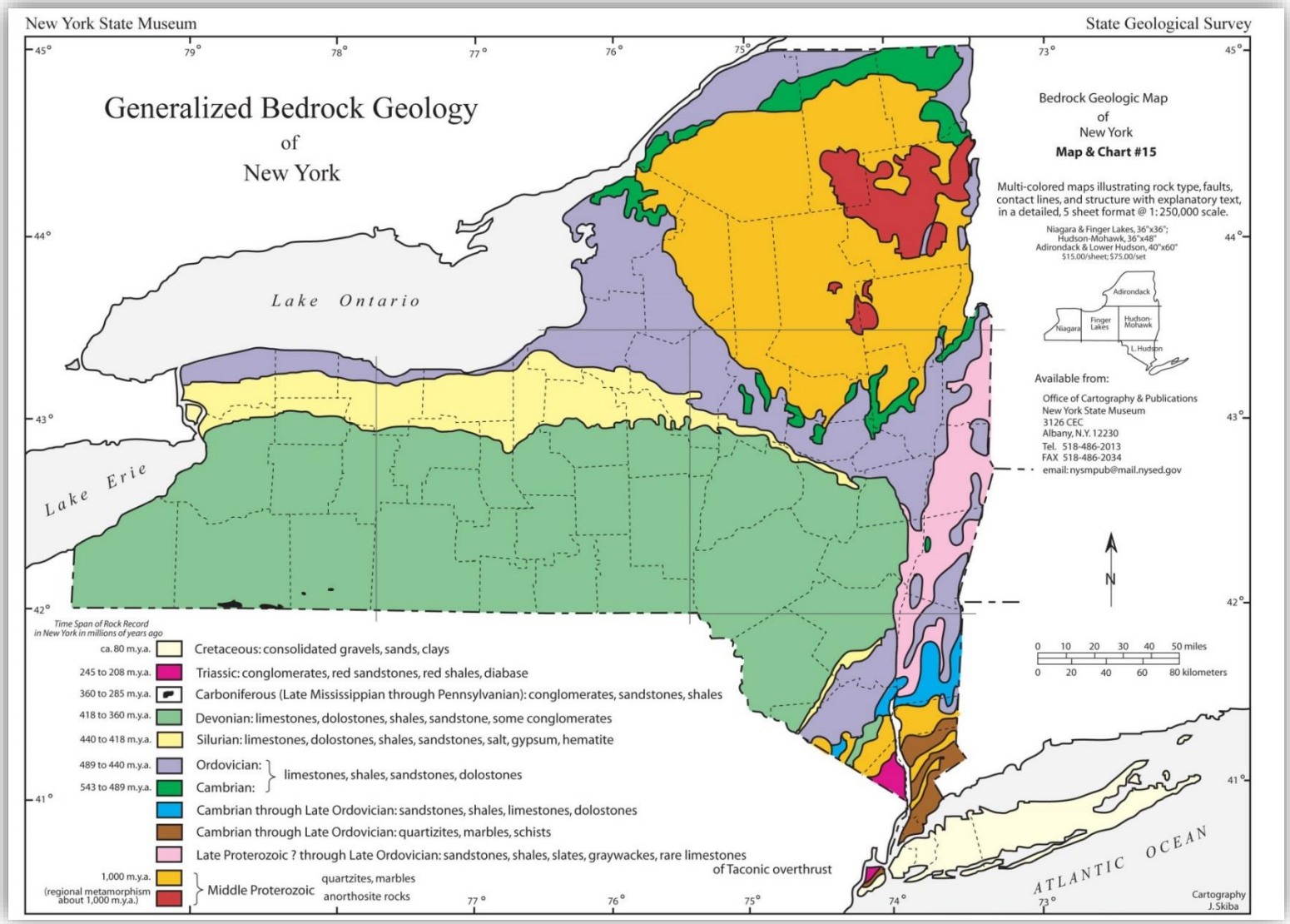
Soil is a dynamic ecosystem composed of:

1. Solids, which are minerals and organic matter.
   - Nutrients and other chemical elements are within the minerals.
   - Biomass/organisms living are within the organic matter.
2. Liquids and gasses, which exist in the spaces between soil solids.

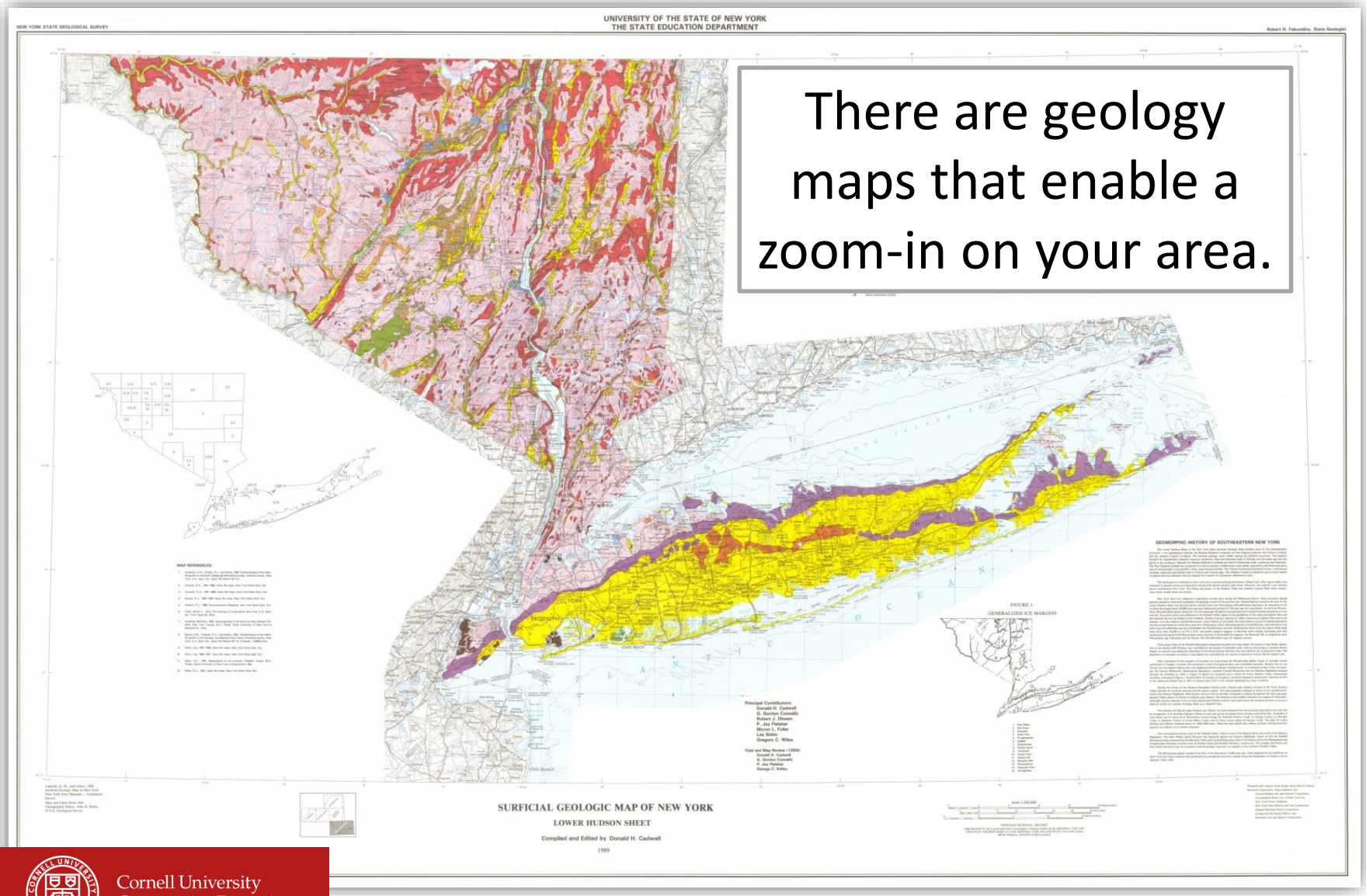
What Does Soil Do?

- It is a natural medium for growing terrestrial plants.
- It regulates and purifies water.
- It recycles nutrients and organic wastes.
- It provides habitat for soil organisms.
- It serves as a physical support for building and construction.

Geology Initially Determines Our Soil



A Closer Look at our Region



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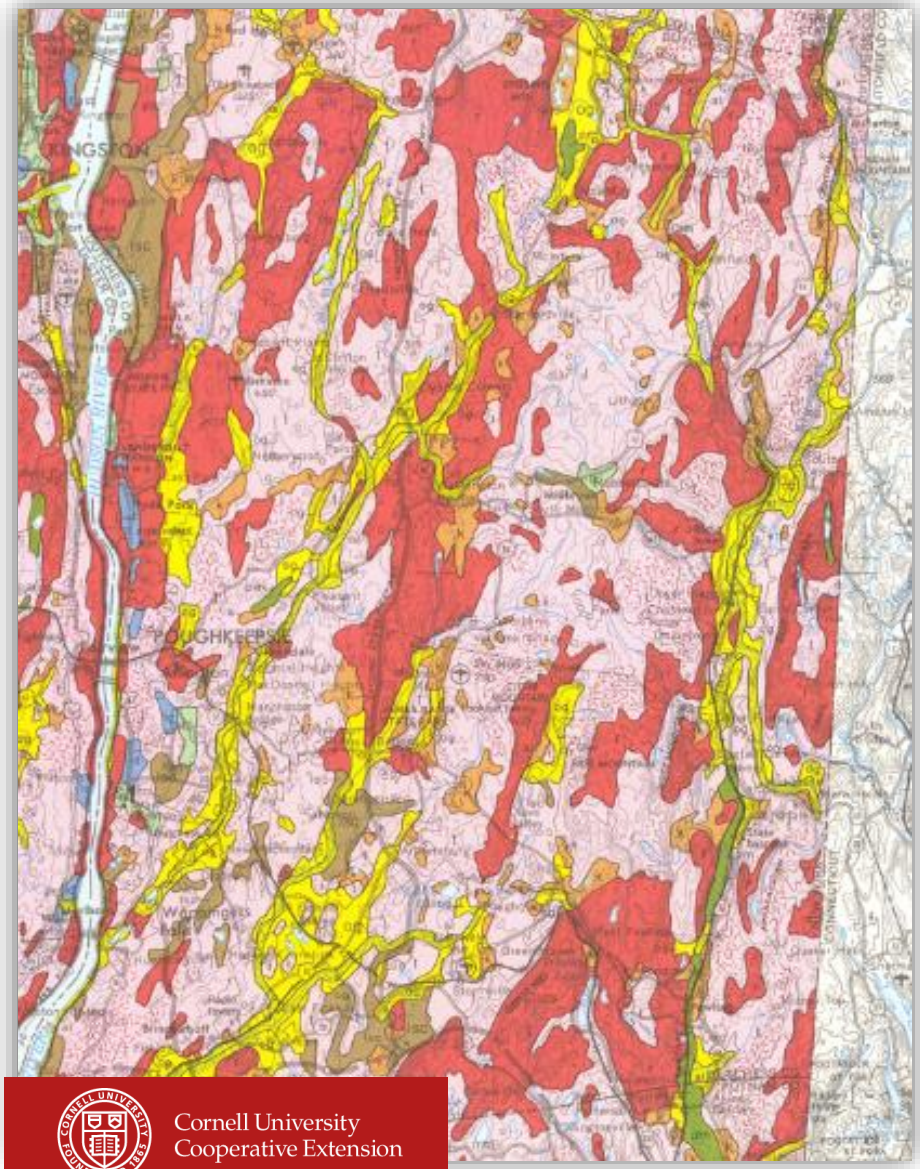
Surficial Geological Map

Dutchess County, NY



pm — **Swamp deposits**
Peat-muck, organic silt and sand in poorly drained areas,
un-oxidized,
may be overlying marl and lake silts,
potential land instability,
thickness generally 2-20 meters.

ld — **Lacustrine delta**
Coarse to fine gravel and sand,
stratified, generally well sorted,
deposited at a lake shoreline,
thickness variable (3-15 meters).

lsc — **Lacustrine silt and clay**
Generally laminated silt and clay,
deposited in proglacial lakes,
generally calcareous,
potential land instability,
thickness variable (up to 100 meters).

ls — **Lacustrine sand**
Sand deposits associated with large bodies of water,
generally a near-shore deposit or near a sand source,
well sorted, stratified,
generally quartz sand,
thickness variable (2-20 meters).

og — **Outwash sand and gravel**
Coarse to fine gravel with sand,
proglacial fluvial deposition,
well rounded and stratified,
generally finer texture away from ice border,
thickness variable (2-20 meters).

km — **Kame moraine**
Variable texture (size and sorting) from boulders to sand,
deposition at an ice margin during deglaciation,
positive constructional relief,
locally cemented with calcareous cement,
thickness variable (10-30 meters).

t — **Till**
Variable texture (e.g. clay, silt-clay, boulder clay),
usually poorly sorted diamict,
deposition beneath glacier ice,
relatively impermeable (loamy matrix),
variable clast content — ranging from abundant well-rounded diverse lithologies in valley tills to relatively angular, more limited lithologies in upland tills, tends to be sandy in areas underlain by gneiss or sandstone,
potential land instability on steep slopes,
thickness variable (1-50 meters).

r — **Bedrock**
Exposed or generally within 1 meter of surface.

Bedrock stipple overprint
Bedrock may be within 1-3 meters of surface,
may sporadically crop out,
variable mantle of rock debris and glacial till.

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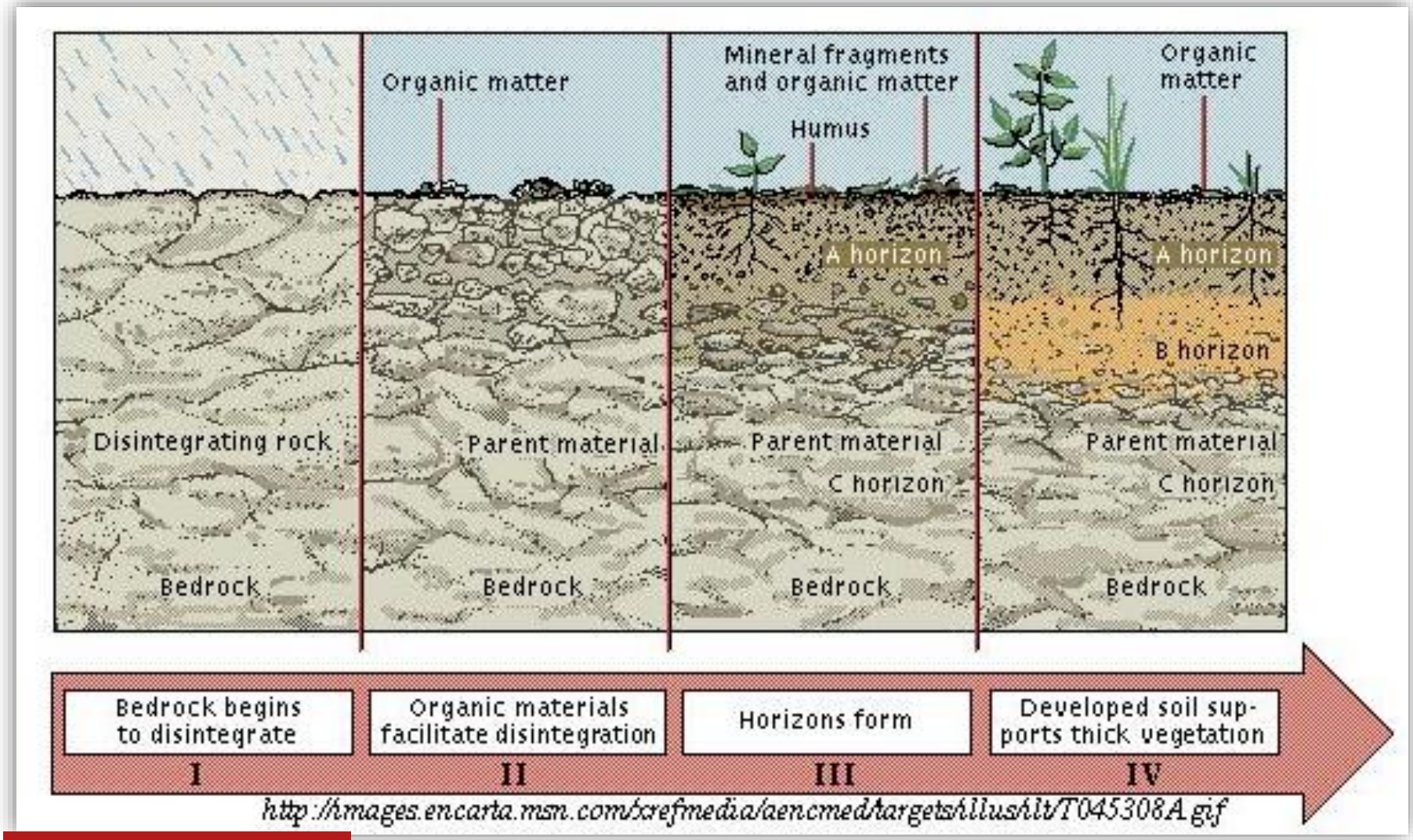
http://www.nysm.nysed.gov/research-collections/geology/gis

Weather Modifies Parent Material

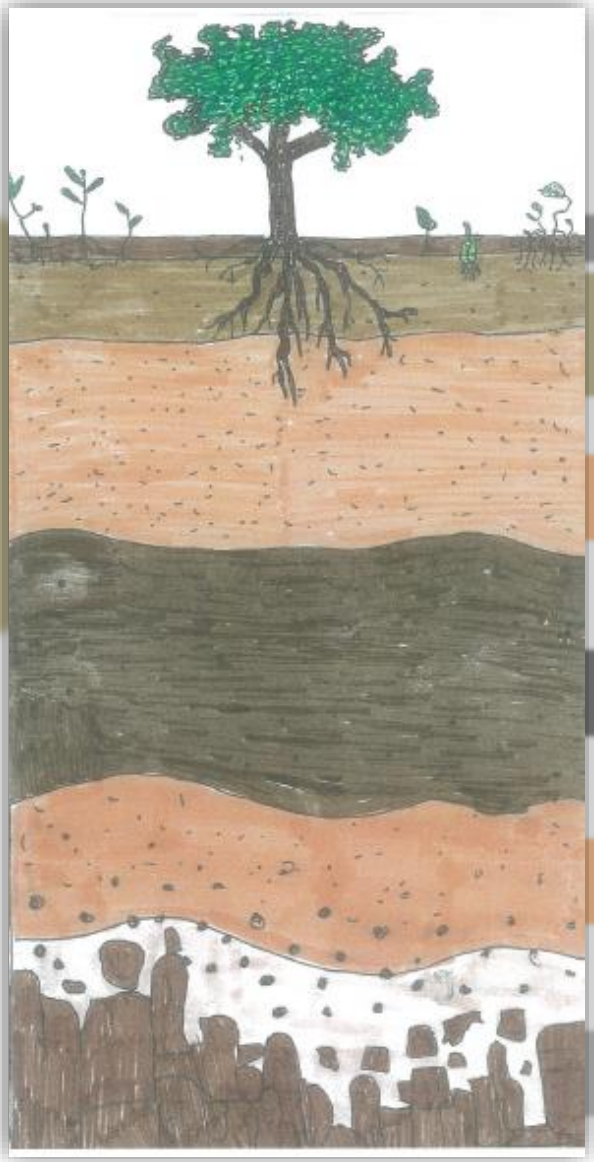


Soil Horizons Form

Top layers are
the most important:

- Location of the roots.
- Area of water retention.
- Area of nutrient exchange.
- Most readily managed.

Not all soils have all
the horizons.



O horizon: leaf litter, OM

A horizon: mineral matter mixed with humus/topsoil

E horizon: sand and silt

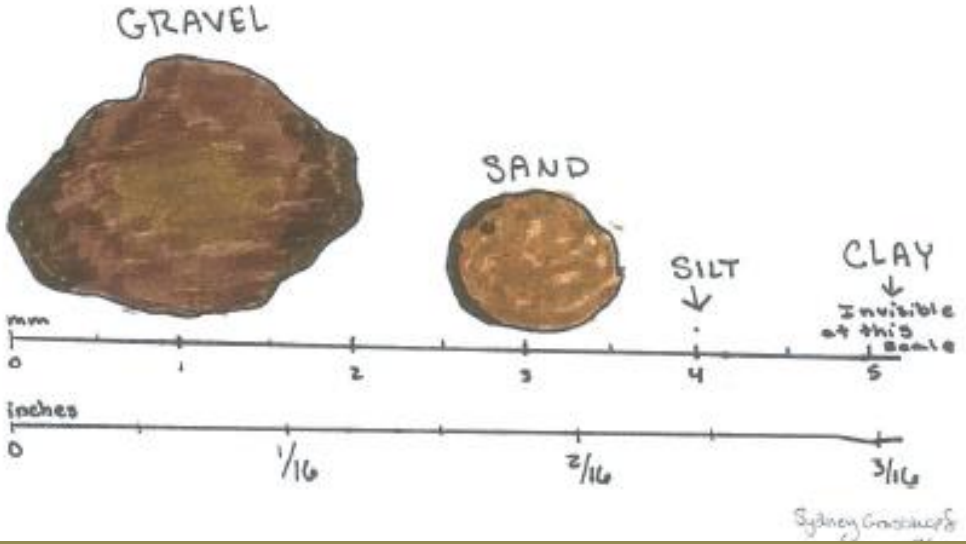
B horizon: subsoil, clay

C horizon: weathered rock

R horizon: bedrock

Soil Texture is Important

- About 45% of soil is minerals of various sizes, representing the soil texture.
- Soil texture is the proportion of sand, silt and clay present in a soil.
- Texture affects drainage, aeration, water holding capacity and nutrient holding/exchanging ability.
- Organic matter does not affect texture.



Soil Texture

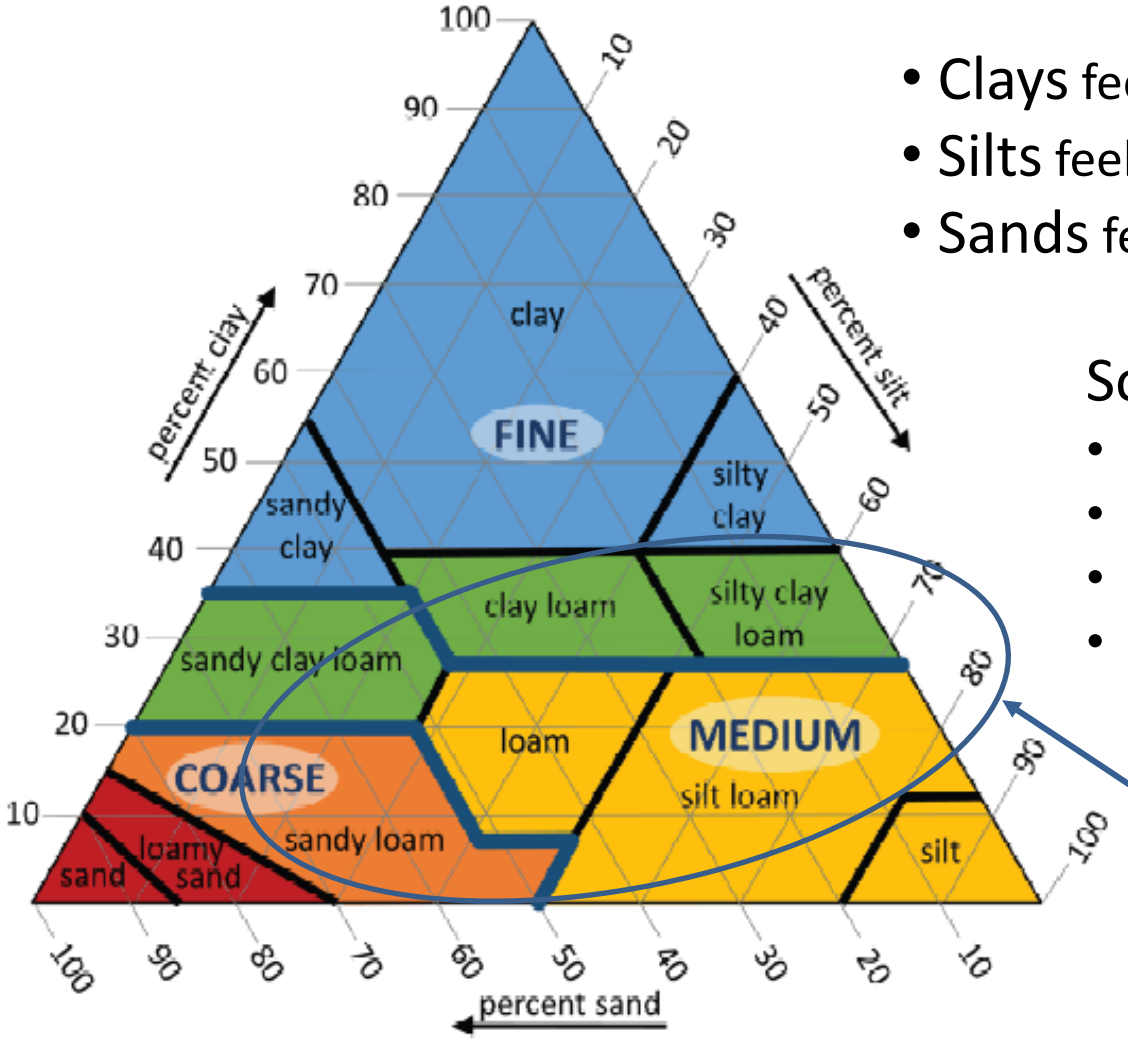


FIGURE 2. Textural triangle used in determining soil textural class.

- Clays feel sticky when wet.
- Silts feel like flour/talcum powder.
- Sands feel gritty.

Soil texture affects:

- Water-holding capacity.
- Susceptibility to erosion.
- Leaching potential.
- Nutrient-retention and exchange capacity.

Loams are best for gardening

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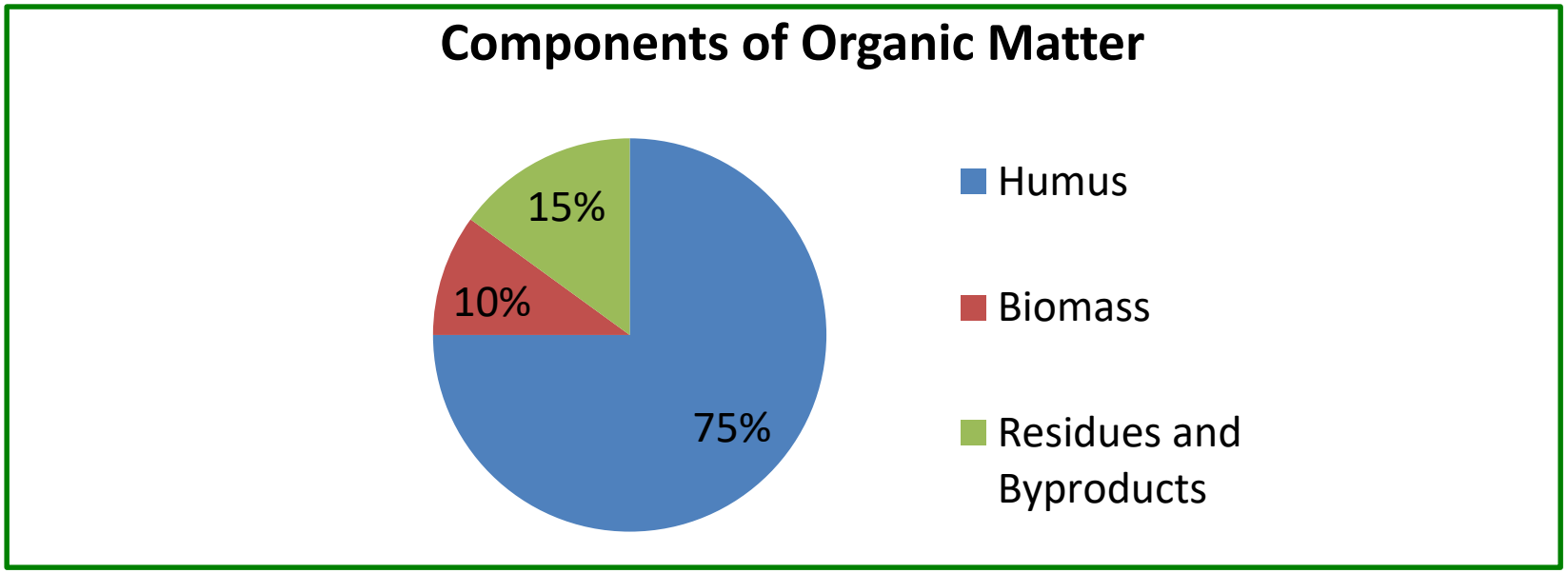
https://soilhealth.cals.cornell.edu/files/2016/12/04_CASH_SH_Series_Texture_Fact_Sheet_040517-10sn6o7.pdf

What is Organic Matter?



5% of the soil is OM:

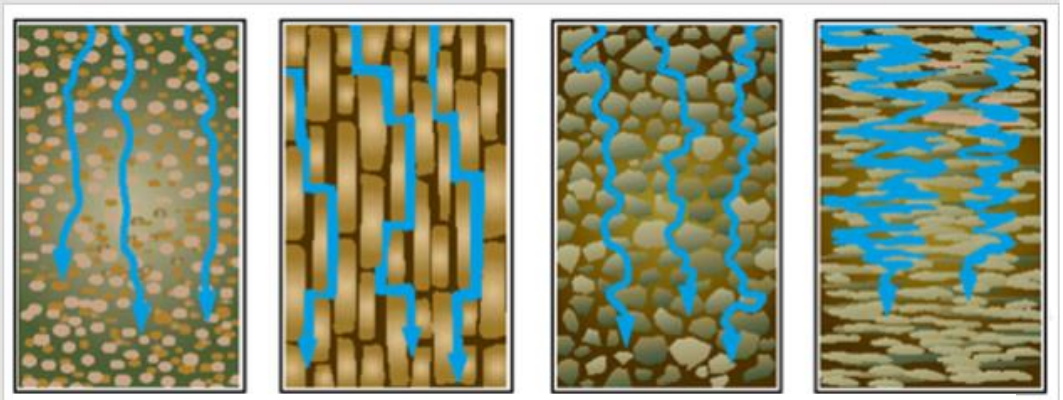
- THE LIVING. **Biomass,** micro/macro organisms and invertebrates.
- THE ALMOST DEAD. **Residues/byproducts**, dead roots, dead remains of soil inhabitants, in varying stages of decomposition.
- THE VERY DEAD. **Humus**, the stable end product of decomposition.

Soil Structure is Key to Health

Soil particles (Minerals & OM) form arrangements of aggregates, also known as peds.

- Aggregate size and stability determine the size of pores.
- Pores provide space for water w/dissolved nutrients, air, biomass.
- Healthy soil has a wide range of aggregate and pore sizes.

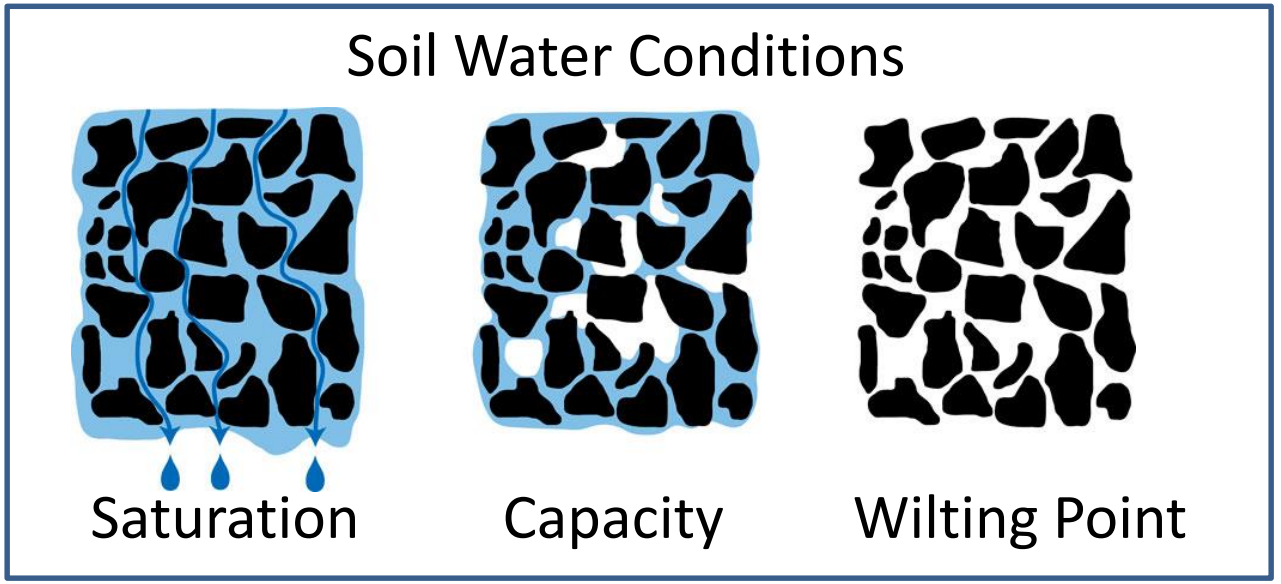
⇒ OM improves soil structures for water, air, biomass, and nutrient movement.



Water movement through different soil structure shapes. Developed by USDA-NRCS.

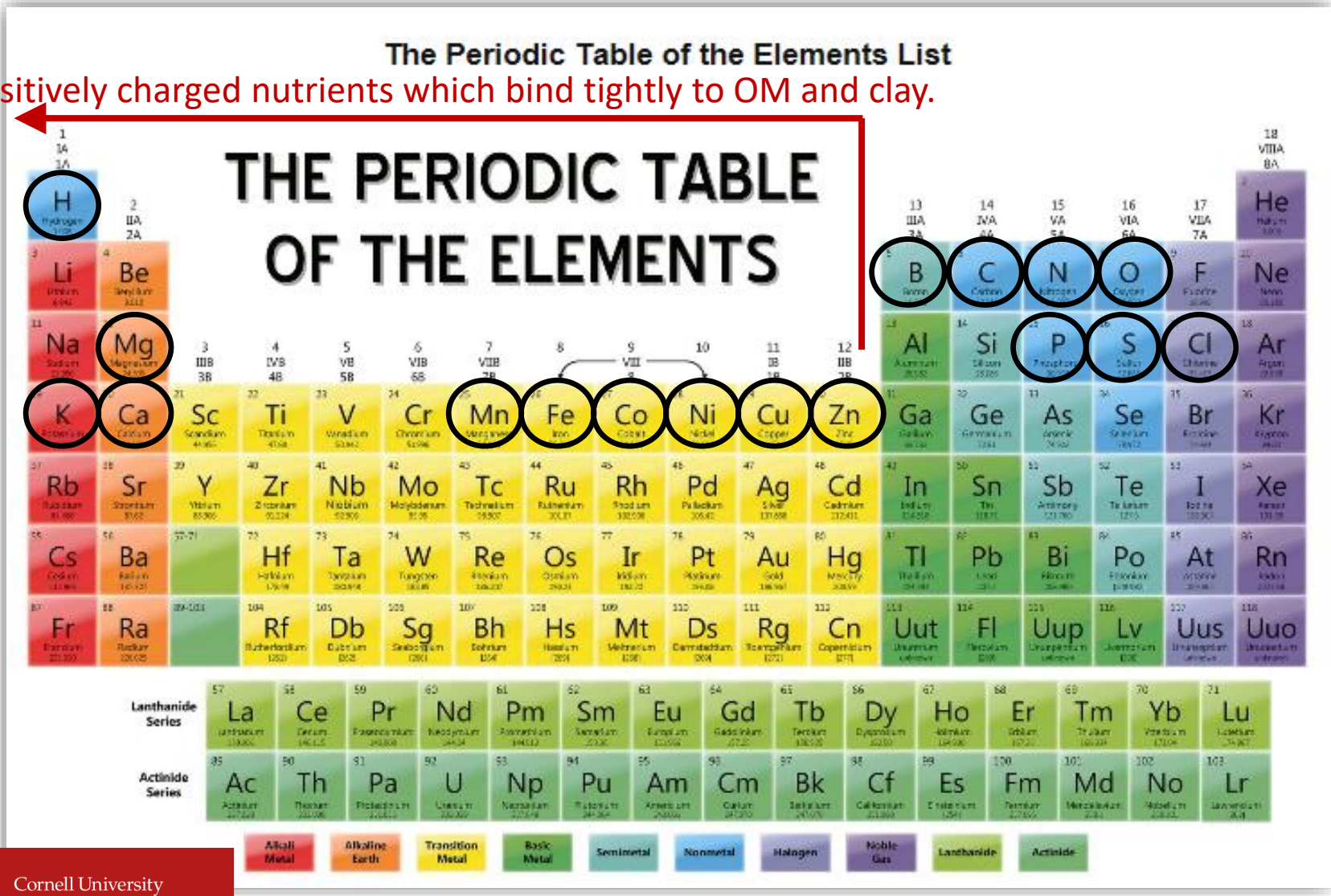
Plants Manage Water

- Plants need the right amount of water. Too little and they wilt. Too much and they rot.
- Plants' ability to regulate water is complex, effective and closely tied to their uptake of nutrients.
- Solutes (dissolved particles) in water seek balance and travel from areas of high concentration to areas of low concentration aided by osmosis and transpiration. These solutes include nutrients.



Essential Plant Nutrients

Positively charged nutrients which bind tightly to OM and clay.



Essential Plant Nutrients

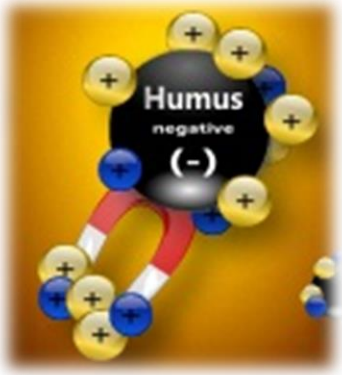
Essential Plant Nutrients			
Type	Element		+/-
Non-Mineral Nutrient	C	Carbon	*
	O	Oxygen	*
	H	Hydrogen	+
Primary Mineral Nutrients	N	Nitrogen	+/-
	P	Phosphorous	-
	K	Potassium	+
Secondary Mineral Nutrients	Ca	Calcium	+
	Mg	Magnesium	+
	S	Sulfur	-
Micro-Nutrients	Fe	Iron	+
	Cl	Chlorine	-
	Mn	Manganese	+
	B	Boron	-
	Zn	Zinc	+
	Cu	Copper	+
	Mo	Molybdenum	-
	Ni	Nickel	+
	Co	Cobalt	+

*neutral

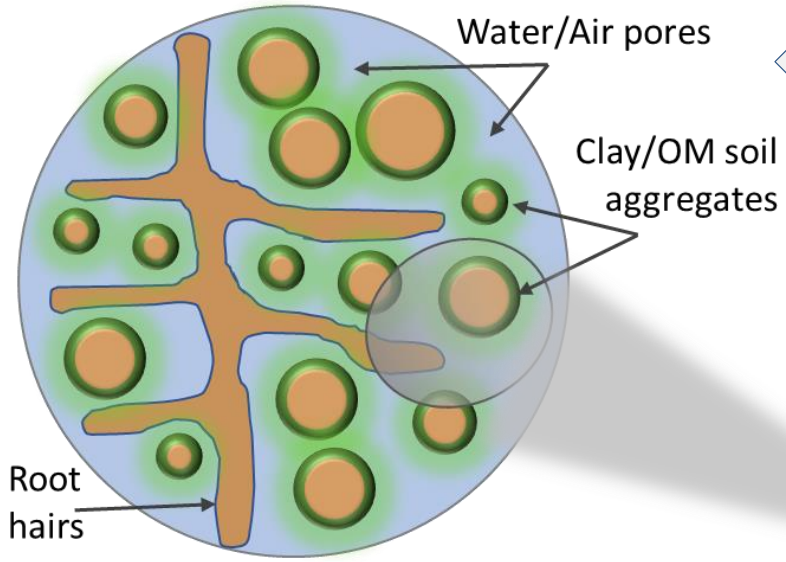
95% of plant weight is C, O, H, and N

- Ions are charged atoms/molecules.
  - Cations: positive charge
  - Anions: negative charge
  - Seek neutrality and will pair up.
- Key nutrients are positively charged: Calcium, Copper, Hydrogen, Iron, Magnesium, Manganese, Nitrogen, Zinc.
- Clay and OM/humus are negatively charged, attracting key nutrients.

⇒ Humus holds nutrients like a magnet!

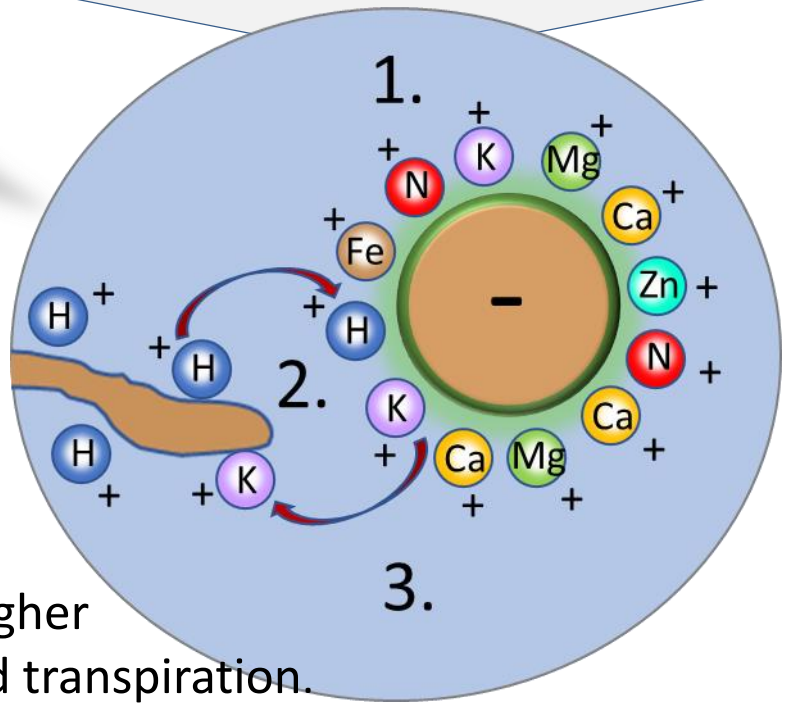


Soil Biochemistry (vastly simplified)



Soil Aggregates

Cation Exchange Capacity



1. Clay particles and humus (- anions) attract positively charged nutrients (+ cations).

2. Nutrients are exchanged for hydrogen ions from the plant root.

3. Mineral nutrients move from regions of higher concentration to lower, aided by osmosis and transpiration.

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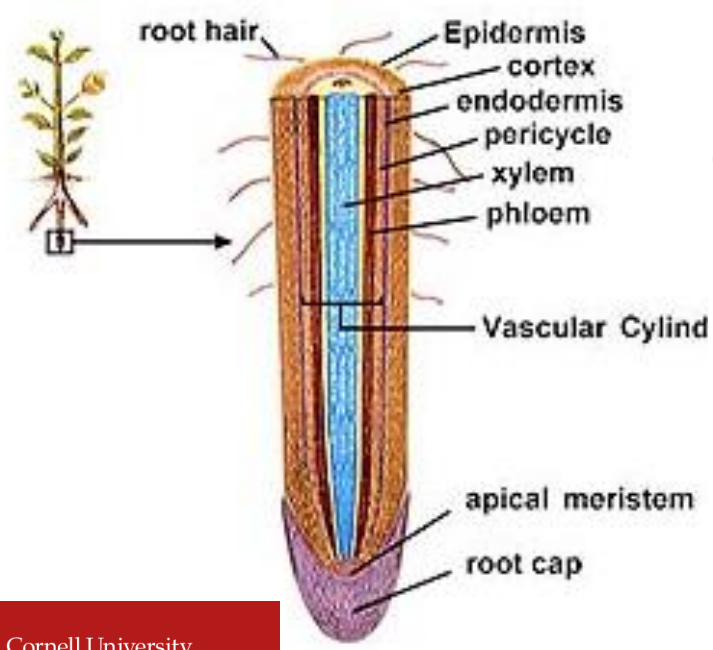
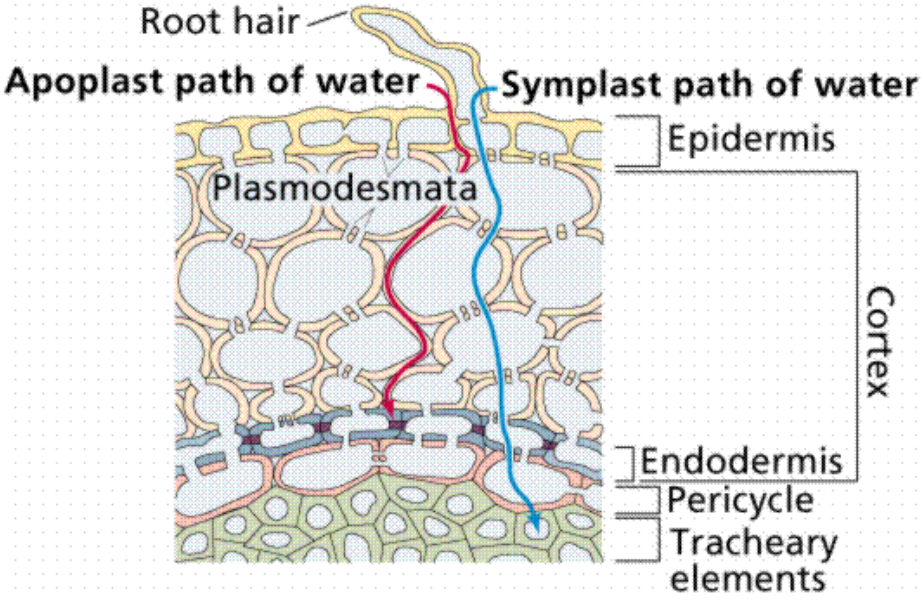
Nutrient Absorption

Plants will absorb needed nutrients via the roots when:

- There are more particles/nutrients outside the roots then inside.
- The soil pH is in proper range.

Note: Extremely acidic or alkaline soil prevents plants from absorbing needed level of nutrients.



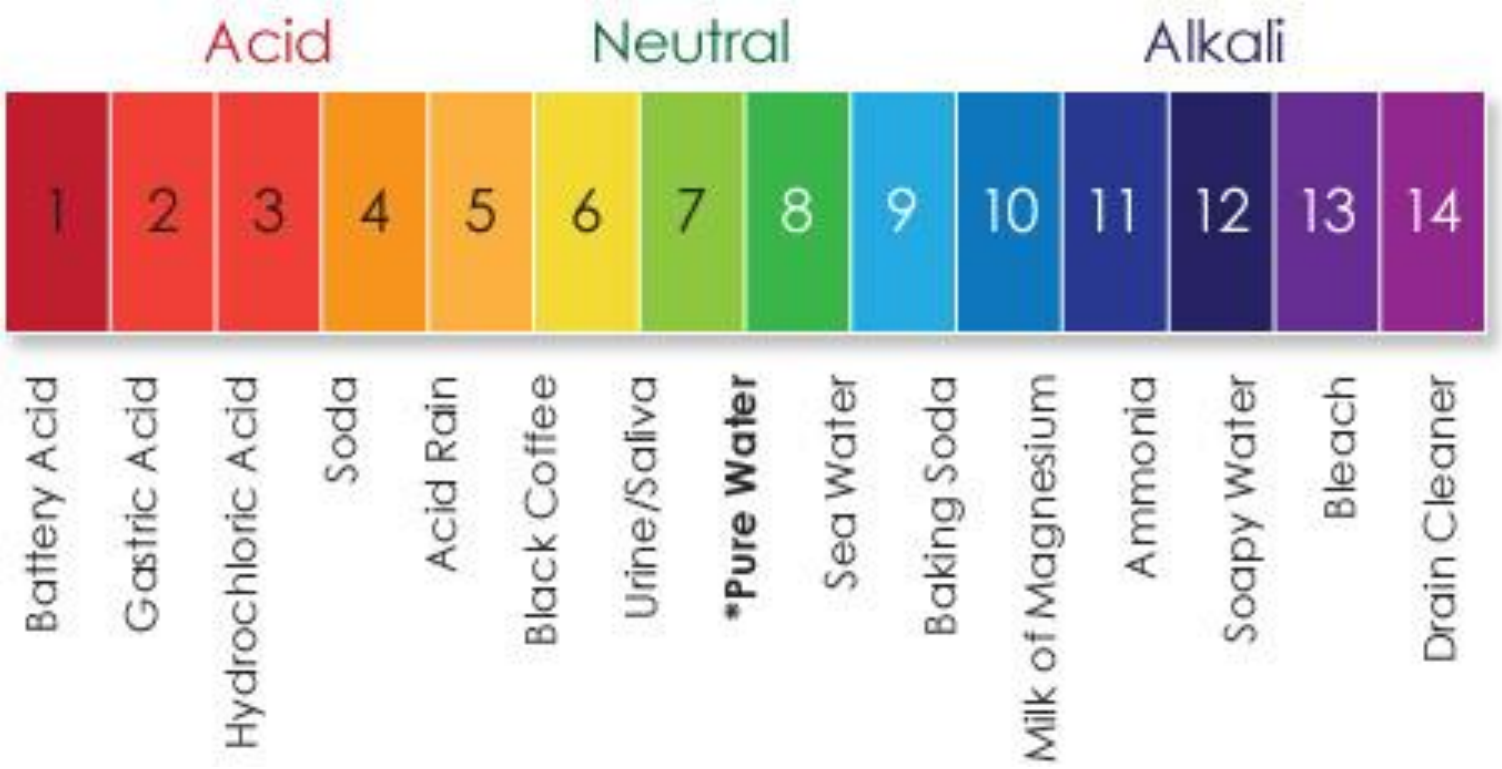


The Effect of pH on Nutrients

- Soil pH (percent Hydrogen) is the measurement of hydrogen ion (H^+) activity in a soil and water solution.
  - Acidic soil has a higher concentration of H^+ ions.
  - Alkaline soil has a higher concentration of OH^- ions.
- Most plant nutrients are not readily available at the extreme ends of the pH scale.
  - In low pH soil, some micronutrients become extremely soluble and ion levels are high enough to injure the plant.
  - In high pH soil, many micronutrients precipitate out of the soil solution and are unavailable to plants.

$\Rightarrow$ The ideal pH for most gardening is 6.0 to 7.0

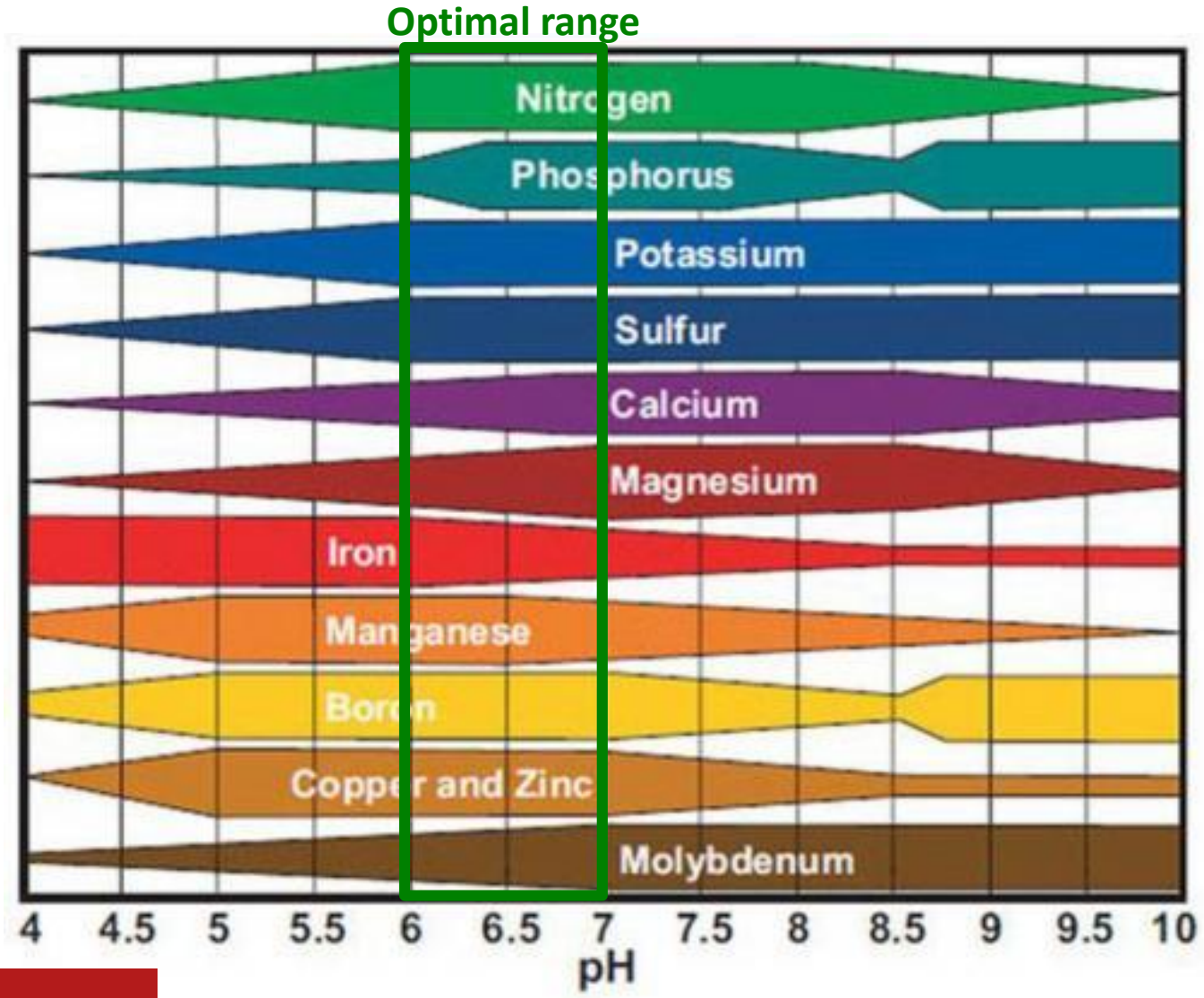
The pH Scale



pH is the probability of Hydrogen (H+) ions in a solution.

- Soil with a pH of 6.9 or below is acidic or sour.
- Soil with a pH of 7.0 is neutral.
- Soil with a pH of above 7.0 is alkaline, sweet or basic.

pH Effect on Nutrient Availability



The Value of Organic Matter in Soil

OM improves soil structure:

- Creates stable granular aggregates and pore spaces.
- Increases both water retention and drainage.
- Increases the amount of air within the aggregates.
- Provides space for biomass, the beneficial soil organisms (fungi, bacteria, nematodes, earthworms, insects, and others).

OM attracts, holds, and releases key nutrients in the soil solution and to the roots.

- OM has the strongest affinity (2-3 times that of clay) to nutrients and maximizes their availability to the root system.

⇒ OM aids decomposition, increases pore space, holds/releases water and attracts/releases nutrients.

Key Messages

- We can reduce solid waste by composting.
- Composting produces organic matter.
- Organic matter (OM) improves soil health:
  - Retains and distributes water more effectively.
  - Attracts, retains and exchanges nutrients more effectively.
  - Promotes healthy plant growth resistant to diseases.

- Soil composition:
  - Minerals (45%)
  - Water (25%)
  - Air (25%)
  - OM (5%)
- Soil structures are aggregates of soil minerals and OM with pores for water and air.
- Clay and OM/humus are negatively charged and attract key positively charged nutrients then make them available for plants to take up through their roots.

Why Compost?

"Because a rind is a terrible thing to *waste"*

Jean Bonhotal
Cornell Waste Management Institute
cwmi.css.cornell.edu

Cornell University
Cooperative Extension

Cornell Home Composting Resources

Web Sites

- Cornell Waste Management Institute
- Cornell Composting Fact Sheets
- Cornell Composting Science & Engineering
- Cornell Composting in Schools

Fact Sheets

- Home Composting Brochure
- Composting at Home – the Green and Brown Alternative
- Basics & Benefits of Composting
- Compost Uses
- Preparation of Food Scraps for Faster Composting
- Welded Wire Cylinder Bin
- Lasagna Composting
- "Stealth" (Indoor) Composting
- Troubleshooting
- Leaf Composting
- Winter Composting
- Vermicomposting
- Vermicomposting - Brochure
- Sources of Composting Worms
- Group Composting
- “Is it done yet?”

Resources

- Cornell Soil Health Assessment Training Manual
- The Maryland Master Gardener Handbook
- PennState Extension Master Gardener Manual
- Cornell Climate Smart Farming Tools - Adaptation Strategy: Soil Health
- Cornell Agronomy Fact Sheet Series: Soil Organic Matter
- Cornell Agronomy Fact Sheet Series: Soil Texture
- Cornell Agronomy Fact Sheet Series: Cation Exchange Capacity (CEC)
- Cornell Solid Waste Management Fact Sheet: Soil Contaminants and Best Practices for Healthy Gardens
- Cornell Healthy Soils, Healthy Communities