



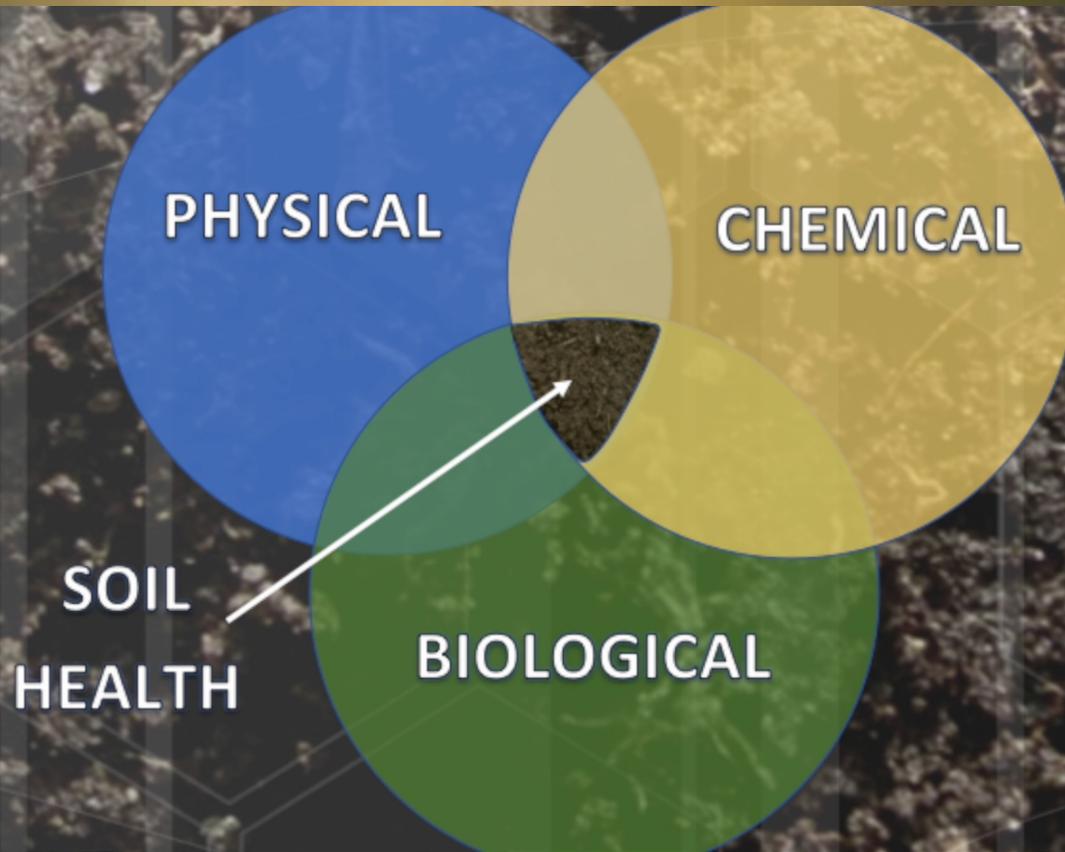
Soil Health - 3 Ways

Physical – Chemical - Biological



ctnofa
Creating an Organic CT Since 1982







Week 2

Biological Properties of Soil





Biological properties of soil

Soil Health and Nutrition in Food

Dead vs. Living Soil

Microbes in our Soil

Life in Compost

Compost Tea and Compost Extract

Summary of Soil Health Practices



WHAT IS SOIL HEALTH?

THE CONTINUED
CAPACITY OF THE SOIL
TO FUNCTION AS A
VITAL LIVING ECOSYSTEM
THAT SUSTAINS PLANTS,
ANIMALS, AND HUMANS

JOHN KEMPF OF ADVANCING ECO-AGRICULTURE

- “BIOLOGY SUPERSEDES CHEMISTRY”
 - YOUR CROPS CAN BE SUCCESSFUL WITHOUT CHEMISTRY AS LONG AS YOU HAVE ABUNDANT MICROBIAL COMMUNITIES.
 - YOUR CROPS CAN NOT BE SUCCESSFUL WITHOUT BIOLOGY EVEN IF YOUR MINERALS ARE WELL BALANCED.

Soil Health and Nutrition in Food



"In nature's economy
the currency is not
money - it is life."

—Environmental Activist, Vandana Shiva

Vandana Shiva

Soil Health and Nutrition in Food



Testing shows that there is a huge variation in the vitamin and mineral content of food, regardless of variety, depending on where and how they were grown and harvested.



HortScience

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Declining Fruit and Vegetable Nutrient Composition: What Is the Evidence?

Donald R. Davis^{1,2,3}

UT News

The University of Texas at Austin



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[UT News](#) > [Press Releases](#) > [Study suggests nutrient decline in garden crops over past 50 years](#)

Study suggests nutrient decline in garden crops over past 50 years

Dec. 1, 2004

Dirt Poor: Have Fruits and Vegetables Become Less Nutritious?

SCIENTIFIC
AMERICAN

Because of soil depletion, crops grown decades ago were much richer in vitamins and minerals than the varieties most of us get today

Nutrient Density in Food

Changes in food composition for 43 garden crops from 1950 to 1999					
Vitamin C	Vitamin B2	Protein	Iron	Calcium	Phosphorus
					
15%	38%	6%	15%	16%	9%
<small>Davis, D. R., Epp, M. D., & Riordan, H. D. (2004). Changes in USDA food composition data for 43 garden crops, 1950 to 1999. <i>Journal of the American College of Nutrition</i>, 23(6), 669-682</small>					

Mineral	1914	1963	1992	% Decline
Calcium	13.5 mg.	7.0 mg.	7.0b mg.	-48.15
Phosphorus	45.2 mg.	10.0 mg.	7.0 mg.	-84.15
Iron	4.6 mg.	0.3 mg.	0.18 mg.	-96.09
Potassium	117.0 mg.	110.0 mg.	115.0 mg.	-1.71
Magnesium	28.9 mg.	8.0 mg.	5.0 mg.	-82.70

ORGANIC VS CONVENTIONAL

		Minerals (in milliequivalents)						
Vegetables	Type of Soil Management	Calcium	Magnesium	Potassium	Sodium	Manganese	Iron	Copper
Snap Beans								
	Organic	40.5	60.0	99.7	8.6	60.0	227.0	69.0
	Conventional	15.5	14.8	29.1	0.0	2.0	10.0	3.0
Cabbage								
	Organic	60.0	43.6	148.3	20.4	13.0	94.0	48.0
	Conventional	17.5	15.6	53.7	0.8	2.0	20.0	0.4
Lettuce								
	Organic	71.0	49.3	176.5	12.2	169.0	516.0	60.0
	Conventional	16.0	13.1	53.7	0.0	1.0	1.0	3.0
Tomatoes								
	Organic	23.0	59.2	148.3	6.5	68.0	1938.0	53.0
	Conventional	4.5	4.5	58.6	0.0	1.0	1.0	0.0
Spinach								
	Organic	96.0	293.9	257.0	69.5	117.0	1584.0	0.0
	Conventional	47.5	46.9	84.0	0.8	1.0	19.0	0.5

Research conducted by Firman E. Bear at Rutgers University in the Natural Gardener's Catalog (1995)



Biological properties of soil

Soil Health and Nutrition in Food

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Microbes in our Soil

Life in Compost

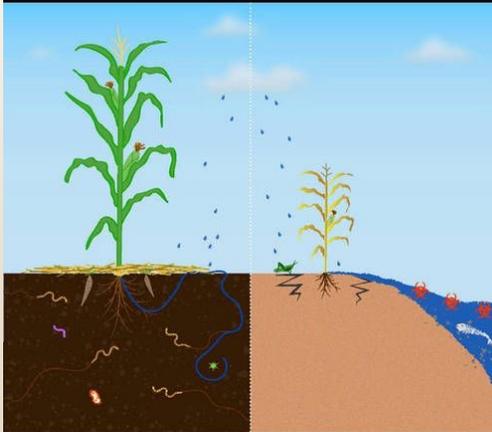
Compost Tea and Compost Extract

Summary of Soil Health Practices

LIVING SOIL VS. DEAD SOIL

WHY SOIL MATTERS TO FARMERS AND THE ENVIRONMENT

An entire world that feeds us lives beneath our feet. Healthy soil holds a wealth of organic matter made up of worms, good bacteria, fungi and other microorganisms that work together to help crops thrive. When soil life is disturbed or unprotected, it becomes difficult for these natural soil builders to be productive and for farmers to grow their crops. Building rich, diverse, and healthy soil ecosystems is a critical life-giving farming practice. Luckily, caring for soil is one of the most effective time-tested ways farmers can increase crop yields while protecting our natural resources.



LIVING SOIL

EARTHWORMS - create vital water channels as they burrow through the soil. These channels allow rain to soak into the soil, where it can help crops grow. Earthworms also add important nutrients to the soil.

RESIDUE - or stubble from previous crops, acts like a garden mulch. It helps soil retain moisture, suppresses weeds, and prevents erosion and contaminated runoff and reduces flooding.

MICROORGANISMS - such as bacteria and fungi, help to filter contaminants and stabilize the soil to prevent erosion. They help form the glue that keeps soil intact.

COVER CROPS - are grown for the purpose of improving soil health. Cover crops deliver natural fertilizer to the soil, prevent erosion, and increase biodiversity. Their roots also create pores in the soil for better water infiltration.

DEAD SOIL

BARE SOIL - without any residue or cover is unprotected from the elements. As a result, it cracks and turns hard and dusty, more like concrete than soil. Water cannot reach the crops' roots to grow effectively. Instead, the sticky dirt becomes runoff that flows right off the field.

EROSION - is more likely to occur from unhealthy and unprotected soils. When soil from fields runs off into nearby streams, it can cause health problems and harm fish and other wildlife.

INCREASED CHEMICALS - like dangerous fertilizers and pesticides, are notorious inputs that crops from unhealthy soils now rely on to grow. These chemicals can cause serious health and environmental problems if they contaminate water.

PESTS - such as insects or weeds, are more likely to invade fields when the soil ecosystem is too weak to defend itself.

Credit: Sarah Bahr, NRDC Policy and Defense Council. Downloaded from www.nrdc.org on 04/11/2016.



DEAD SOIL

BARE SOIL: UNPROTECTED, TURNS SOIL HARD, NON-POROUS

EROSION: NOTHING HOLDING SOIL IN PLACE

INCREASED CHEMICALS: DANGEROUS FERTILIZER AND PESTICIDE INPUTS THAT CROPS RELY ON TO GROW

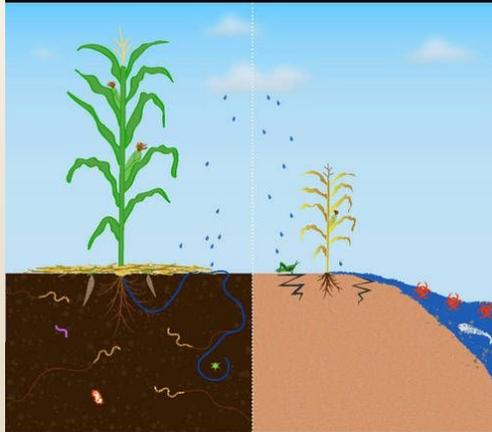
PESTS: INSECTS AND WEEDS MORE LIKELY TO INVAD



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Credit: Sarah Bales, NRDC's Precision Agriculture Council. Downloaded from www.nrdc.org.



LIVING SOIL

EARTHWORMS: ADD NUTRIENTS, CREATE WATER CHANNELS

RESIDUE: FROM PREVIOUS CROPS, ACTS AS MULCH, ORGANIC MATTER

MICROORGANISMS: STABILIZE THE SOIL, FEEDS PLANTS

COVER CROPS: IMPROVE SOIL HEALTH, ADDS NUTRIENTS



Cover Crops: any crop used to cover and protect the surface of the soil and prevent erosion.

Green Manures: anything grown specifically to feed the soil; anything chopped up and turned into soil.

Green manures have 2 main benefits:

- **When incorporated at the succulent stage (pre flowering)** the crop *decomposes quickly and acts primarily as a fertilizer* for the “follow crop, in our area usually a summer or fall crop.
- **When incorporated at a more mature stage (half to full bloom)** with a higher carbon content, *it adds to the organic matter content* of the soil. In this instance nutrients are stored in the reservoir of humus and released slowly over a number of years.



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Microbiologists estimate that there may be as many as 1,500,000 species of soil fungi, and 3,000,000 species of soil bacteria

... most agricultural soils have no more than 5,000 species present



BIONUTRIENT
Food Association

Symbiotic Relationship

“In nature, plants produce sugar (through photosynthesis) that is then fed by the plant (through its roots) to beneficial micro-organisms; namely bacteria and fungi...

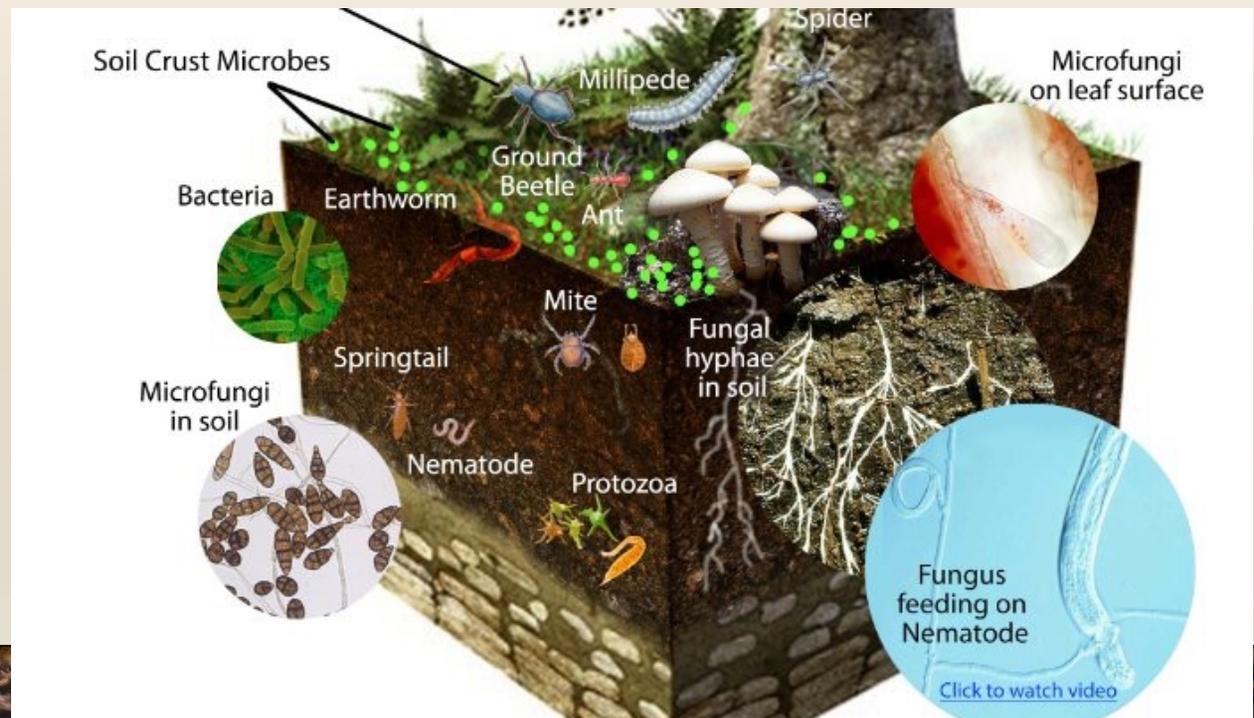
Visit <http://bionutrient.org>



Symbiotic Relationship

...These microbes use that sugar to reproduce and access minerals out of the soil. These minerals are digested and then fed back into the plant.

This symbiotic relationship is at the core of soil fertility.”

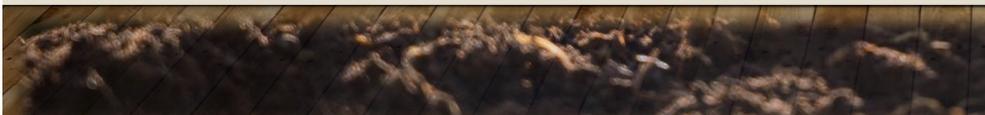


CAKES AND COOKIES

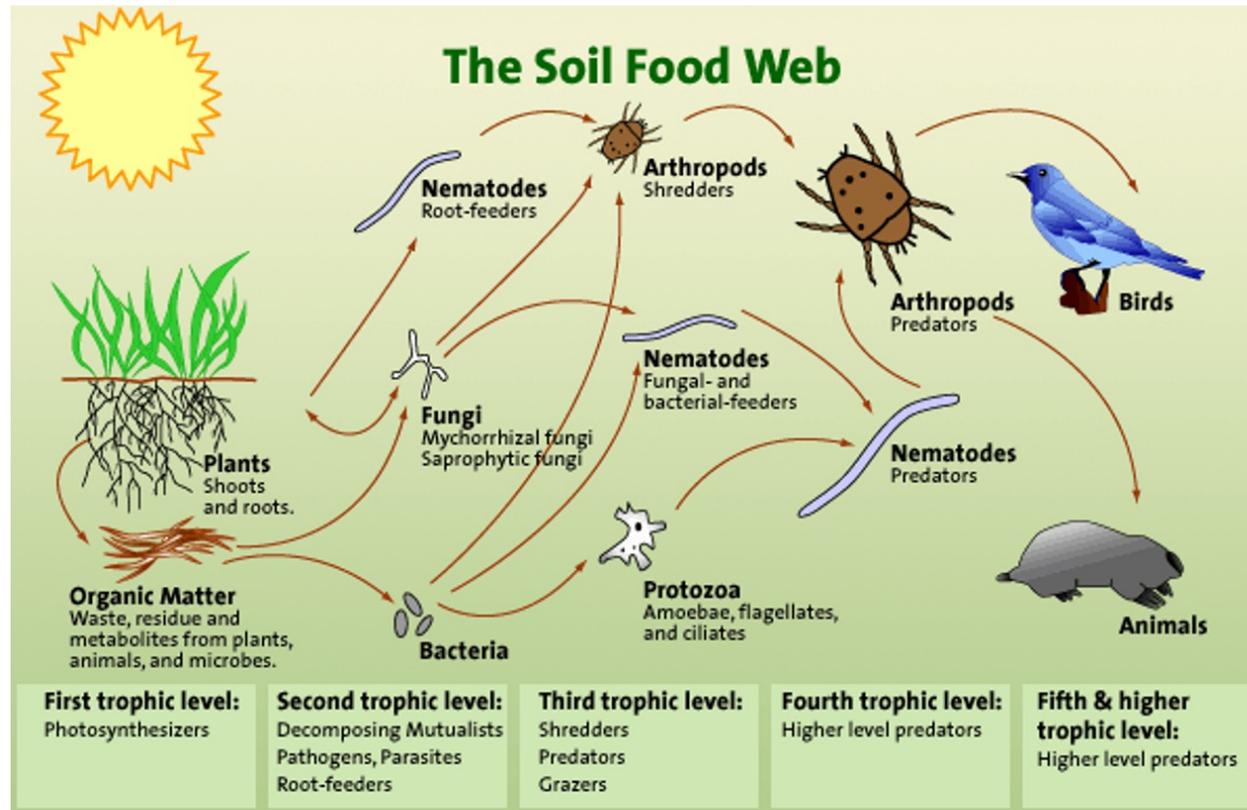
- “Roots release ‘Cakes and Cookies’ to feed microbes to:
 - protect the root system from diseases and pests
 - enhance nutrient cycling
 - build structure to allow roots to grow”
- From the book ‘Adding Biology by Dr. Elaine Ingham.
- *(Diagram Courtesy of Soil Foodweb)*



PLANTS FEED MICROBES
Exudates of Protein, Carbohydrates and Sugar
“Cake and Cookies”

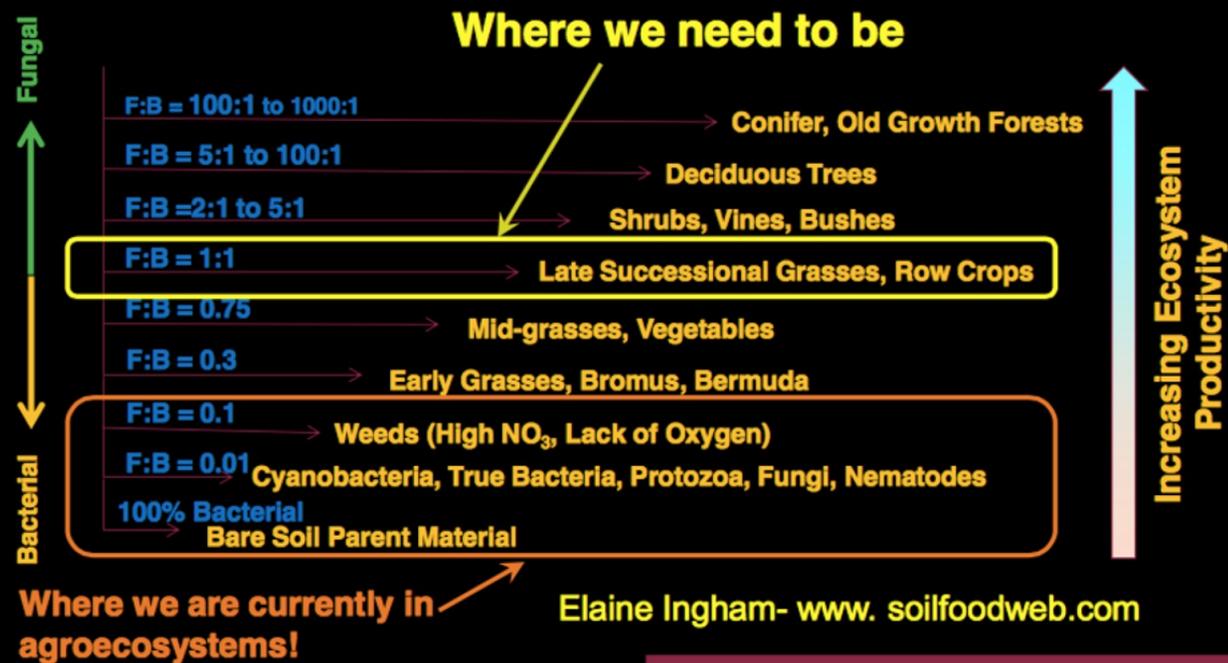


“The soil beneath us is alive! There are more organisms in a teaspoonful of healthy soil than there are people on earth.”

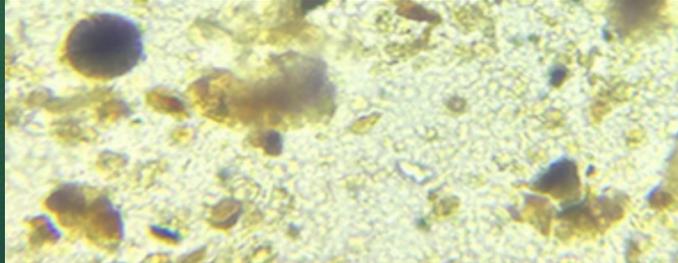


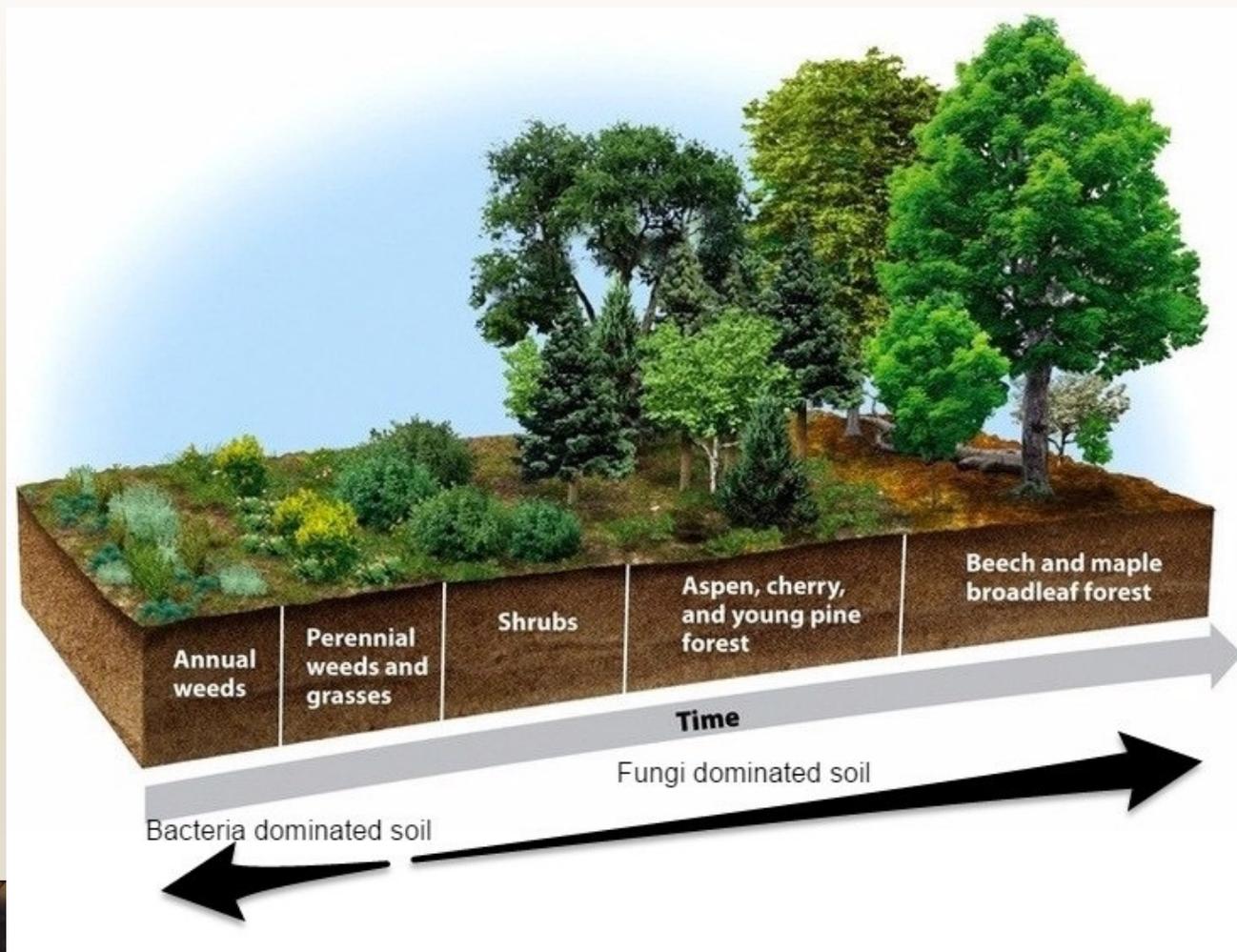
USDA's Natural Resources Conservation Services 'Soil Biology Primer'

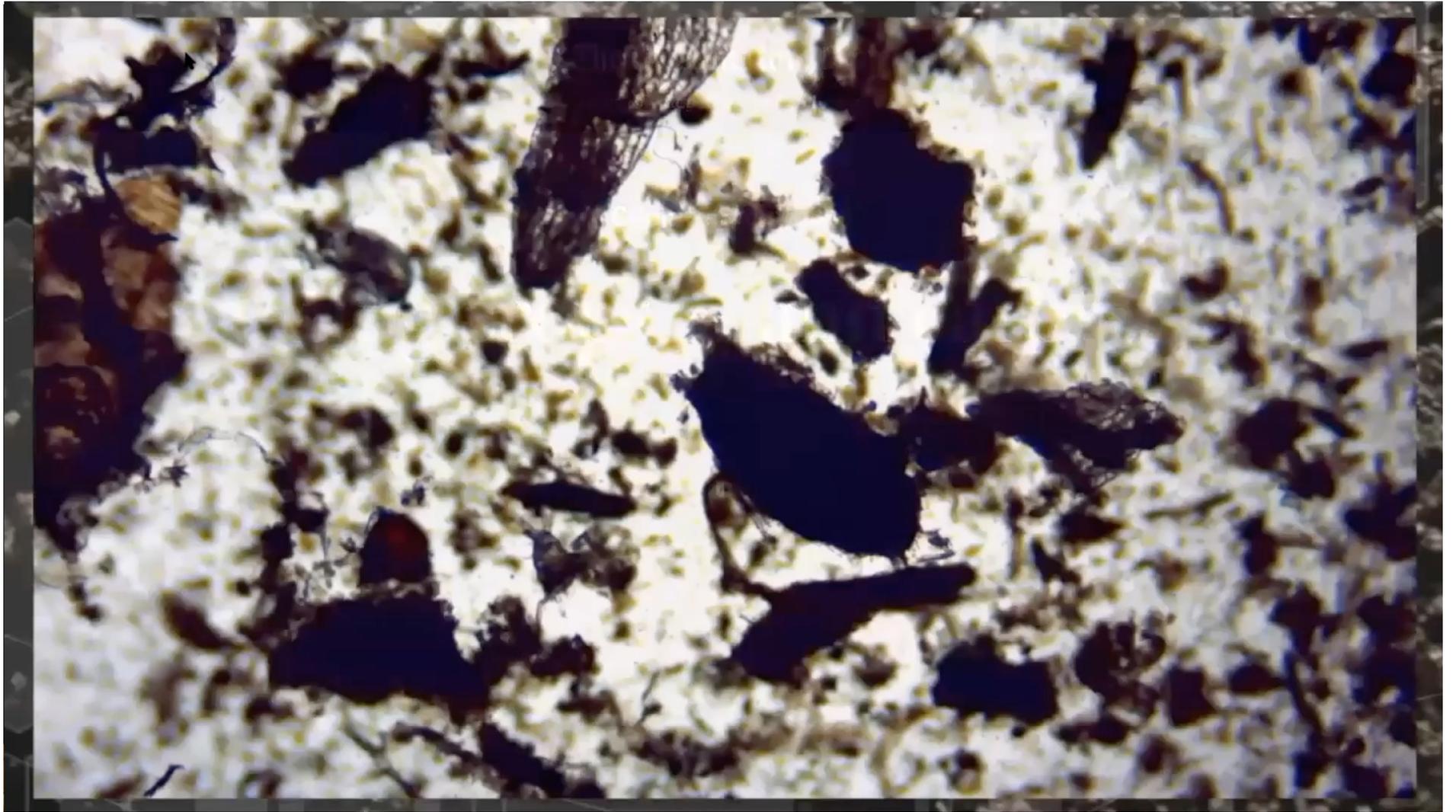
Different plants need different soil microbe communities



Different plants need different soil microbes







Microbes that thrive in anaerobic conditions



CILIATE 200X

Microbes that thrive in anaerobic conditions



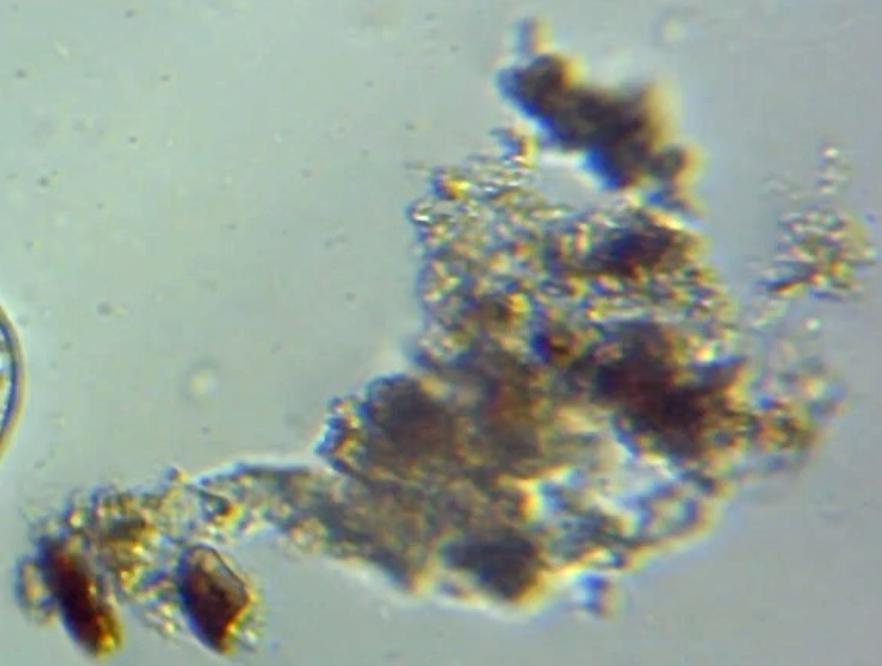
CILIATES 100X

Microbes that thrive in anaerobic conditions



Ciliates taking over

Microbes that thrive in anaerobic conditions



VORTICELLA (STALKED CILIATE)

Microbes that thrive in anaerobic conditions



VORTICELLA (STALKED CILIATE)

Microbes that thrive in anaerobic conditions

Insect Larvae



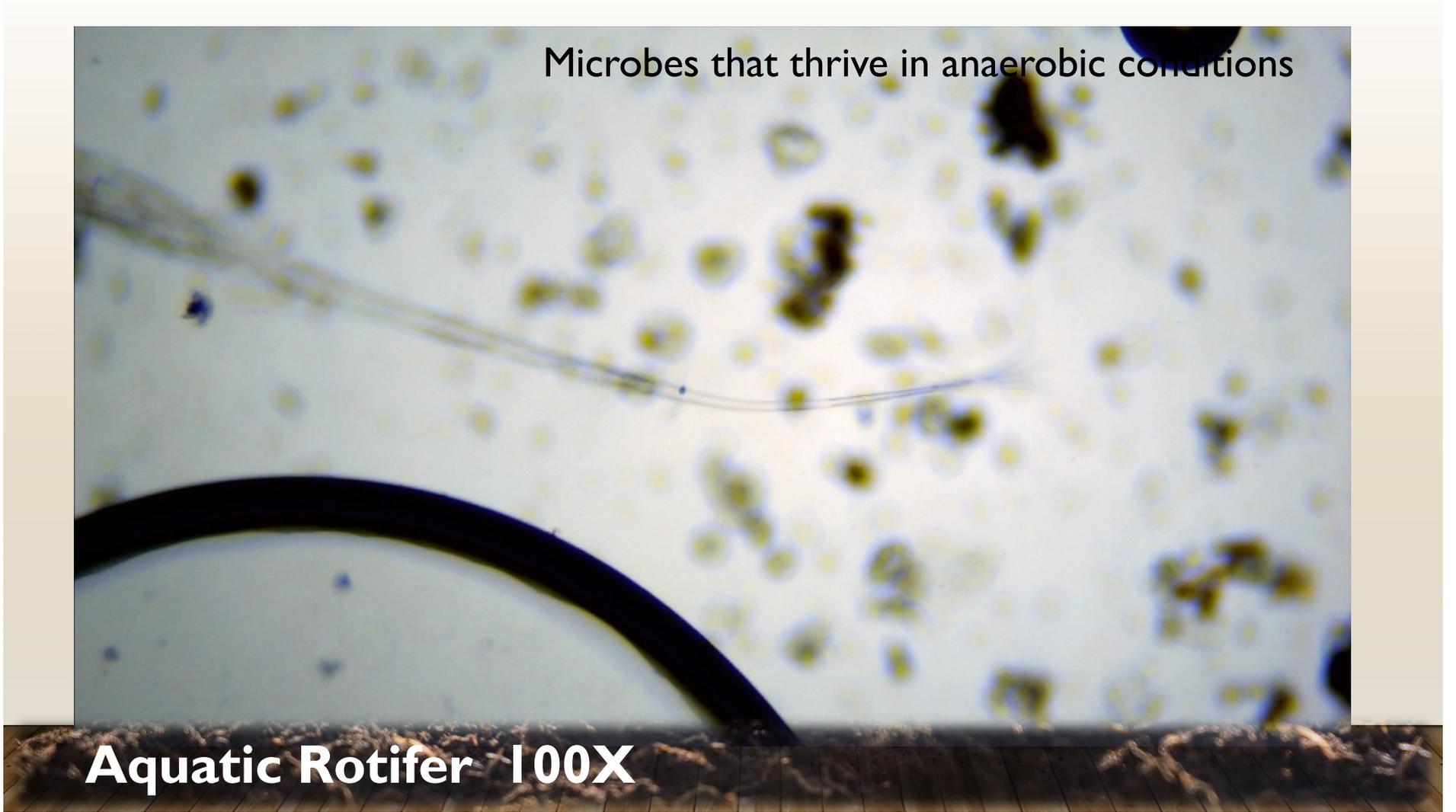
Microbes that thrive in anaerobic conditions



Rotifer

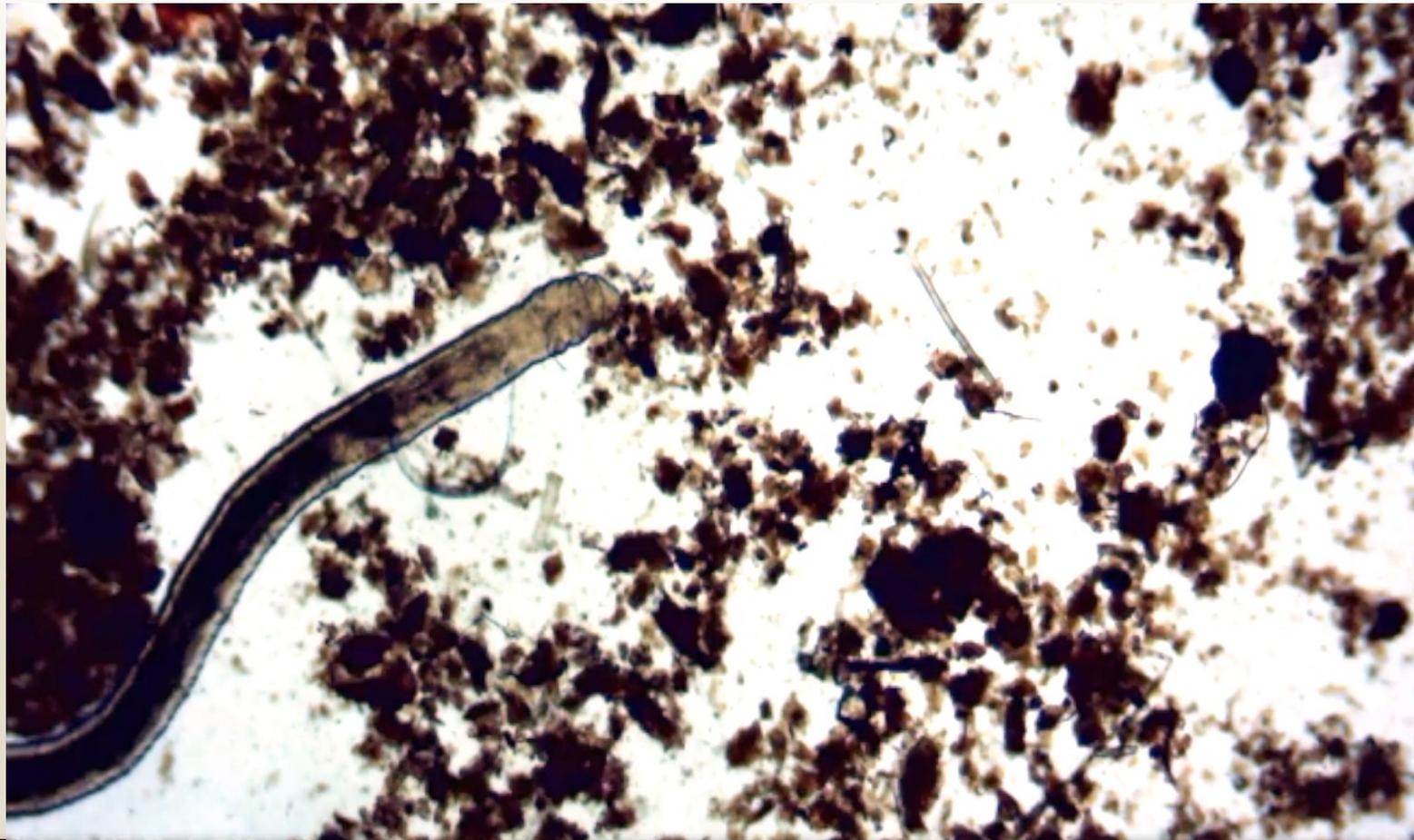
Microbes that thrive in anaerobic conditions

Aquatic Rotifer - 100X

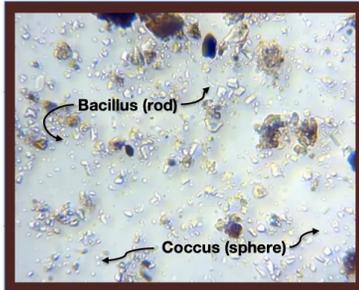




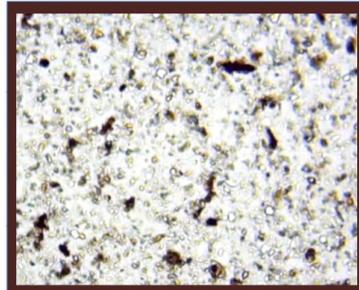
Microscopy Training at Bard College at Simon's Rock



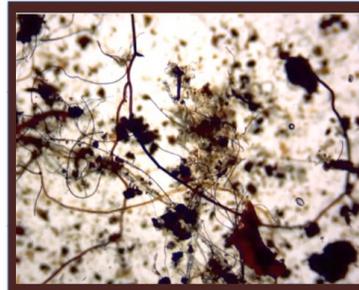
Baby pot worm, Nematode, Fungal Hyphae



BACTERIA



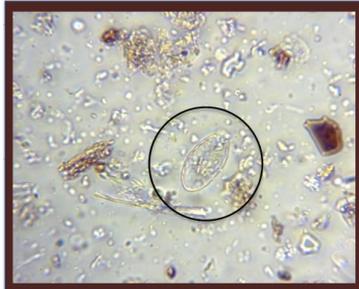
BACTERIAL DOMINANT SOIL



FUNGAL DOMINANT SOIL



FUNGAL HYPHAE



TESTATE AMOEBEA



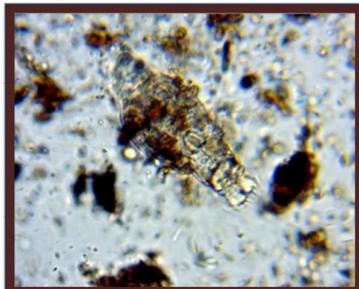
BACTERIAL FEEDING NEMATODE



FUNGAL FEEDING NEMATODE



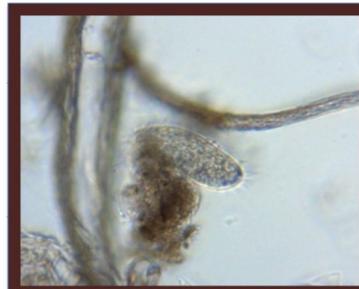
MICROARTHROPOD



ROTIFER



INSECT LARVAE



CILIATE



STALKED CILIATE



Mac Litishin (farmer at Greenagers, Egremont MA)

ADDING BIOLOGY

In Soil and Hydroponic Systems

For Conventional, Sustainable and Organic
Plant Growing Systems

*Outdoor Applications and Indoor Controlled Environments
In Soil and Soilless Media*

Elaine R. Ingham, Ph.D.

Carole Ann Rollins, Ph.D.

“The only way to get things back in balance is to introduce the full spectrum of beneficial biology back into our growing systems through inocula such as occur in properly made compost, worm castings and compost teas.”

Dr. Elaine Ingham



Build up the Soil Food Web by:

Add organic matter in the form of compost and mulches





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COMPOST UNDER THE MICROSCOPE



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Compost Tea:

Compost tea is the result of aerobically brewing compost in water with added amendments to produce a highly nutritious food source for your plants



Compost Extract:

Compost Tea

Compost extract is compost suspended in water, no amendments added.

Microbes are released into the water, which is then added to plants



Compost Tea

Compost Tea vs. Compost Extract:

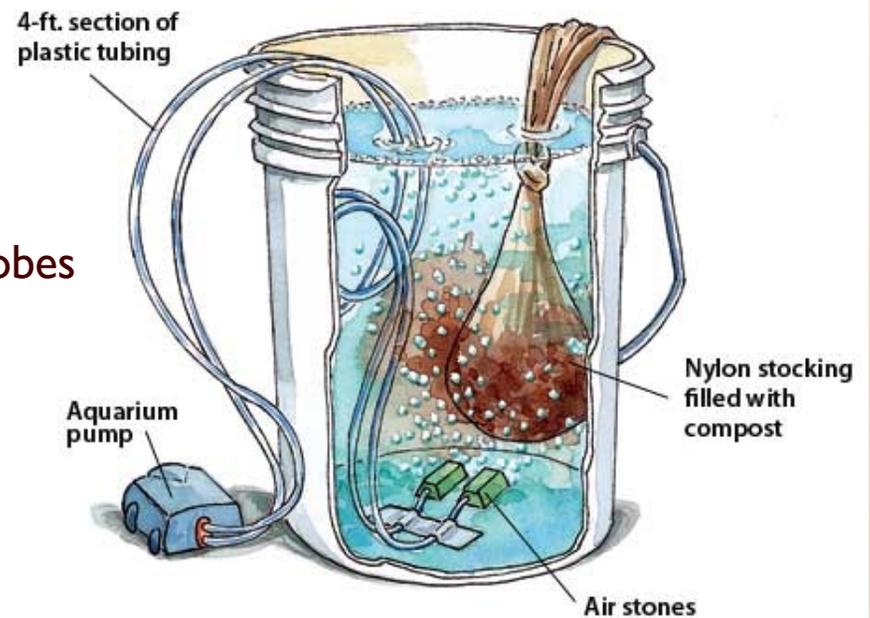
Compost tea is actively aerated (usually for 24 hours)

Compost and amendments are added

Oxygen is added with an electrical pump

Microbes consume the amendments and multiply

The finished liquid is teeming with beneficial microbes



Potential Benefits of Compost Tea

“Water retention in soil is improved, reducing water use by up to 70% in the first year in some cases.”



Dr. Elaine Ingham

Potential Benefits of Compost Tea

“Plants take up nutrients needed to resist infection more rapidly.”

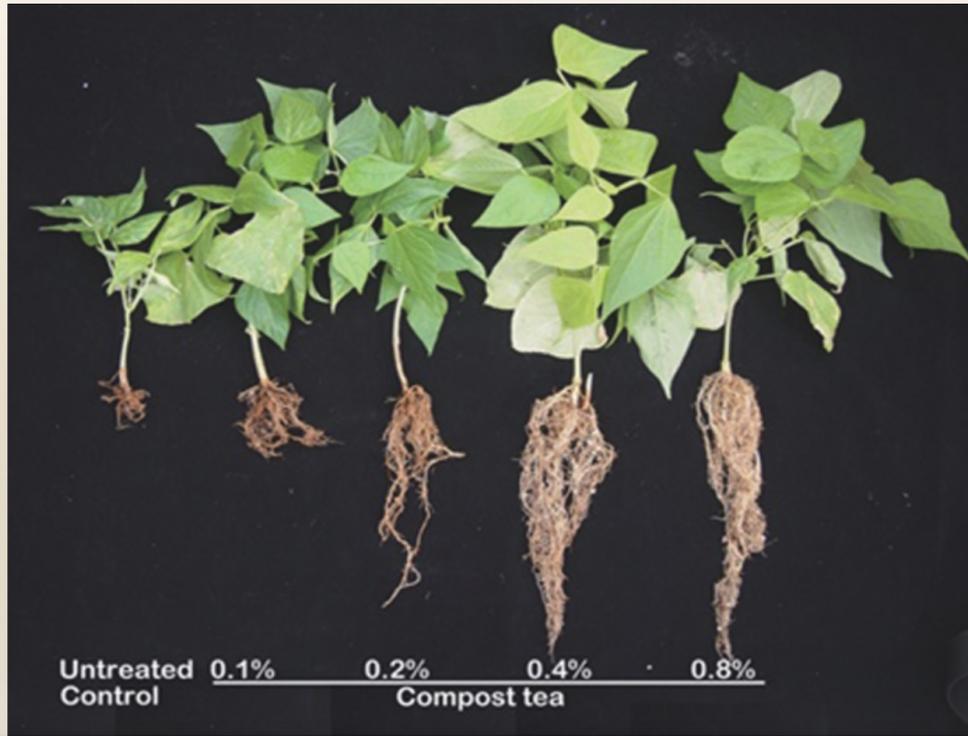


Dr. Elaine Ingham



Potential Benefits of Compost Tea

“Rooting depth of the plants is increased, increasing the nutrients the plant can access.”



Dr. Elaine Ingham



Potential Benefits of Compost Tea

“Decomposition of dead plant material and toxins is increased.”



Dr. Elaine Ingham

Potential Benefits of Compost Tea

- “Chemical-based pesticides, herbicides and fertilizers are no longer used, and beneficial microorganisms in the ecosystem are no longer killed or harmed”



Dr. Elaine Ingham



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Build up soil and sequester carbon by:

1. Minimize or avoid chemical, physical and biological stressors



Build up soil and sequester carbon by:

1. Minimize or avoid chemical, physical and biological stressors

Chemical: artificial pesticides and fertilizers

- Actively destroy soil life
- Destabilize and degrades soil structure
- Halt soil carbon building processes

Physical: manual tilling



Soil Health

“Rototilling is equally damaging to the soil as spraying chemicals.”



Over time, high concentrations of mineral salts from synthetic fertilizers will:

- decrease microbial diversity
- alter soil pH, and damage soil structure



**Disadvantages of
Chemicals in Farming**

Build up soil and sequester carbon by:
2. Use plant diversity to increase soil diversity

MONOCULTURE vs POLYCULTURE

- Definition: growing only one species in a crops in the same space

Definition: using multiple crops in the same space, in imitation of the diversity of natural ecosystems



Build up soil and sequester carbon by: Soil Health

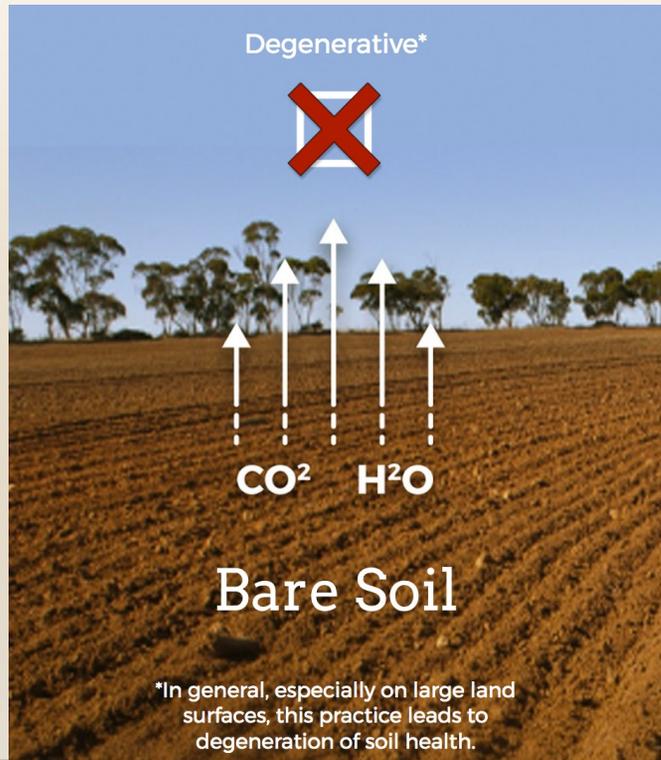
3. Keep living roots in the soil year-round to feed your soil

- Perennial plants
- Groundcovers
- Cover Crops
- Intercropping



Build up soil and sequester carbon by:

4. Keep the soil covered as much as possible

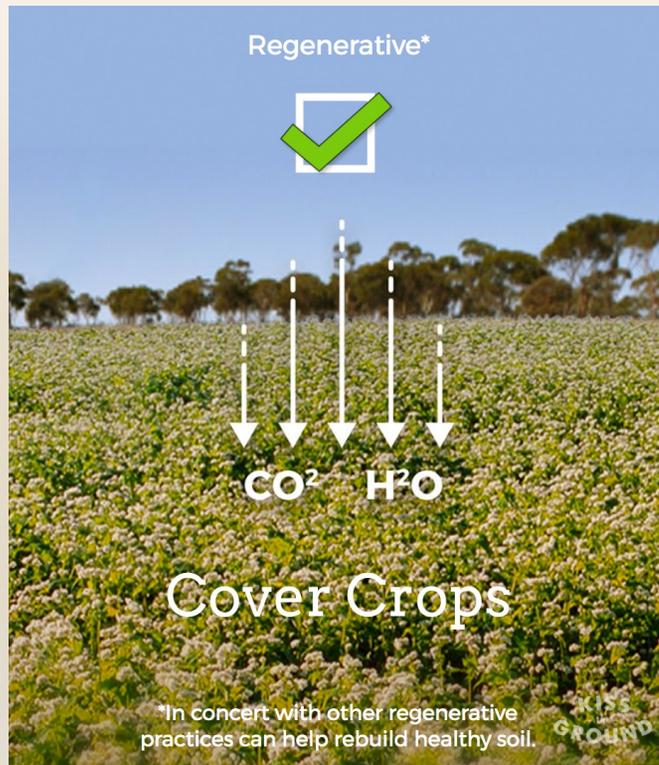


If you can see the soil, it is losing carbon, vitality, life.



Build up soil and sequester carbon by:

4. Keep the soil covered as much as possible



The most effective way to regenerate soil is to maintain living cover of diverse plants as the year as possible.



**“Essentially all life depends
on the soil. There can be
no life without soil and
no soil without life;
they have evolved together.”**

Charles E Kellogg,
USDA Yearbook of Agriculture, 1938

