Soil Biology and Soil Water

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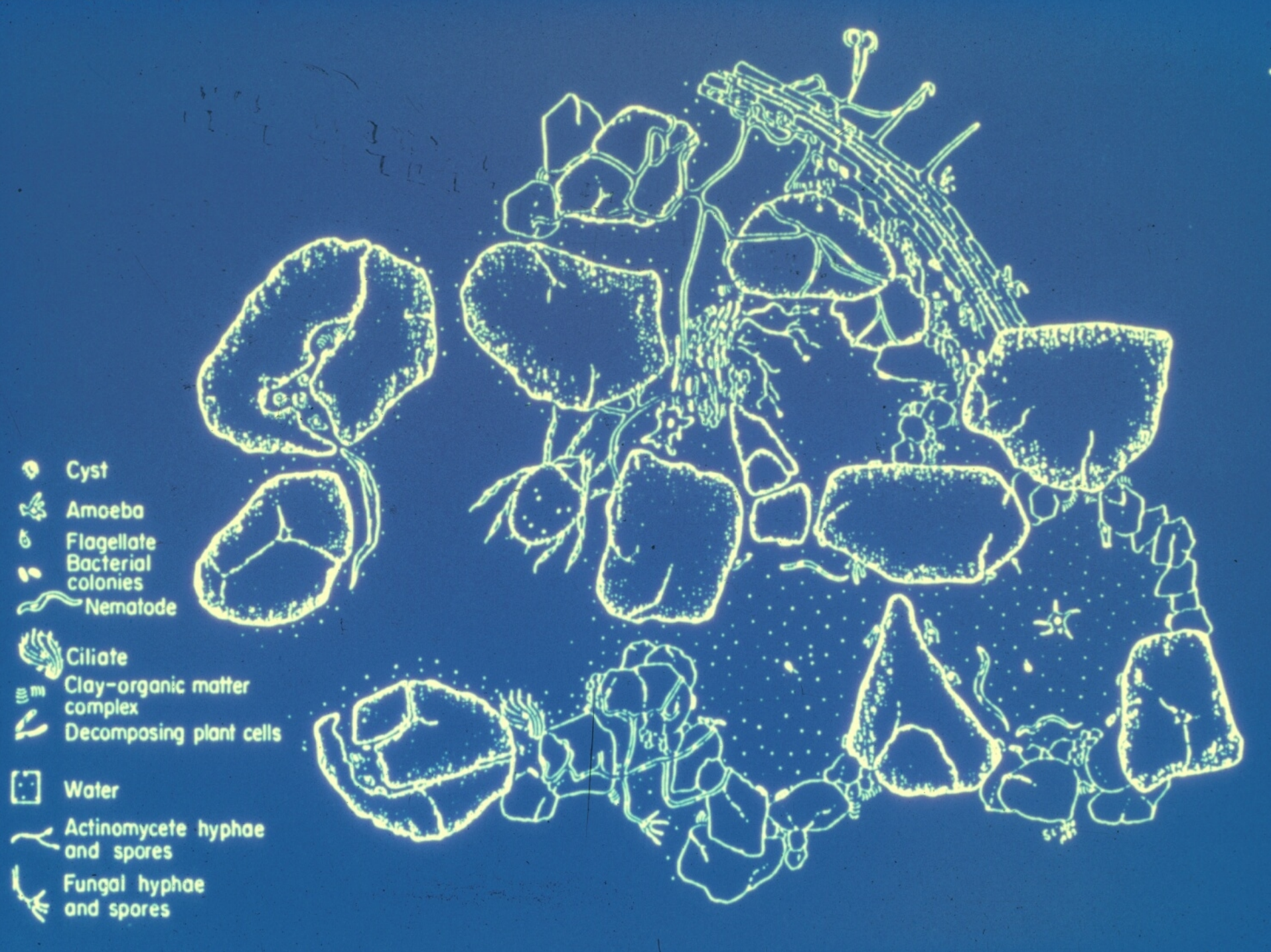
Soil Biology directly impacts
rates of erosion,
run-off,
sedimentation,
compaction,
droughtiness,
water quality
and plant fertility


Cyst
Amoeba
Flagellate
Bacterial colonies
Nematode
Ciliate
Clay-organic matter complex
Decomposing plant cells
Water
Actinomycete hyphae and spores
Fungal hyphae and spores

Microbes make hallways and passageways in soil

Bacteria makes glues that hold clays, silt, sand and organic matter together

Fungi are strands that make glue and threads that hold bacterial aggregates together

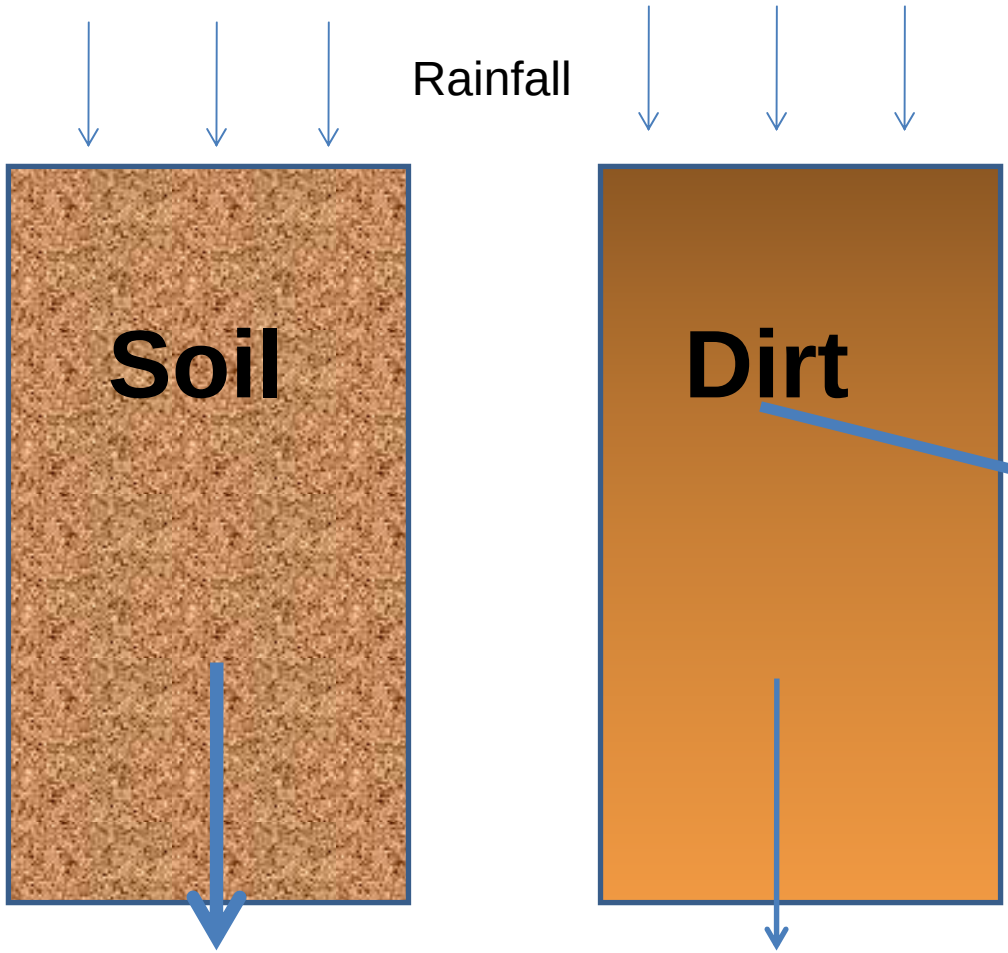
Protozoa control bacterial populations

Nematodes open up larger pore areas

Microarthropods engineer the larger pores

Roots engineer the freeways

Soil results in clean water; dirt results in a bigger problem



-Organisms build structure

-Nutrients held

-Water is retained and moves slowly thru the soil

-no organisms, no structure

-Nutrients move with the water

-Water not held in soil pores, moves rapidly thru soil

-Leaching, erosion and run-off are problems

Clean Water

Water moves clay, silt and inorganic chemicals so no “cleaning” process

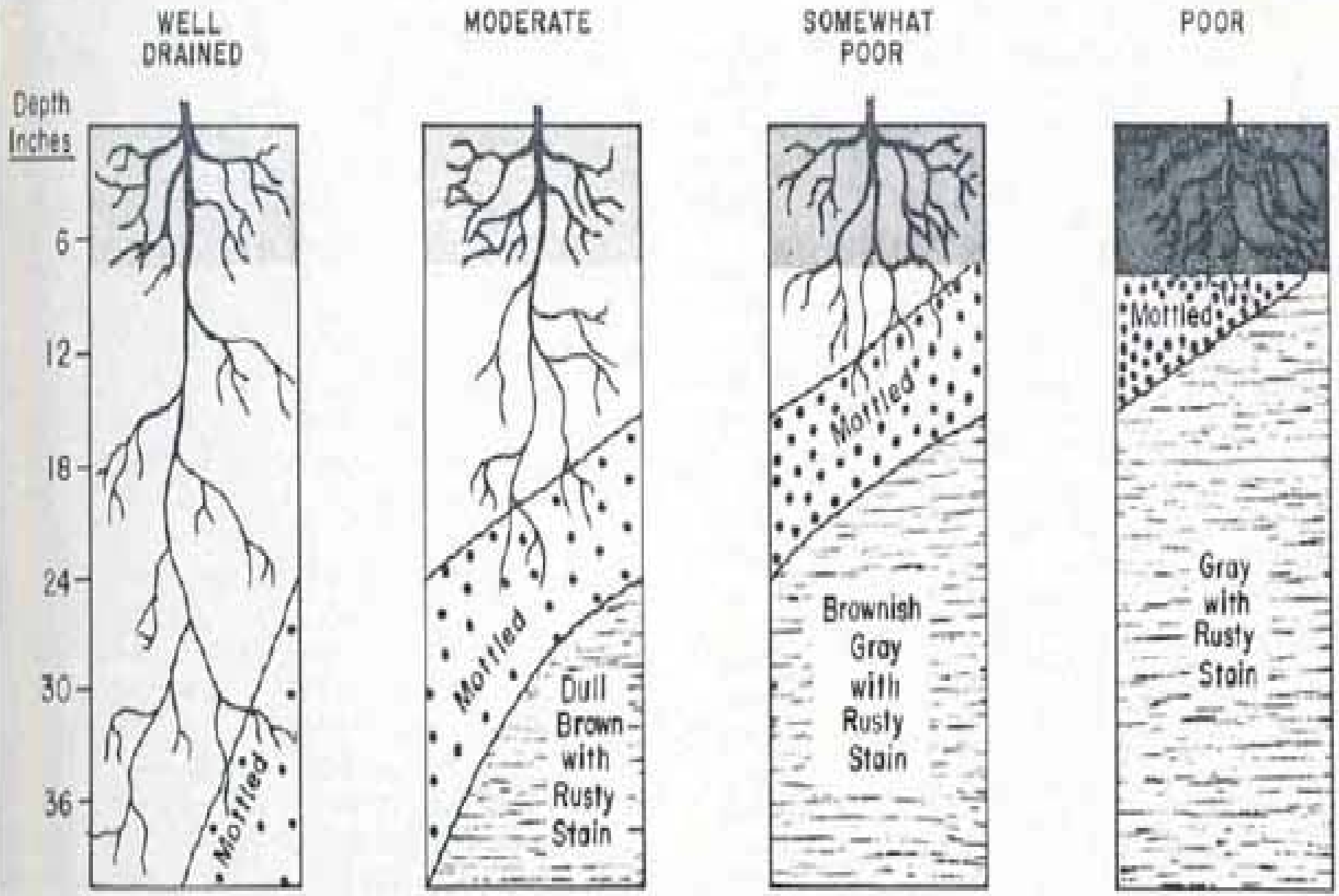


Figure 5.—Effect of soil drainage on root development.

The root of the matter is infiltration

Oxygen? Disease?

Source: Conservation Research Institute


LOW
MEDIUM
HIGH

Peter M. Wild, Boston Tree

What Biology?
How can it impact soil water

1. "The Cast" – which organisms?
2. How do they influence erosion, run-off, leaching, sedimentation, ability to hold water and water quality
3. Practicalities of resuscitating these organisms in the soil

The Soil Food Web

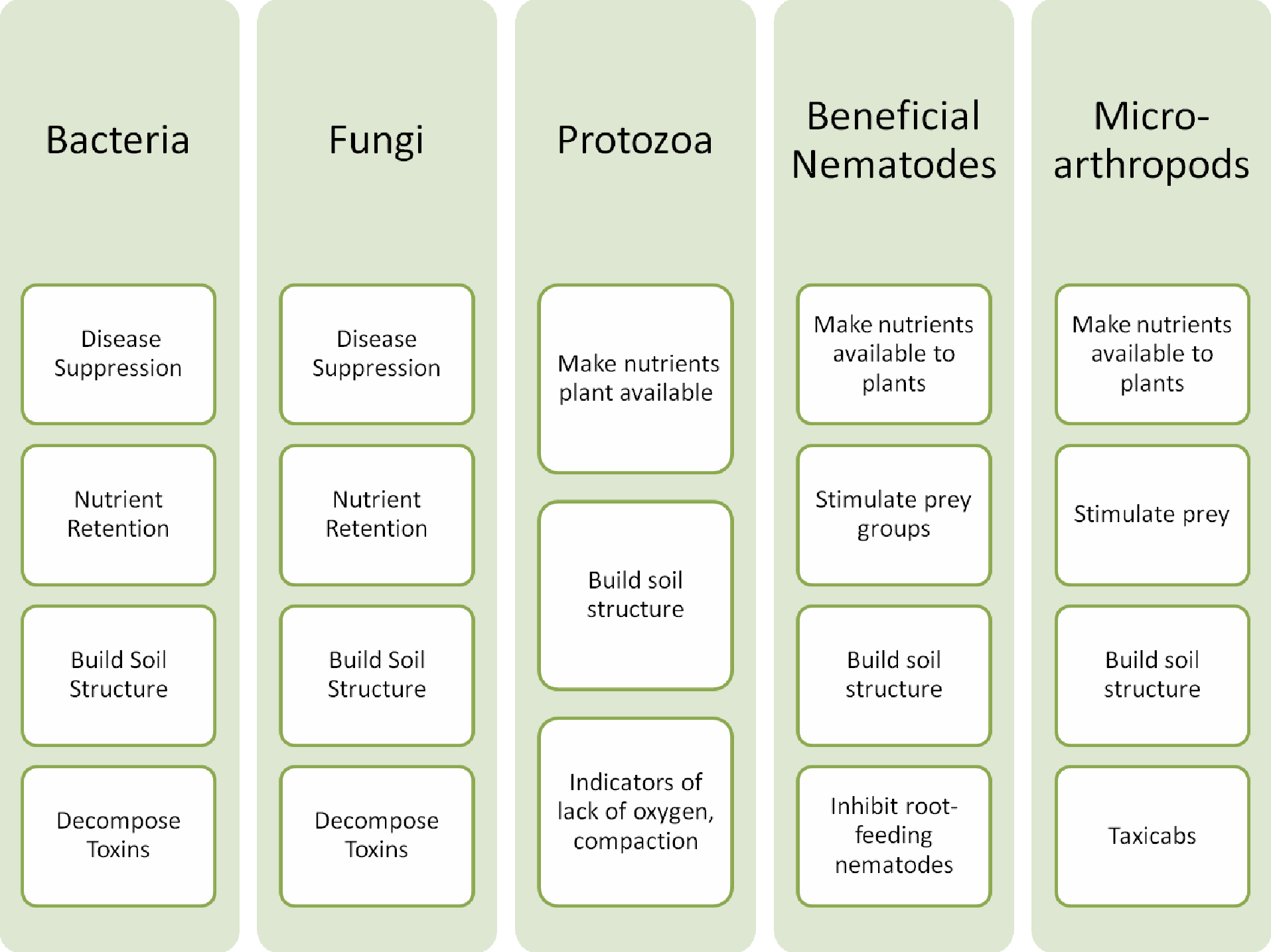
First trophic level:
Photosynthesizers

Second trophic level:
Decomposers
Mutualists
Pathogens, parasites
Root-feeders

Third trophic level:
Shredders
Predators
Grazers

Fourth trophic level:
Higher level predators

Fifth and higher trophic levels:
Higher level predators

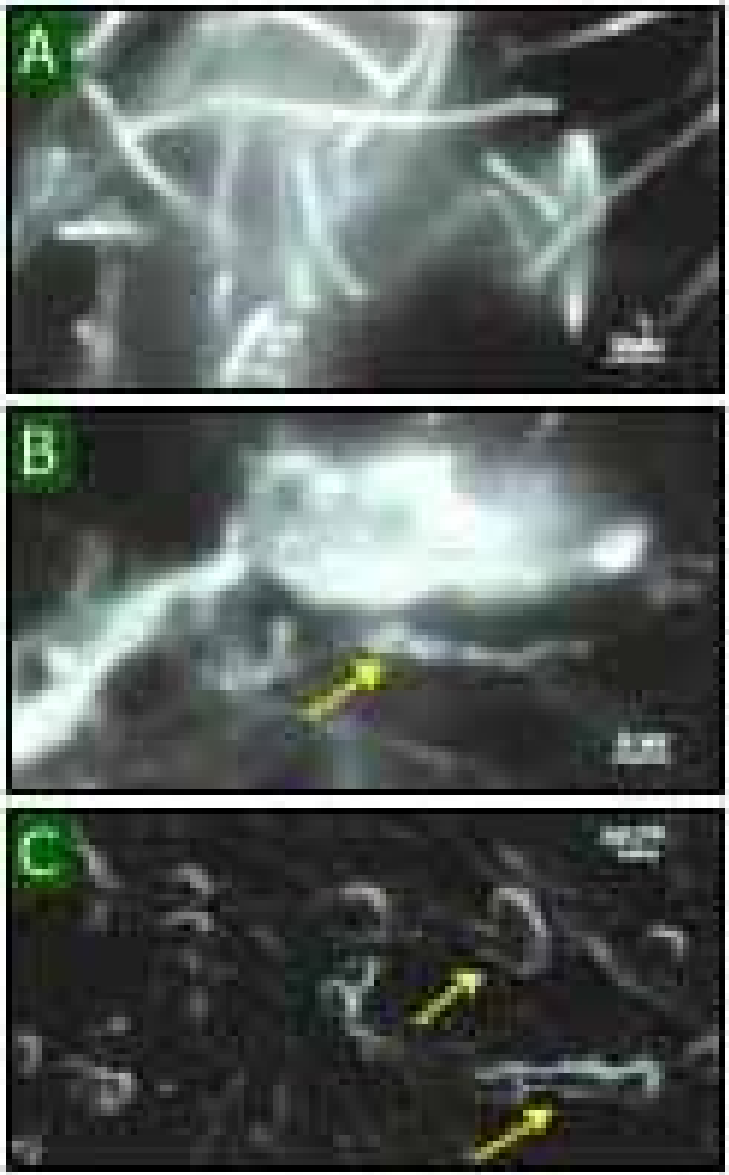

Bacteria
Disease Suppression
Nutrient Retention
Build Soil Structure
Decompose Toxins
Fungi
Disease Suppression
Nutrient Retention
Build Soil Structure
Decompose Toxins
Protozoa
Make nutrients plant available
Build soil structure
Indicators of lack of oxygen, compaction
Beneficial Nematodes
Make nutrients available to plants
Stimulate prey groups
Build soil structure
Inhibit root-feeding nematodes
Micro-arthropods
Make nutrients available to plants
Stimulate prey
Build soil structure
Taxicabs

The right biology enhances these functions:

- Disease protection (no more pesticides!)
- Nutrient immobilization (stop leaching)
- Nutrient availability (right forms in the right place at the right time)
- Decomposition of toxins and organic debris
- Build soil structure, increase root

Fungal amended soil aggregates are water stable

Non amended soil aggregates are not water stable



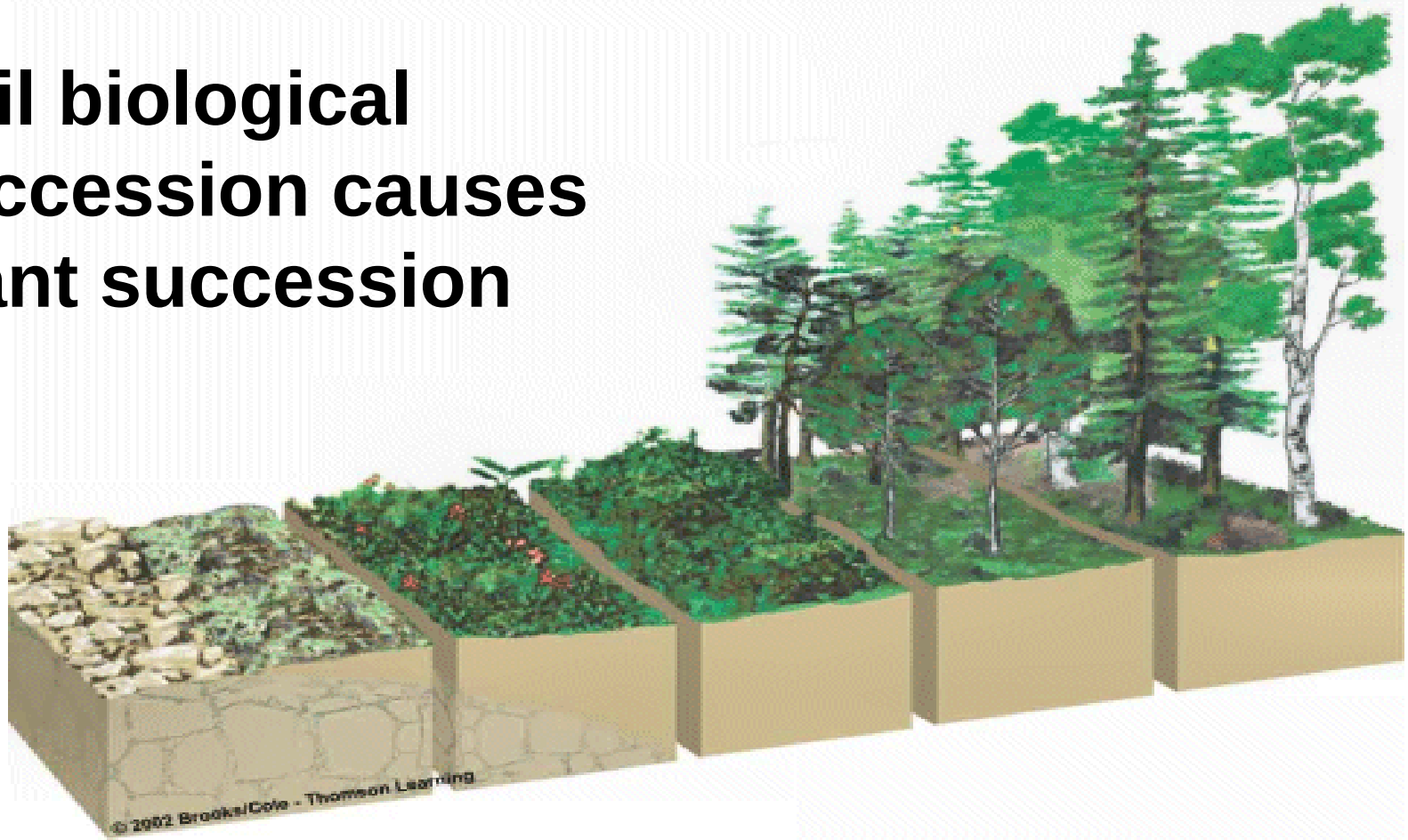
Large amounts of polysaccharides secreted by a saprophytic lignin decomposing basidiomycete that acts as a soil binding agent.

A. Chitin stained with FITC conjugated wheat germ agglutinin

B. Mucilage contains fucosyl residues stained with FITC-Ulex Europaues agglutinin 1

C. Cryo-scanning electron micrograph showing patches of extracellular mucilage

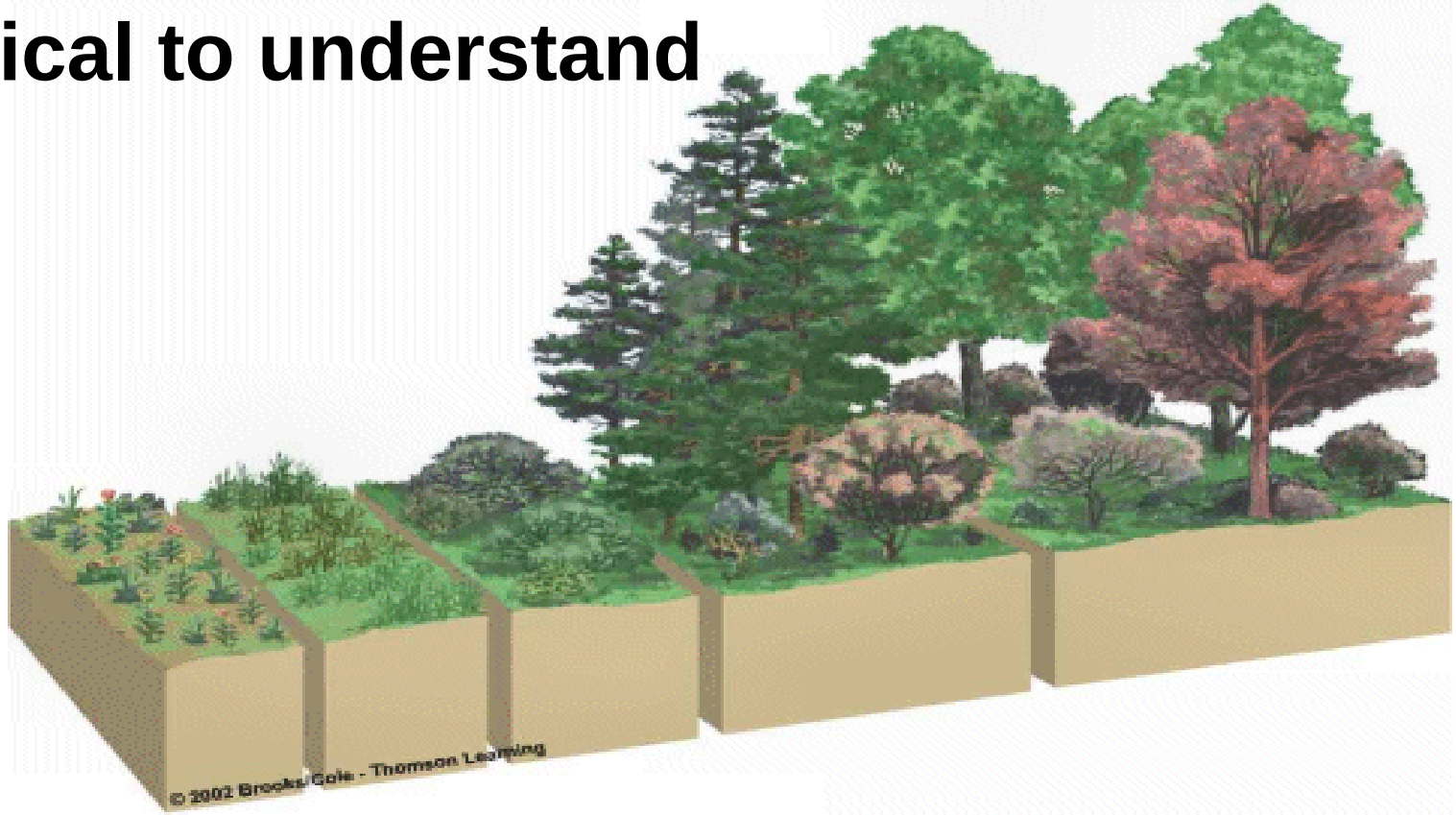
Soil biological succession causes plant succession



Bacteria ……A few Fungi……Balanced……..More Fungi…… Fungi

Bacteria: 10 µg 100 µg 500 600 µg 500 µg 700 µg

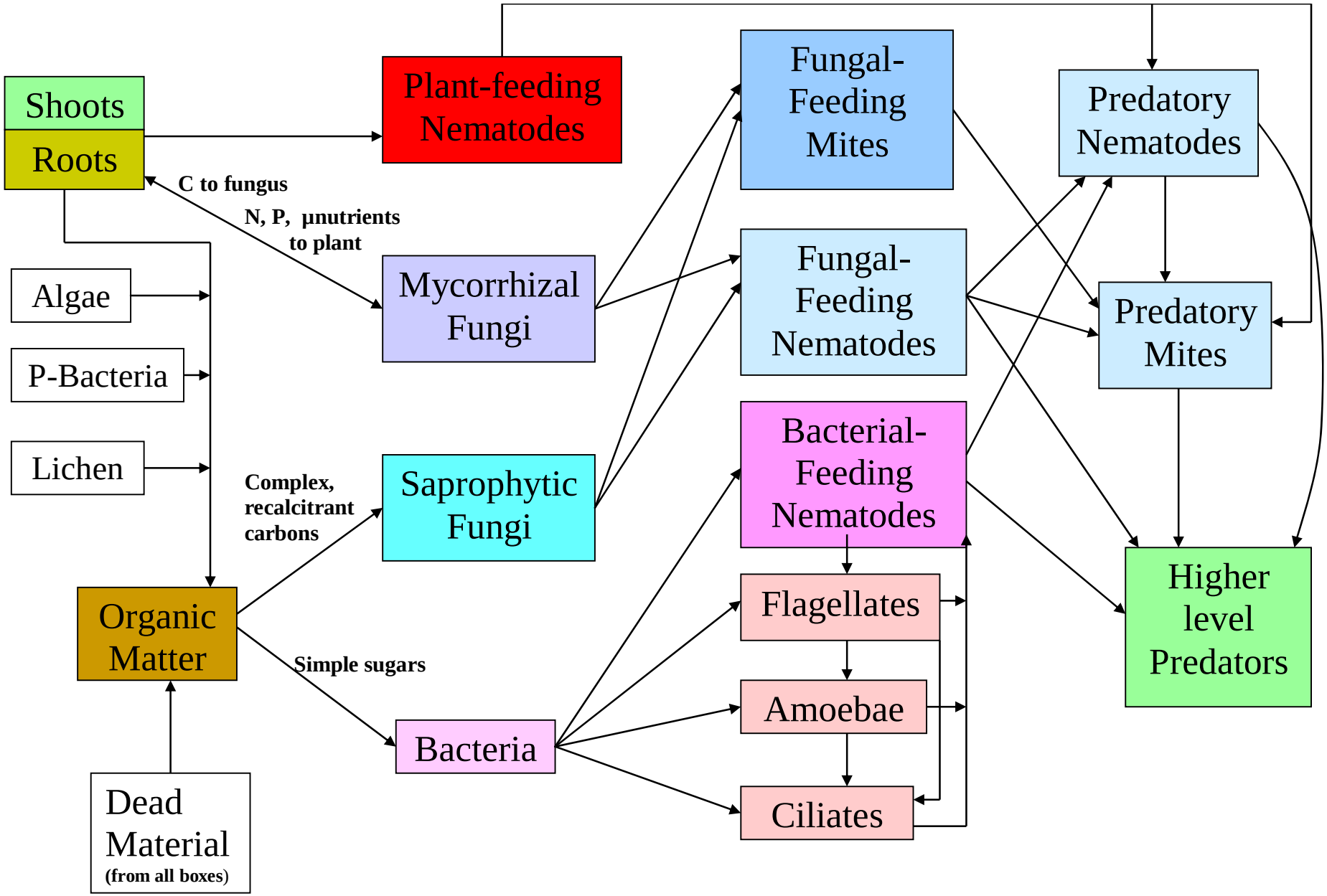
Forms of nutrients:
Critical to understand



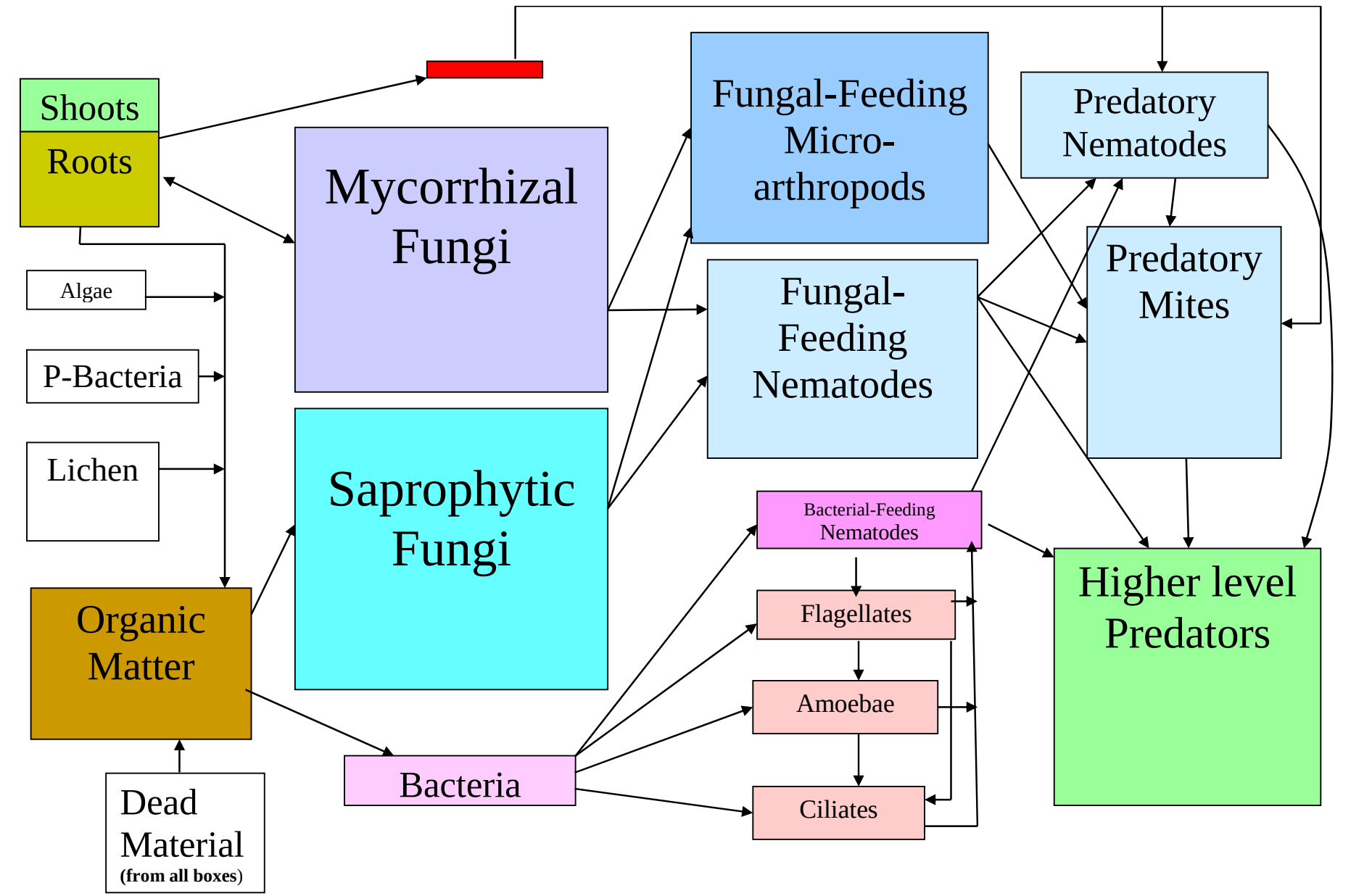
limited……NO_3……balanced……
…..NH_4

cycling NO_3 and NH_4

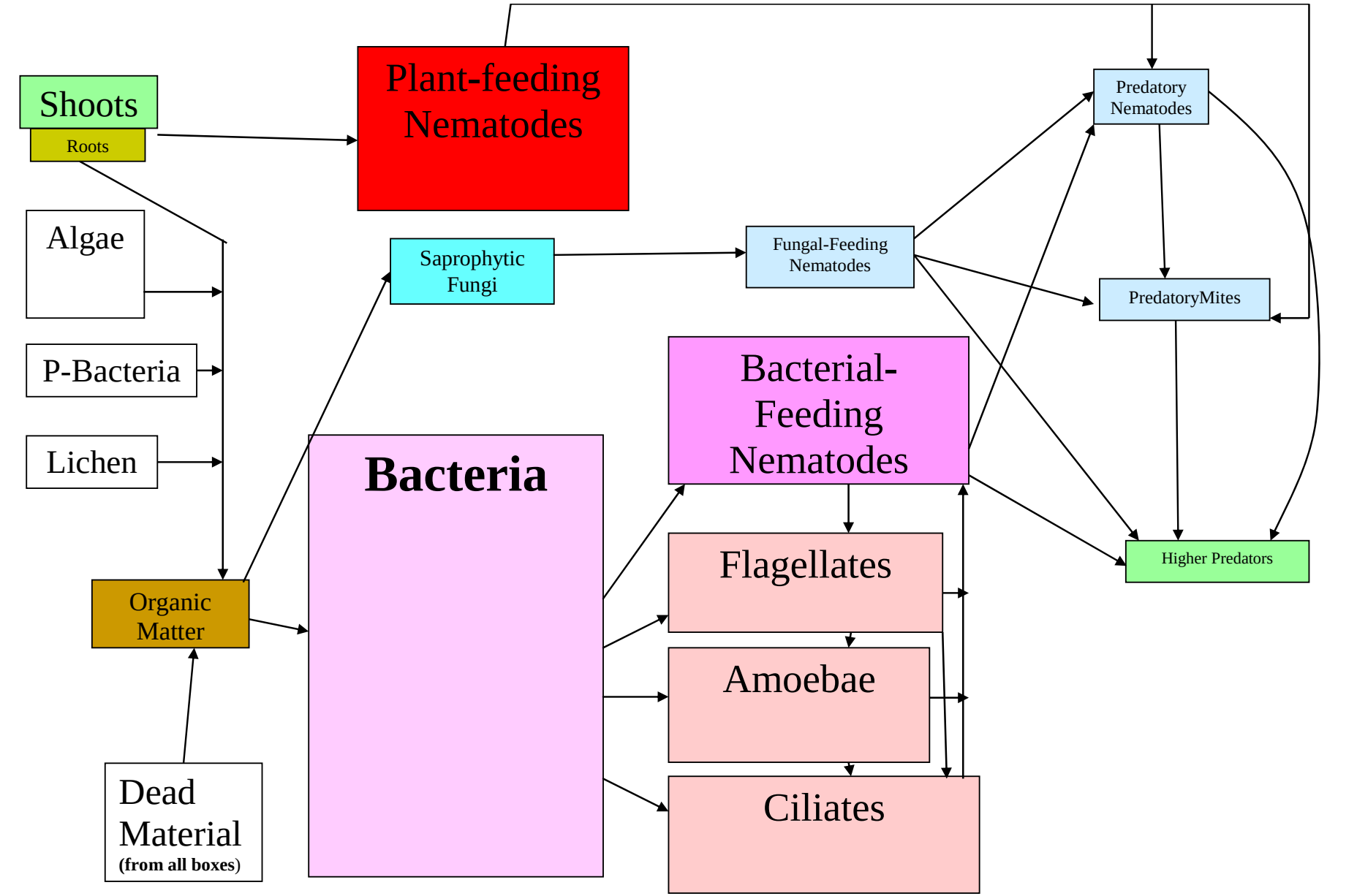
Protozoa B-f F-f Predatory



The Soil Foodweb in Lawns, Vegetable and Row Crops systems



The Soil Foodweb in Healthy Orchard and Forest Systems



The Soil Foodweb in Weed Systems

Prevention and Remediation

How do you add available nutrients AND the organisms needed?

- As shown by the work with soildynamics.com, with hundreds of people all over the world,
- COMPOST
- COMPOST TEA
- INOCULA of:
  - BACTERIA,
  - FUNGI, MYCORRHIZAL FUNGI
  - PROTOZOA,
  - NEMATODES
  - MICROARTHROPODS

What is compost?

- Aerobic decomposition of a mix of organic matter
- Thermal compost:
  - Heat minimum 131 F (55C) for3 days to kill weed seed, pathogens, pests
  - But NOT HIGHER than 155 – 160 F (70 C) so beneficials NOT killed
  - Turned whenever too hot because too hot means lack of oxygen, loss of N, S, P, build acidic conditions
- Worm or Vermi-compost (cold composting)
  - Worms turn the compost, kill pathogens, pests

Compost Standards

- Measured in fresh compost, expressed per gram dry compost
- 15 to 30 or more µg active bacteria /g dry weight compost
- 150 µg (fungal compost) to 300 or more µg (bacterial compost) total bacteria /g dry weight compost

- 2 to 10 µg or more active fungi /g dry weight compost
- 150 (bacterial compost) to 500 or more (fungal compost) µg total fungal biomass/g dry weight compost
- Hyphal diameters on average 2.5 micrometers or greater

- 50,000 or more protozoa per gram dry weight compost
  25,000 or more flagellates
  25,000 or more amoebae
  50 - 100 ciliates. Higher numbers indicate anaerobic conditions resulting from compaction, water-logging, discontinuities in soil
- 20 to 100 BENEFICIAL nematodes per gram dry weight of

Compost Tea Definitions

- **Actively-Aerated** Compost Tea – brewed water extract
  - Active, total bacteria, fungi, protozoa, nematodes (sp vs #s)
  - soluble nutrients from the compost
  - aerobic (O2 above 6 ppm) vs anaerobic (pathogen growth, loss of nutrients, toxins)
  - with or without added foods to grow beneficials
- **Non-aerated Compost Tea – variable results**
- **Compost Extract – no brewing time**
- **Compost Leachate – no brewing, few organisms removed**
- **Plant tea – compost not involved**
  - bacteria, fungi from plant surfaces, aerobic or anaerobic
- **Manure tea – compost not involved**
  - anaerobic (pathogens present, 90 to 120 day rule required)

•Put-to-sleep teas – loss of species, minimal activity

Compost Tea Standards

- 2 to 10 or more µg active bacteria /ml compost tea
- 150 µg to 3000 or more µg total bacteria /ml compost tea

- 2 to 10 µg or more active fungi /ml compost tea
- 5 to 20 or more µg total fungal biomass/ml compost tea

- 2,000 or more protozoa
  1,000 or more flagellates
  1,000 or more amoebae
  5 - 10 ciliates. Higher numbers indicate anaerobic conditions resulting when organism growing so fast that oxygen is consumed

- 2 to 10 BENEFICIAL nematodes/ ml (desired; typically lacking in tea)
  1 - 5 bacterial-feeders
  up to 5 fungal-feeders
  1 - 5 predatory nematodes (typically lacking in tea)
- Minimum of 10% active bacteria and fungi

ALL the biology must be present

- Which is “most important?”
- Holistic system, can’t forget any part
- No retention without bacteria and fungi
- No return to plant available forms without protozoa, beneficial nematodes and microarthropods
- Need to understand the **WHOLE** foodweb