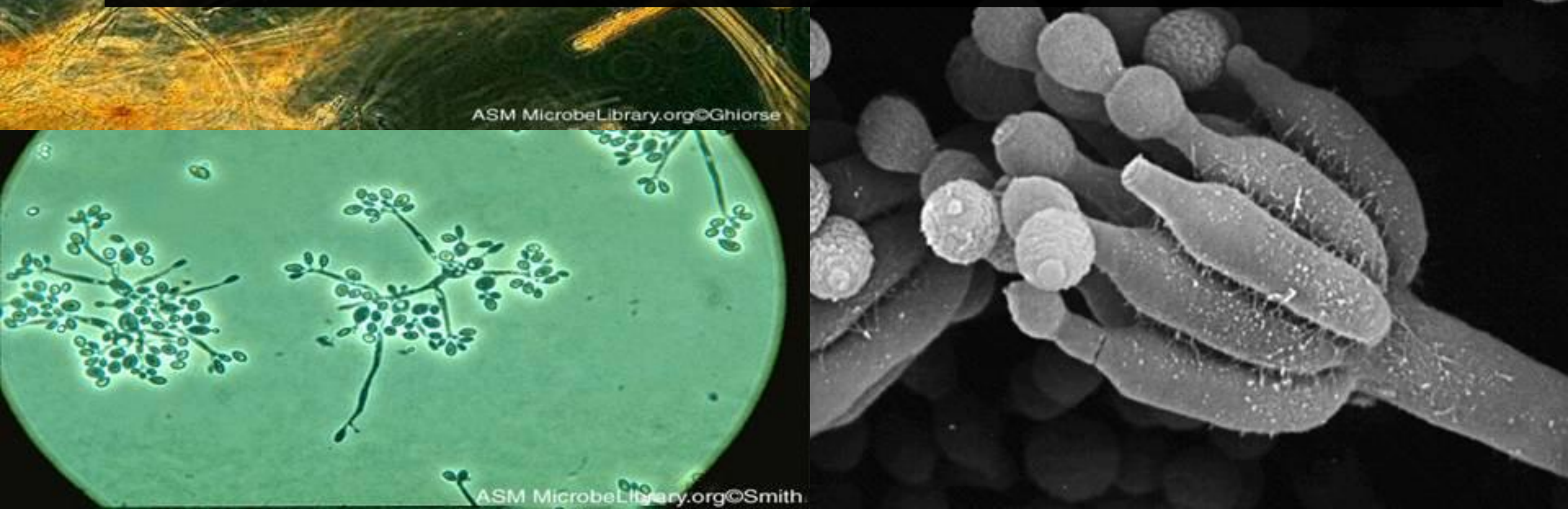
Biologi Tanah

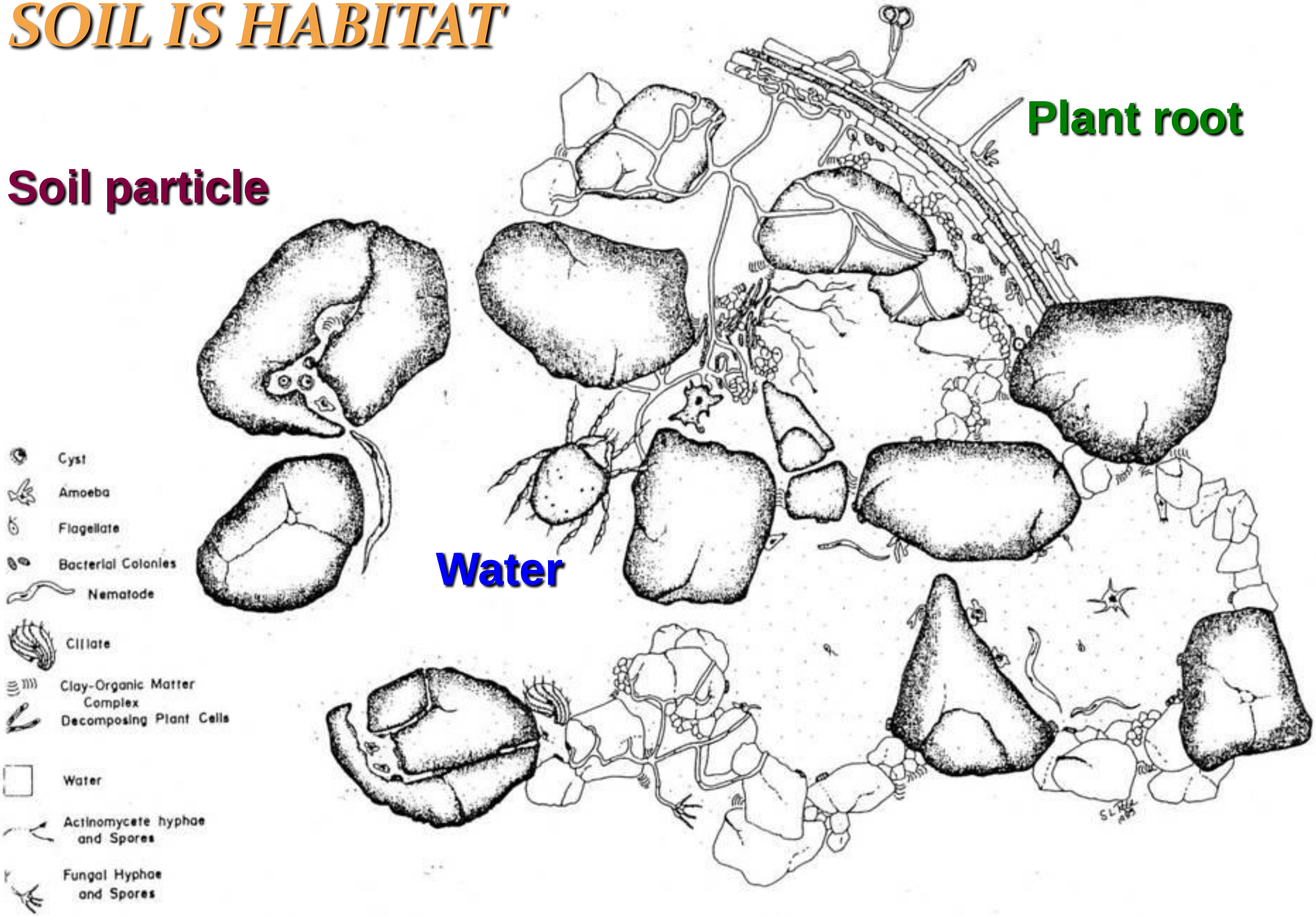
nasih@ugm.ac.id

Soil biology: Important relationship with soil quality

- Organic matter
- Residue decomposition
- Soil structure
- Nutrient cycling
- 1 g of soil has 100,000,000 bacteria

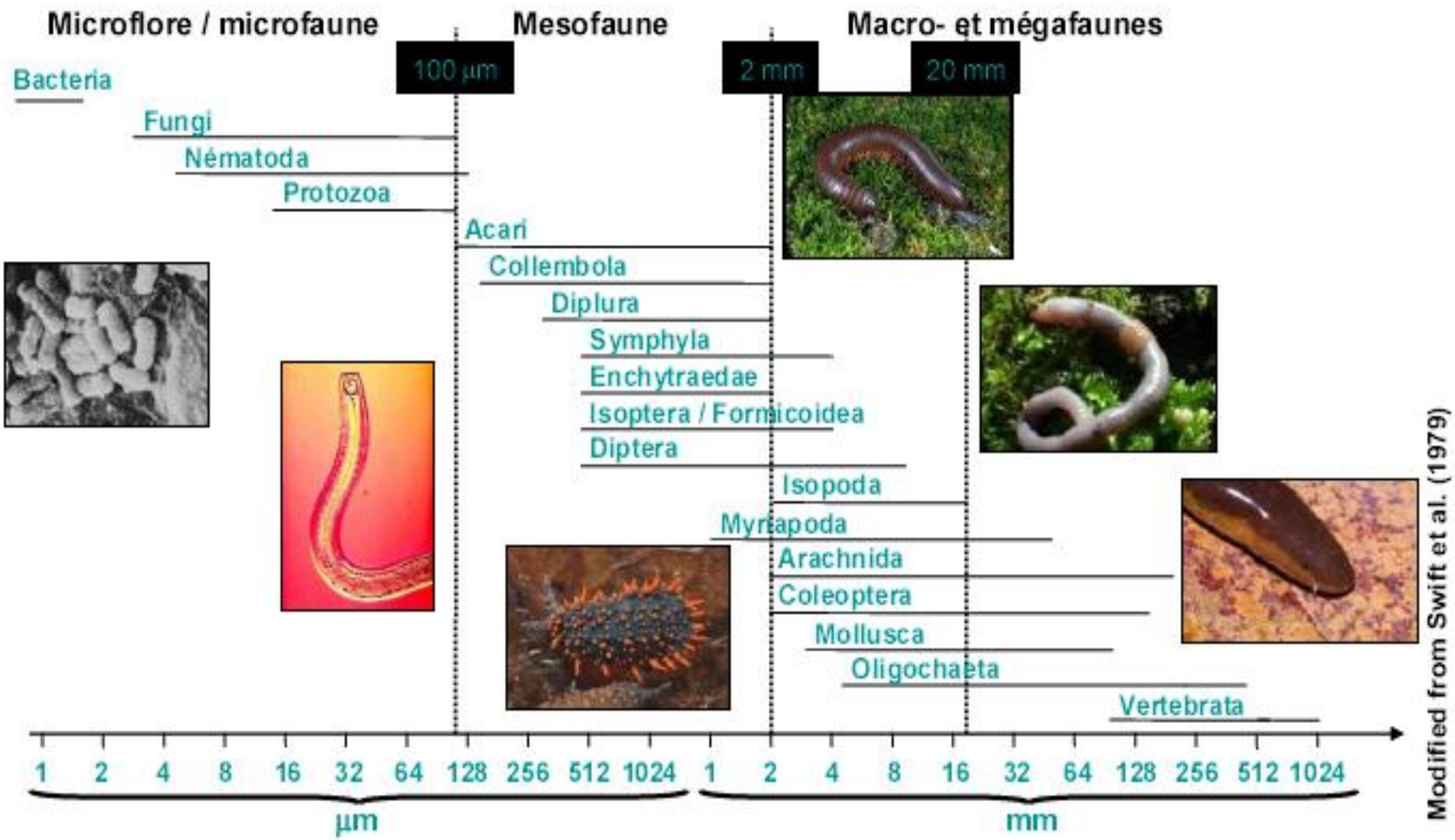


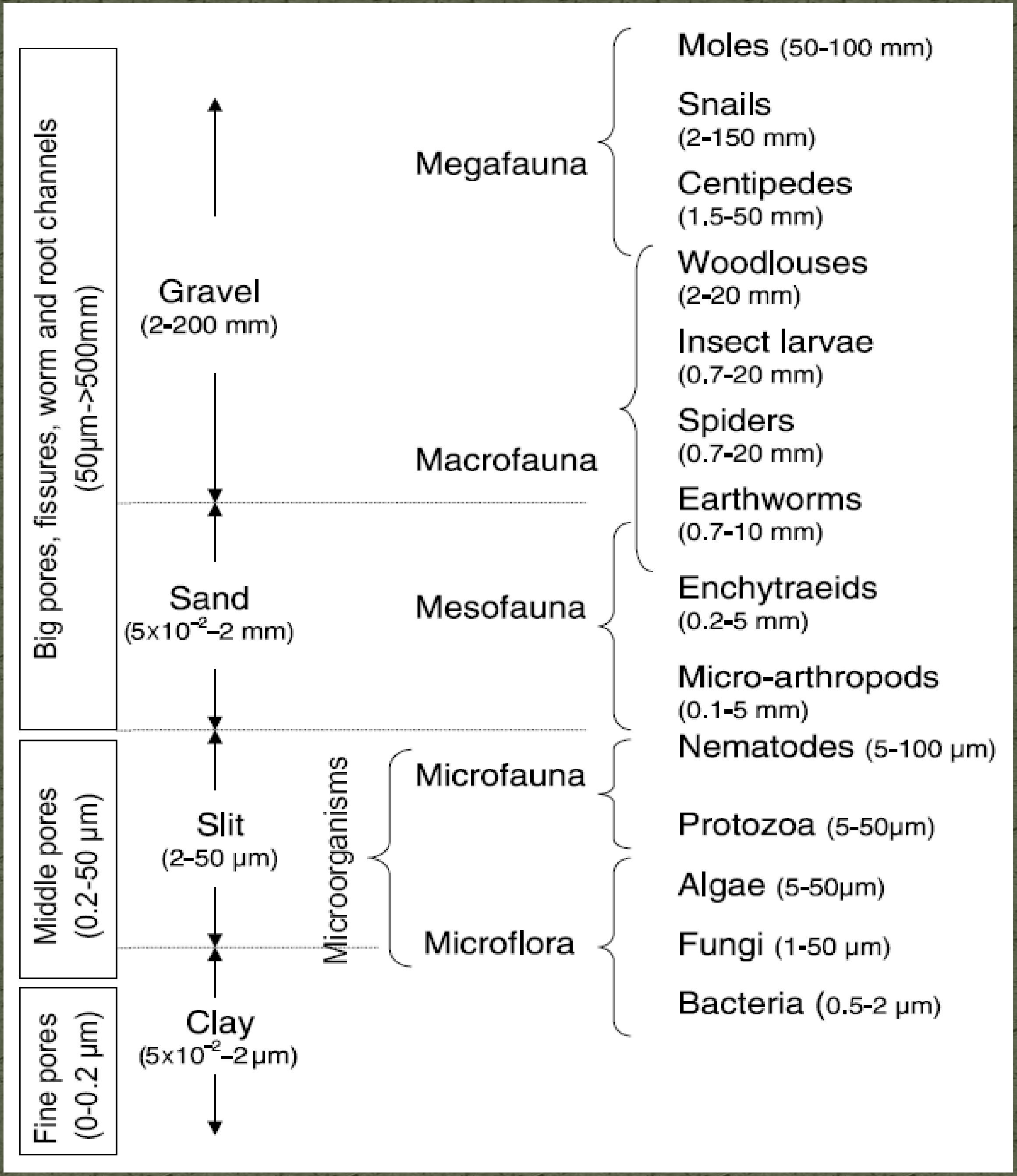
SOIL IS HABITAT



Does Size Matter?

(from T. Decaëns, 2008)





Classification of soil biota in relation to size of pores and particle in soils used in soil biology. (Adapted from Gisi et al. 1997)

Functions of Soil Organisms

Type of Soil Organism		Major Functions
Photosynthesizers	• Plants • Algae • Bacteria	**Capture energy** • Use solar energy to fix CO_2. • Add organic matter to soil (biomass such as dead cells, plant litter, and secondary metabolites).
Decomposers	• Bacteria • Fungi	**Break down residue** • Immobilize (retain) nutrients in their biomass. • Create new organic compounds (cell constituents, waste products) that are sources of energy and nutrients for other organisms. • Produce compounds that help bind soil into aggregates. • Bind soil aggregates with fungal hyphae. • Nitrifying and denitrifying bacteria convert forms of nitrogen. • Compete with or inhibit disease-causing organisms.
Mutualists	• Bacteria • Fungi	**Enhance plant growth** • Protect plant roots from disease-causing organisms. • Some bacteria fix N_2. • Some fungi form mycorrhizal associations with roots and deliver nutrients (such as P) and water to the plant.
Pathogens **Parasites**	• Bacteria • Fungi • Nematodes • Microarthropods	**Promote disease** • Consume roots and other plant parts, causing disease. • Parasitize nematodes or insects, including disease-causing organisms.
Root-feeders	• Nematodes • Macroarthropods (e.g., cutworm, weevil larvae, & symphylans)	**Consume plant roots** • Potentially cause significant crop yield losses.
Bacterial-feeders	• Protozoa • Nematodes	**Graze** • Release plant available nitrogen (NH_4^+) and other nutrients when feeding on bacteria. • Control many root-feeding or disease-causing pests. • Stimulate and control the activity of bacterial populations.
Fungal-feeders	• Nematodes • Microarthropods	**Graze** • Release plant available nitrogen (NH_4^+) and other nutrients when feeding on fungi. • Control many root-feeding or disease-causing pests. • Stimulate and control the activity of fungal populations.
Shredders	• Earthworms • Macroarthropods	**Break down residue and enhance soil structure** • Shred plant litter as they feed on bacteria and fungi. • Provide habitat for bacteria in their guts and fecal pellets. • Enhance soil structure as they produce fecal pellets and burrow through soil.
Higher-level predators	• Nematode-feeding nematodes • Larger arthropods, mice, voles, shrews, birds, other above-ground animals	**Control populations** • Control the populations of lower trophic-level predators. • Larger organisms improve soil structure by burrowing and by passing soil through their guts. • Larger organisms carry smaller organisms long distances.

Classification of Soil Organisms

Classification	Body Width	Examples
Microflora	< 10 µm	Bacteria
		Fungi
Microfauna	< 100 µm	Protozoa
		Nematodes
Mesofauna	100 µm to 2 mm	Acari
		Collembola
Macrofauna	2 mm to 20 mm	Earthworms
		Snails

Fauna: Macrofauna (> 2mm):

Vertebrates

- Organisms: Moles, mice, shrews
- Functions: Mix soil with burrowing, hasten decomposition

Arthropods

- Beetles: Primary consumer, transport and mixing of organics
- Ants: Primary consumer, transport and mixing of organics, movement of B horizon to surface
- Centipedes: Predator, minor role in soil formation
- Millipedes: Saprophageous (feed on dead organic matter), transport and mixing. Mostly mulls
- Springtails: Primary consumer, affect soil structure
- Mites: Saprophageous, very important in numbers, affect soil structure

Annelids

- Earthworms (Lumbricidae spp.)

Fauna: Microfauna (<0.1 mm):

Nematodes

- Nearly microscopic roundworms
- Important as population regulators and nutrient concentrators
- Common in mull and grassland soils; some in forest soils
- Can be parasites

Protozoa

- 1-celled organisms
- Consume decomposing organic matter and bacteria
- Most abundant soil fauna

Flora: Soil Microflora

Four major groups:

1. Bacteria
2. Actinomycetes
3. Fungi
4. Algae

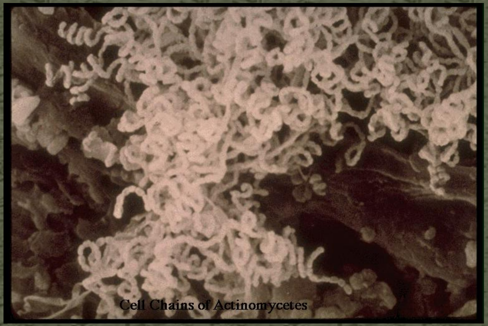
Can also classify according to how they obtain energy:

- Autotrophic: Use sunlight of inorganic chemical reactions for energy
- Hetertrophic: Use organic compounds for energy

organisms in Soil

Bacteria

Fungi



Actinomycetes

Protozoa

Mites

Nematodes

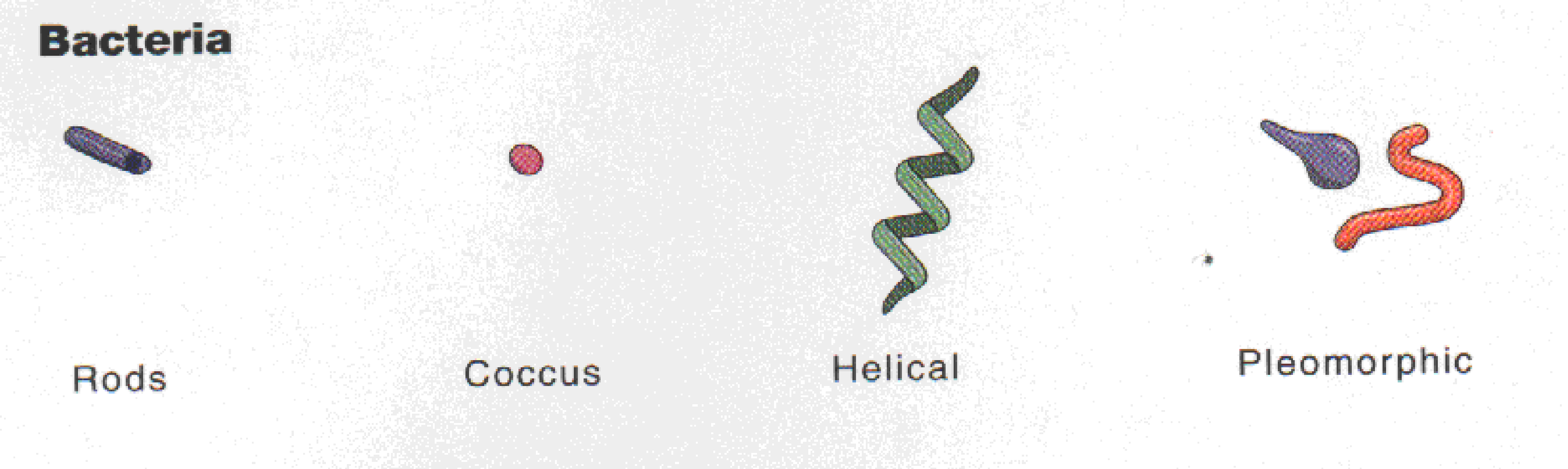
Earthworm

Isopods

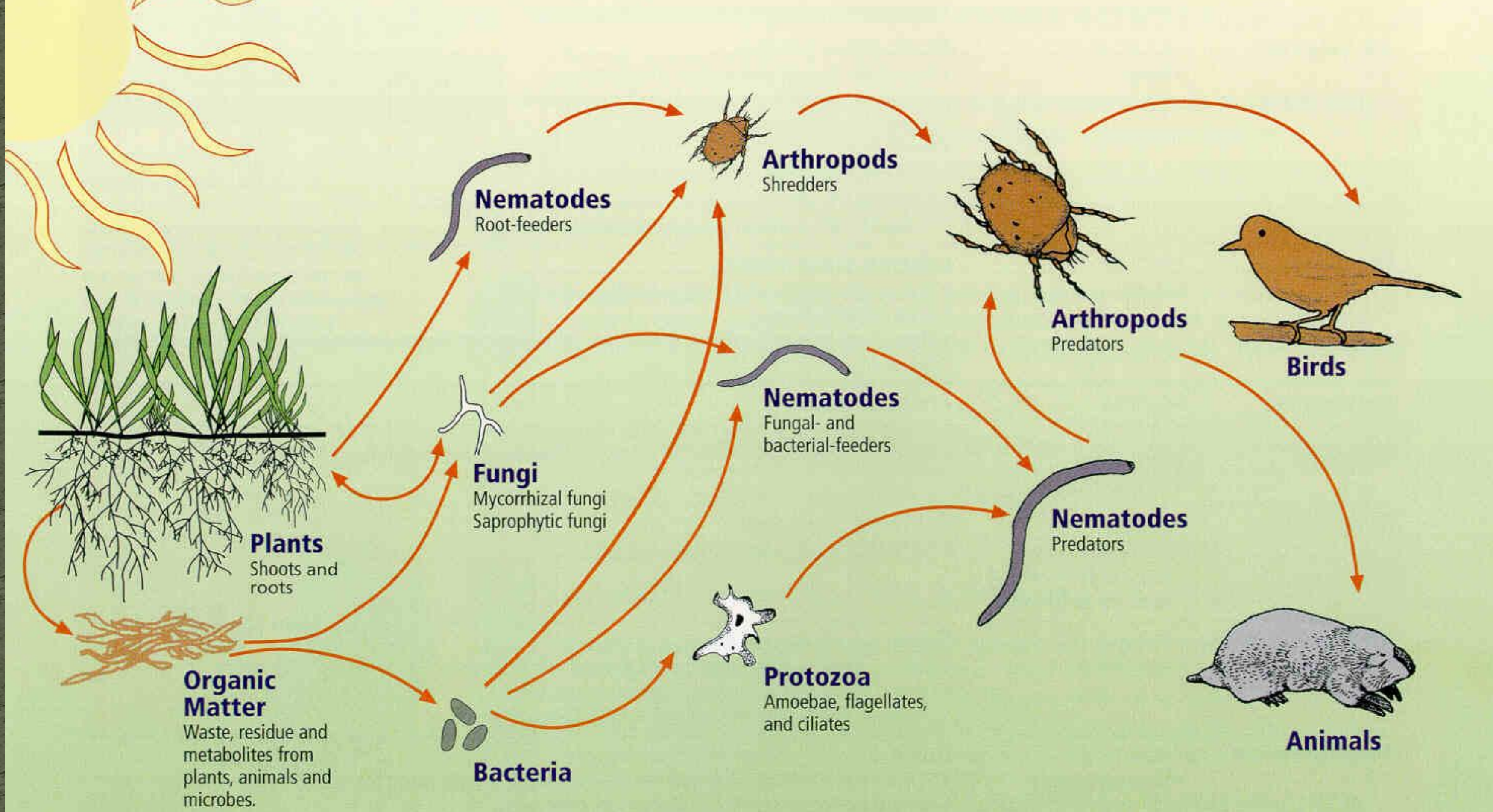
Myriapods

Organism	Length or (diameter) mm	Abundance (arable systems)
Bacteria	(0.001)	3,000,000,000 / g
Fungi	(0.005-0.020)	50 meters / g
Protozoa	0.010-0.200	100,000 / g
Nematodes	1-4.5	7,000,000 / m^2
Earthworms	20-200	950 / m^2
Potworms	10-50	65,000 / m^2
Isopods	3-18	??
Centipedes	5-80	??
Millipedes	5-50	??
Symphylans	2-15	4,500 / m^2
Pauropods	0.5-1.5	5,000 / m^2
Diplurans	2-7	30 / m^2
Proturans	0.4-2	1,000 / m^2
Springtails	1-7	100,000 / m^2
Mites	0.1-3	250,000 / m^2

“Ordinary “ Bacteria,



The Soil Food Web



First trophic level:
Photosynthesizers

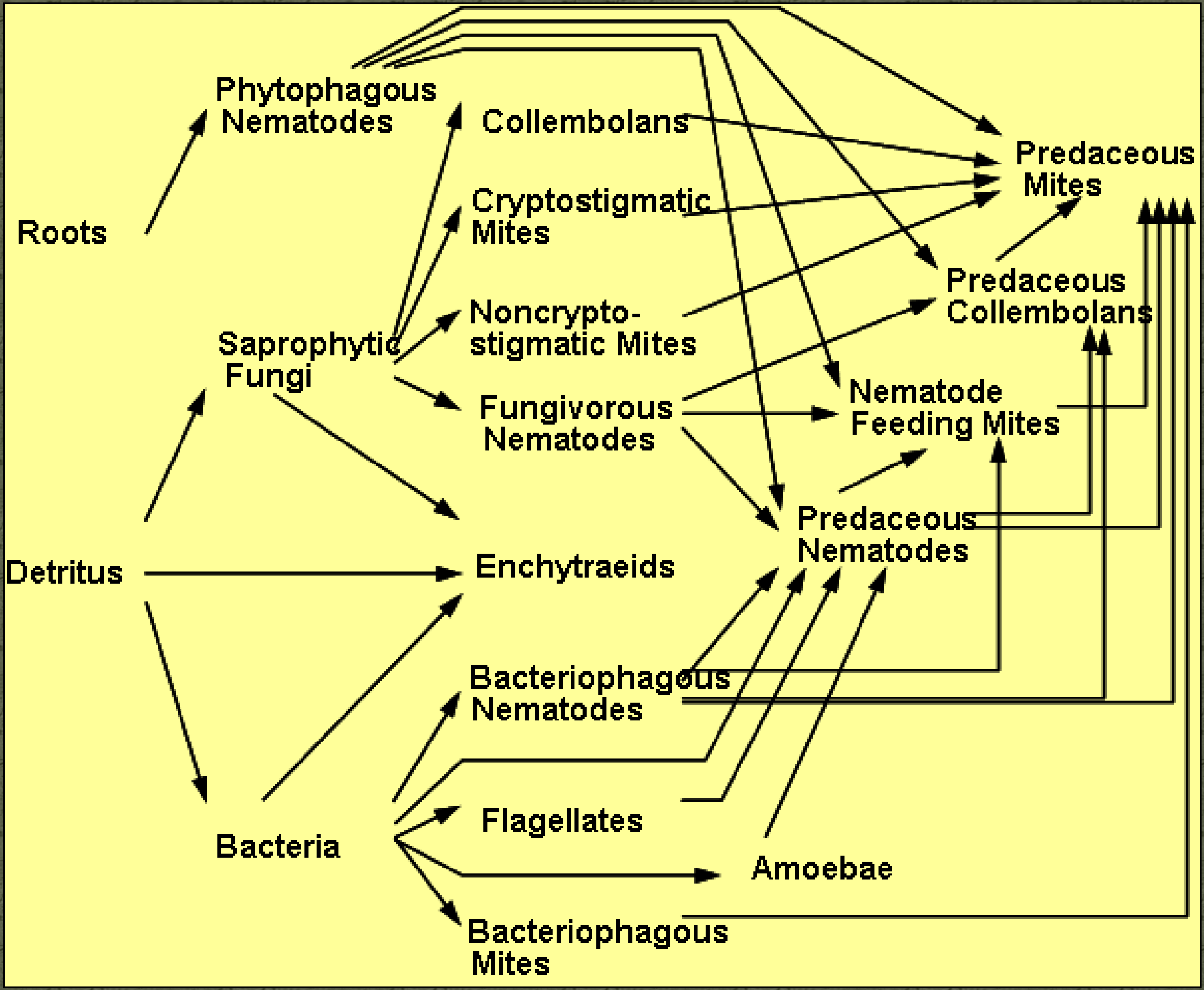
Second trophic level:
Decomposers
Mutualists
Pathogens, parasites
Root-feeders

Third trophic level:
Shredders
Predators
Grazers

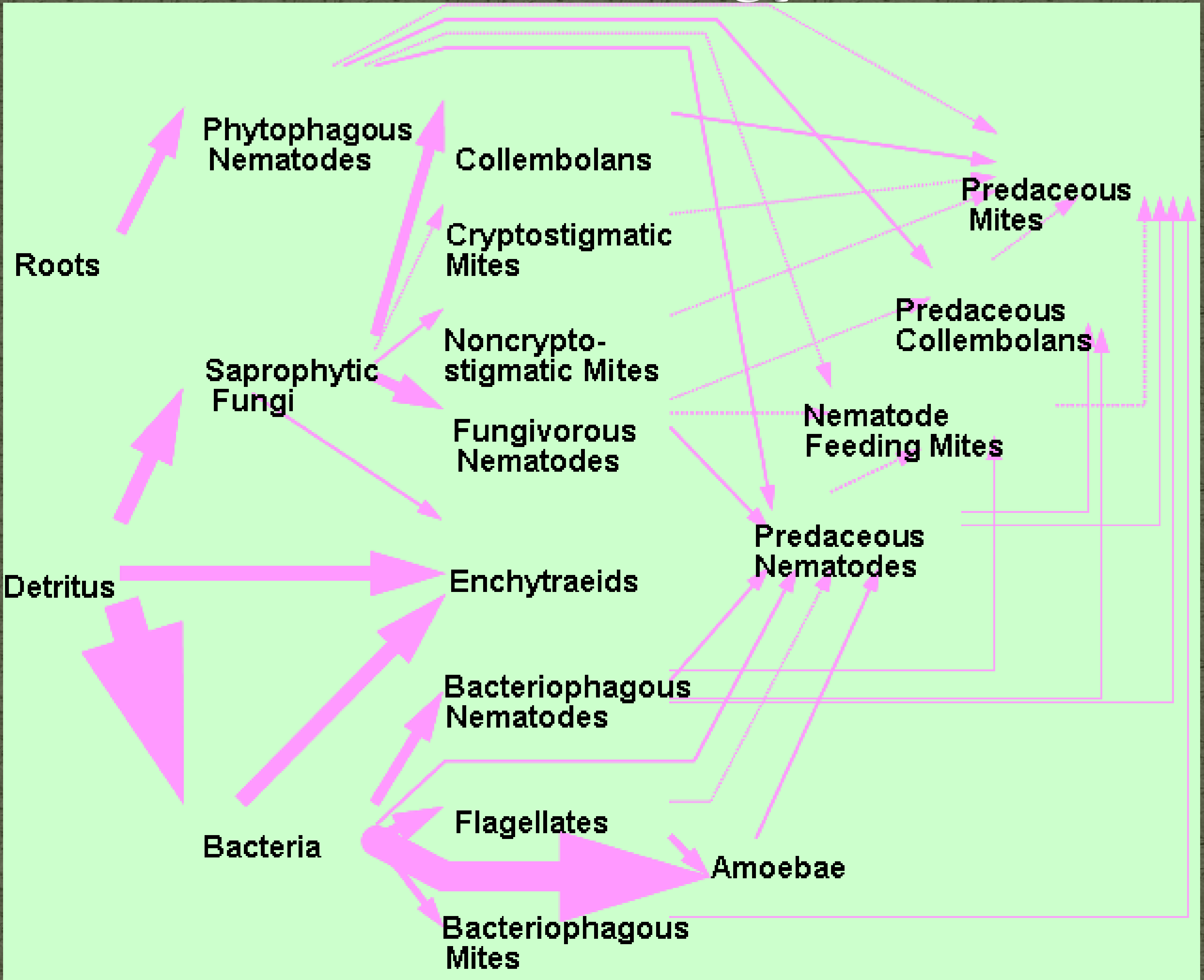
Fourth trophic level:
Higher level predators

Fifth and higher trophic levels:
Higher level predators

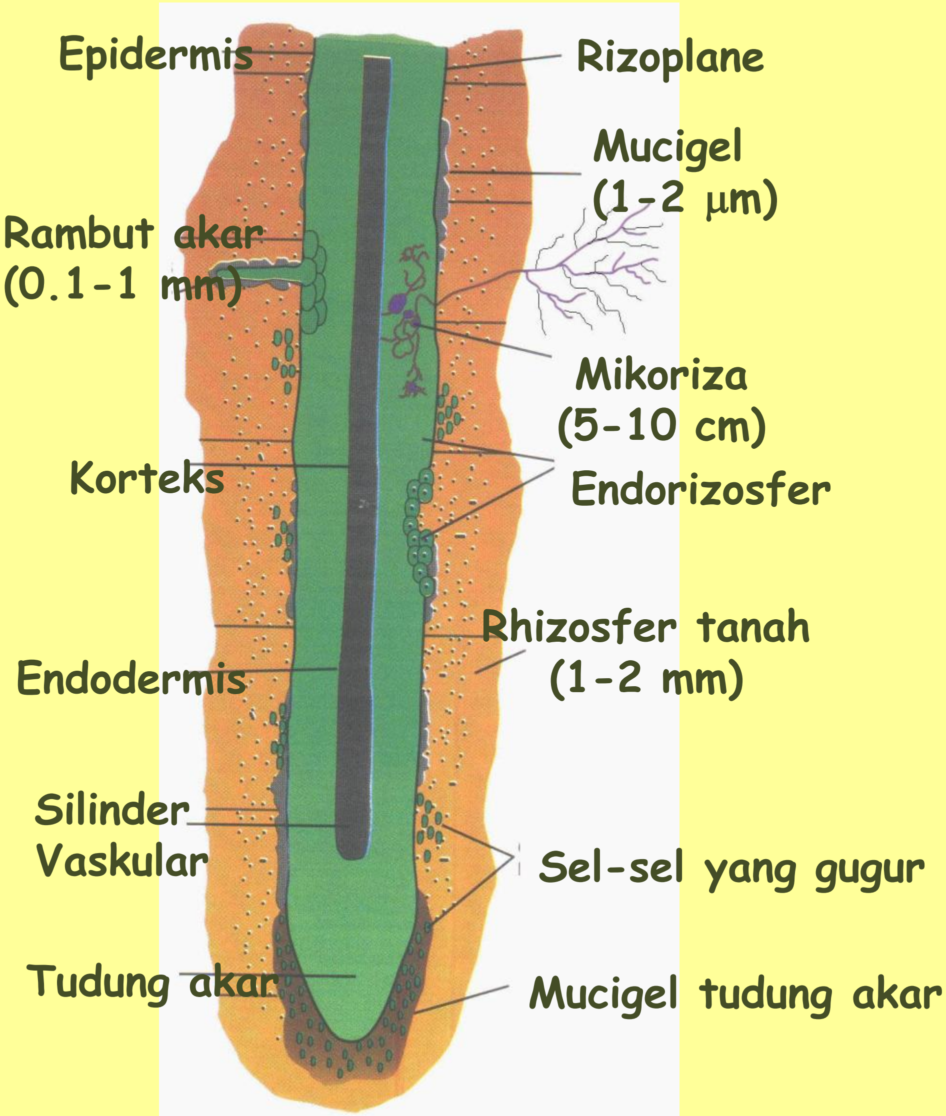
Community Structure – Food Web



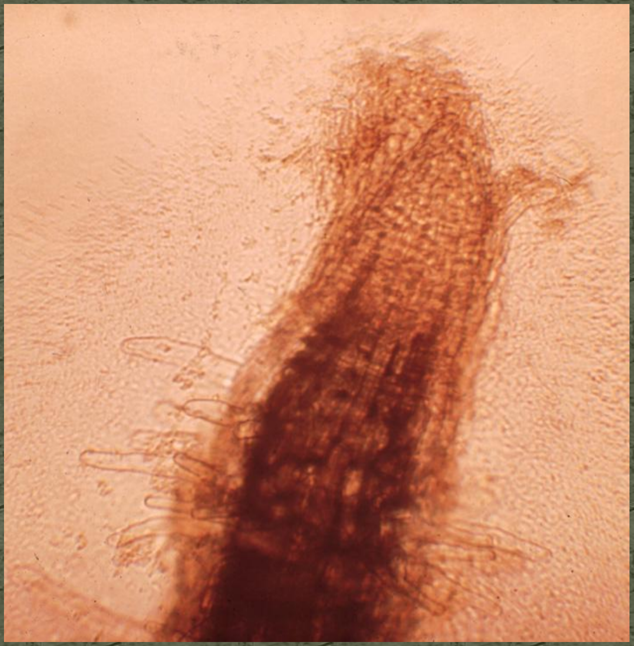
The soil food web - energy flows



Rhizosfer



Penampang akar



Beneficial Microbes in Soil-Plant System

Microbes		Function
Saprophytic	Rhizobacteria & fungi	Seedlings Growth Plant Protection Nutrient Cycling
	Specific Bacteria	Decontamination
Simbion mutualistik	*Rhizobium* dll	N_2 Fixation
	Fungi Mycoriza	Seedlings Growth Nutrient Cycling Plant Protection Decontamination Plant Conservation Plant Succession

N-Fixation: *Frankia*

- actinomycetes

- associates with desert shrubs (e.g., *Ceanothus*) and various tree species (e.g., alder)

Frankia Nodules on Alder

Fungi-Plant Interaction

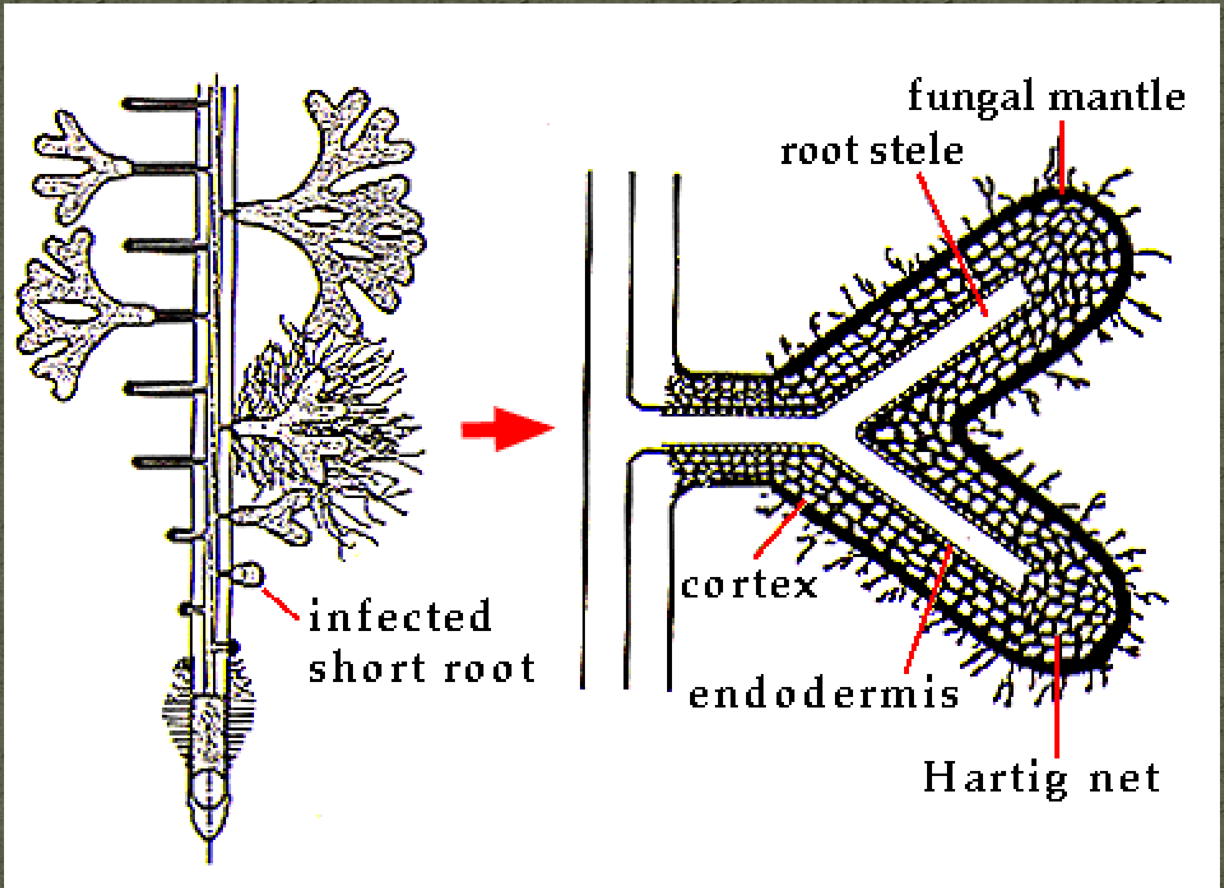
Mycorrhizae

(root fungus)

- extension of root system
- fungus enhances nutrient and water intake
- plants provide carbon source

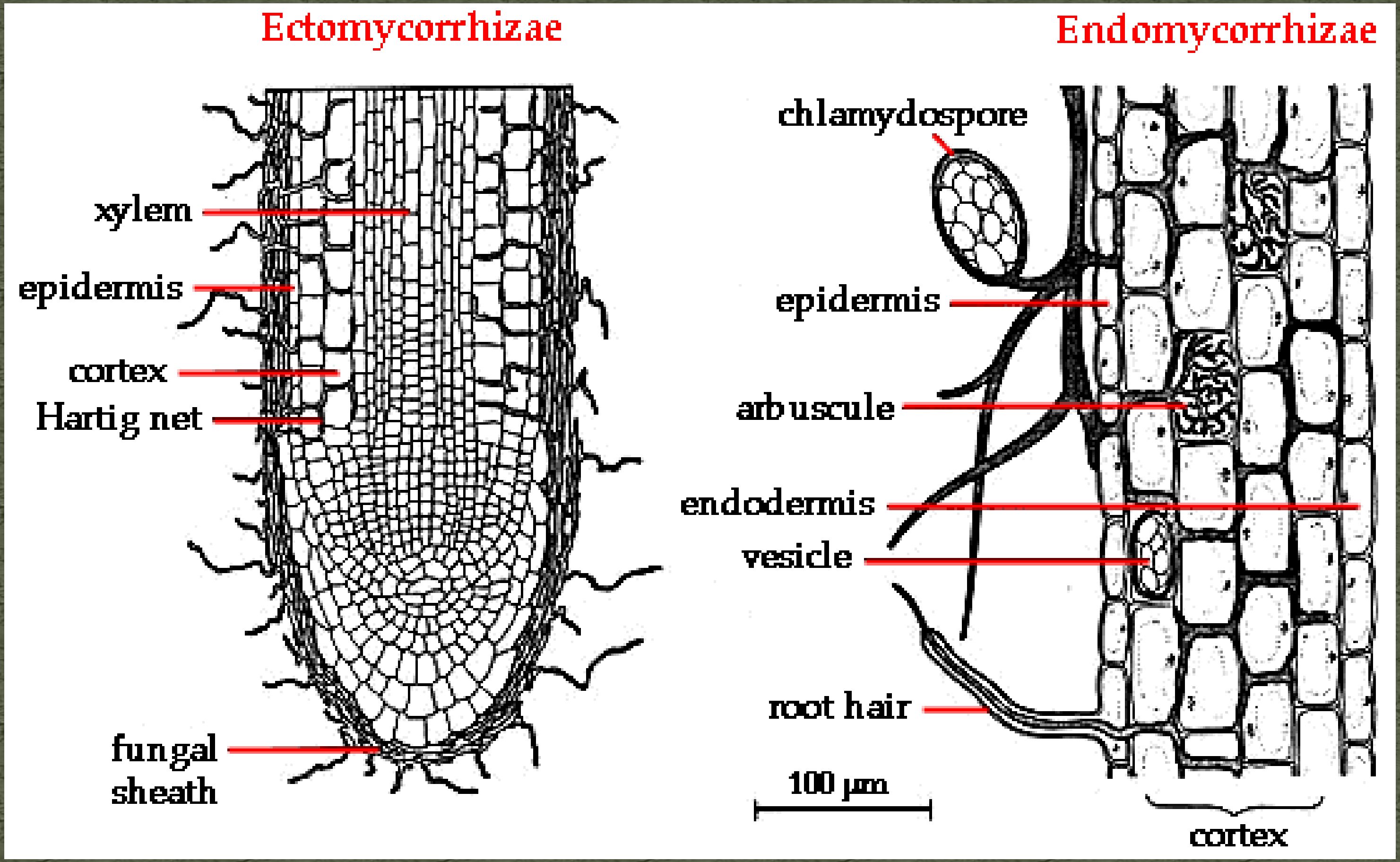
Nearly 90% of native plants have mycorrhizae association

Ectomycorrhyzae



- association at exterior of root
- develop on evergreen trees and shrubs

Mycorrhizae

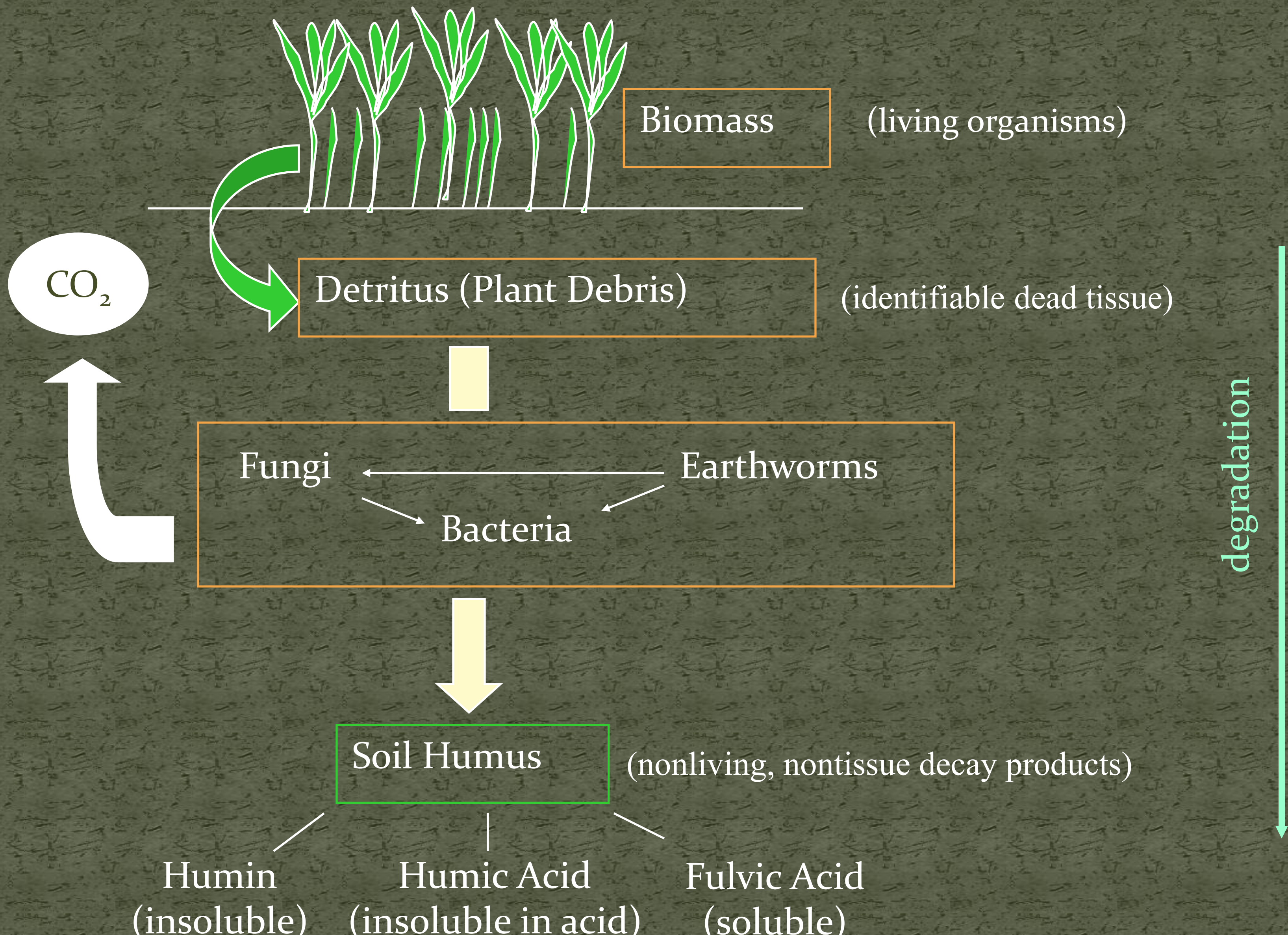


Endomycorrhizae

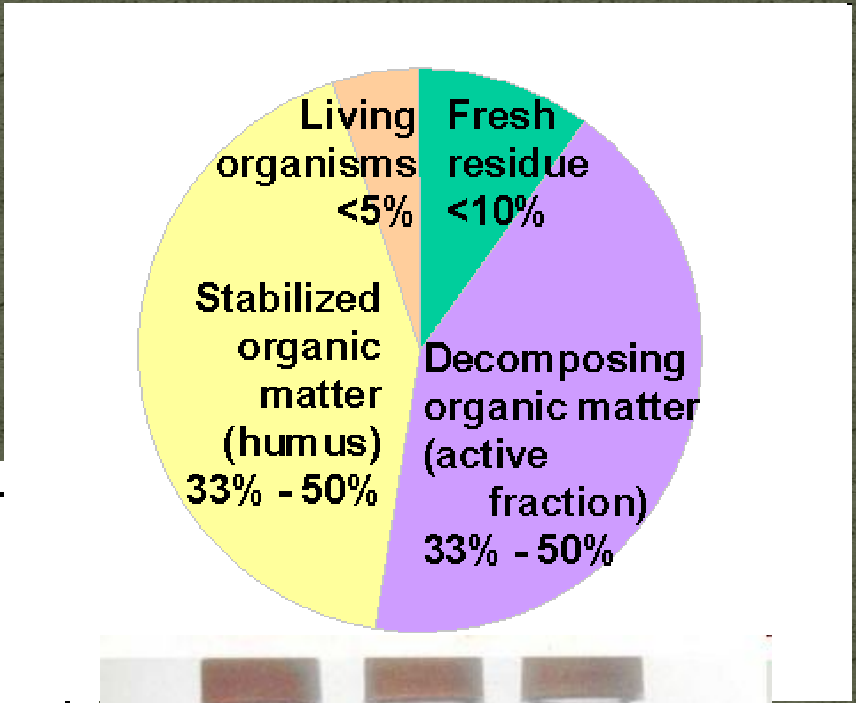
- Associations occur in root interior between cells

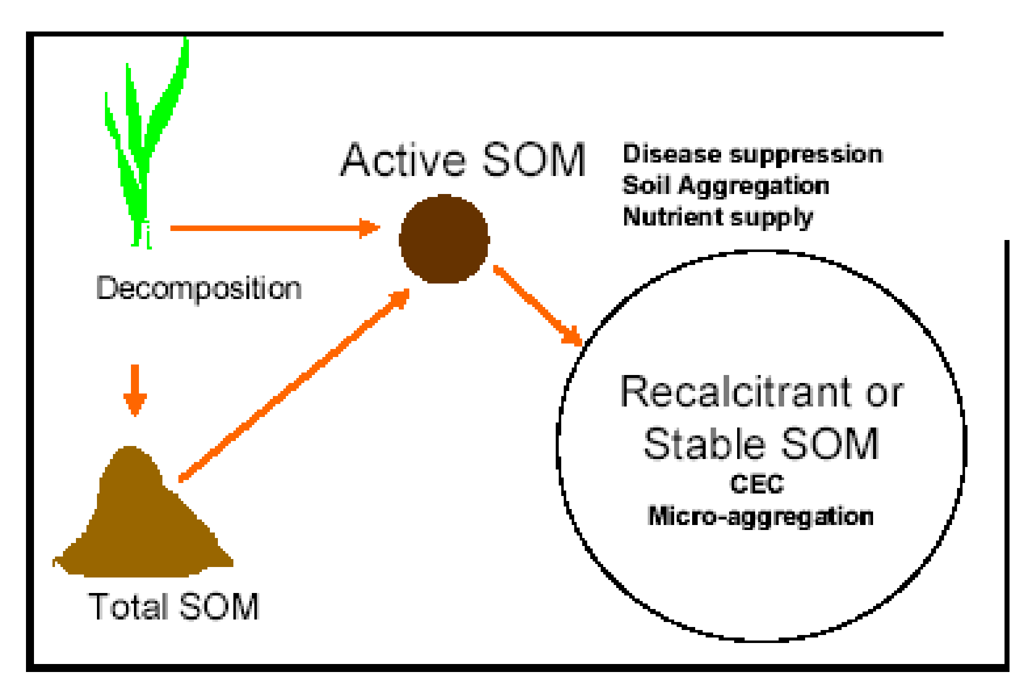
- Develop on deciduous trees, annual and herbaceous plants

Organic Matter

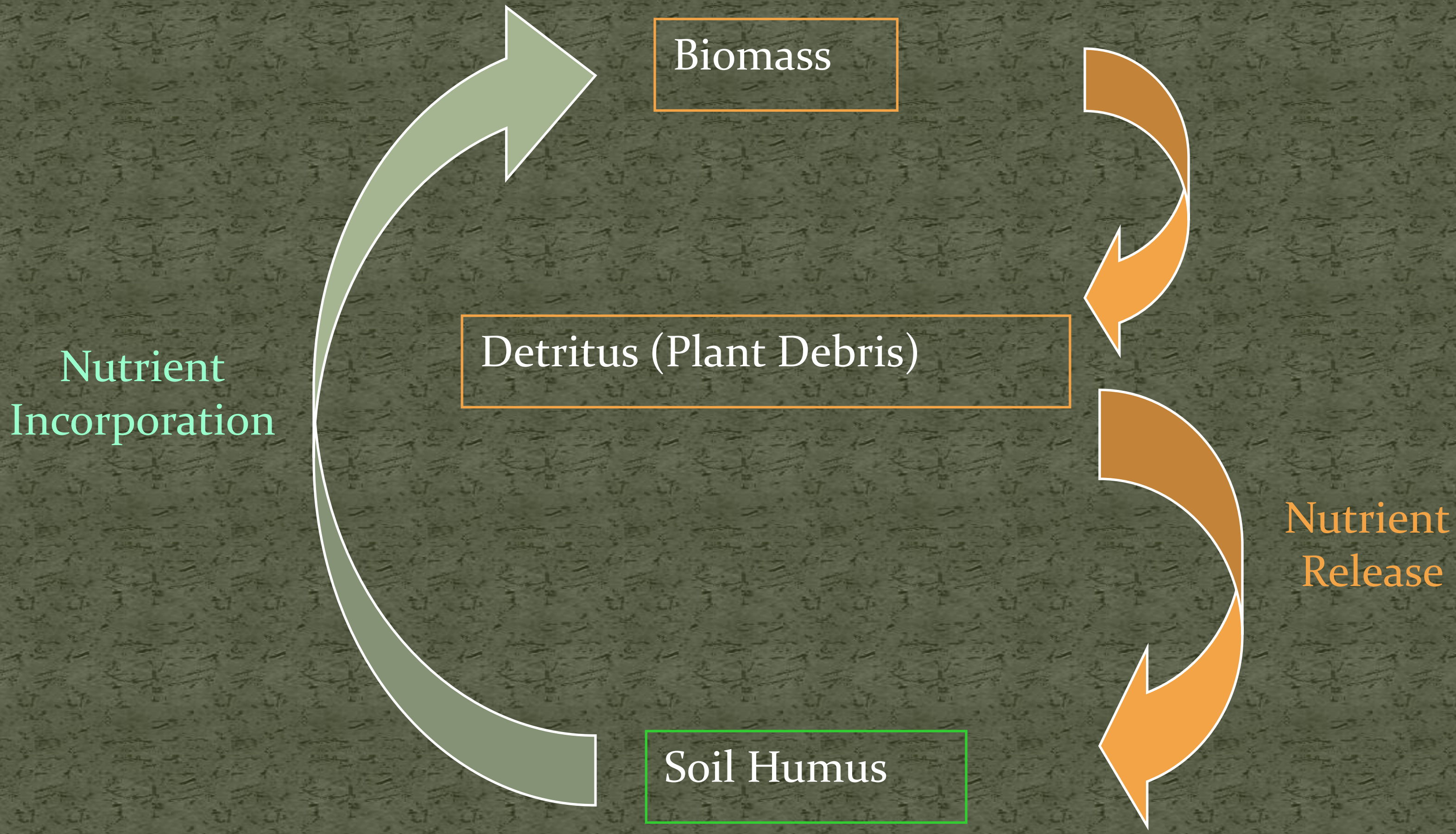


Pools of Soil Organic Matter

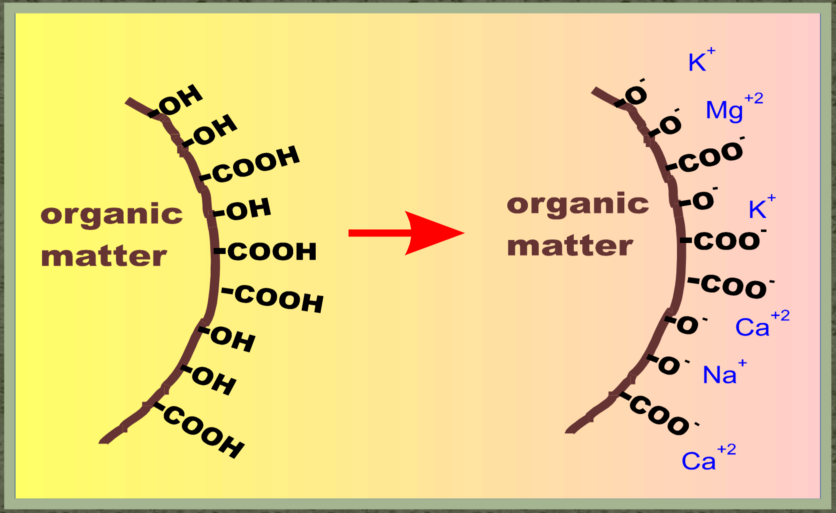




Organic Matter Degradation: Nutrient Cycling



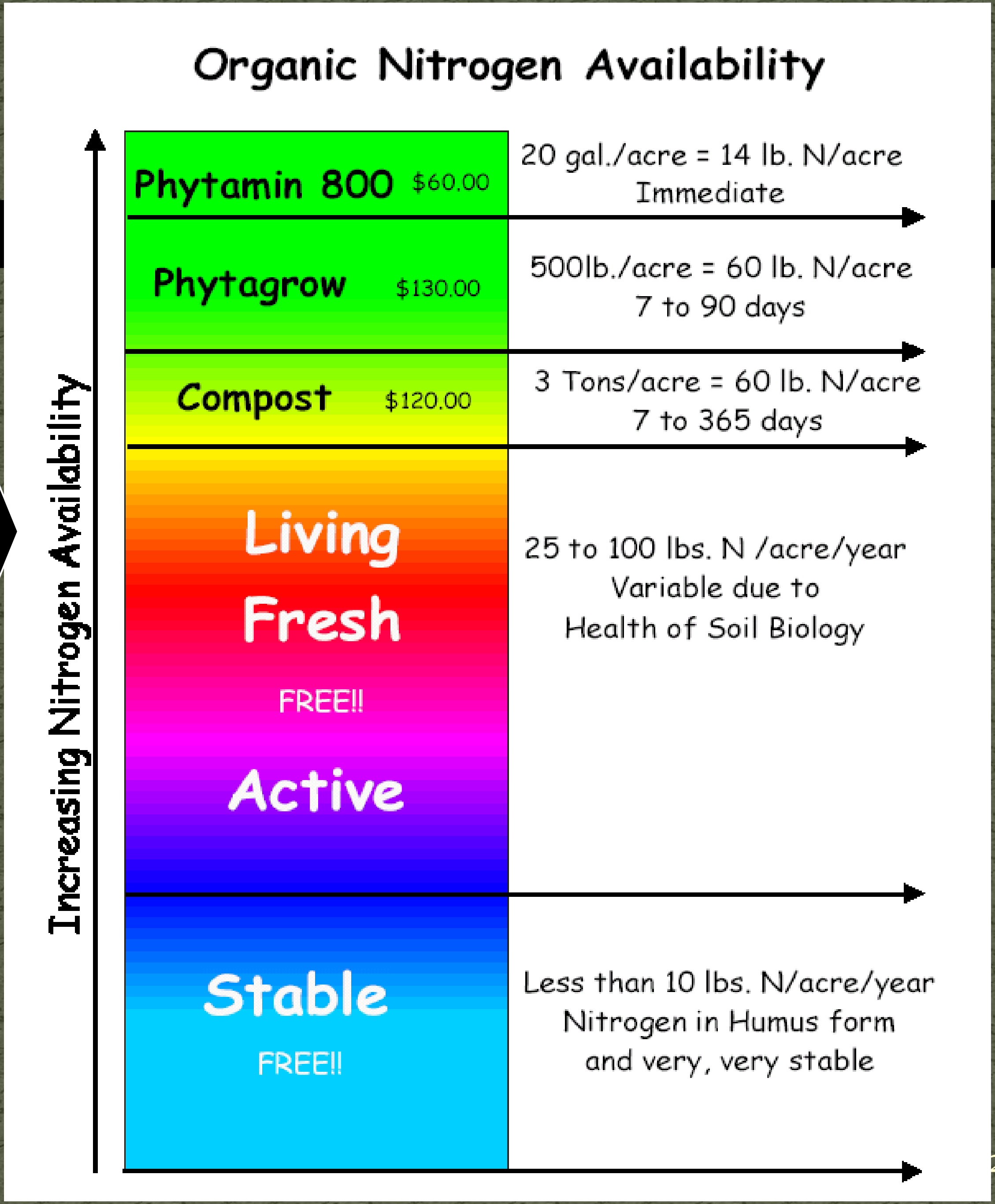
Soil Organic Matter: Humus



-reactive functional groups:
-carboxyl, hydroxyl, phenolic

- High cation (anion) exchange capacity
- High water holding capacity
- Promotes soil aggregation

Increase in Active Fraction increases nutrients!



Soil Sustainability Model

- Quality
  - Structure
    - Physical
      - Gross structure
        - Visual score
        - Bulk Density
      - Pore structure
        - Air permeability
        - Water Retention
        - Faunal Pores
          - Earthworms
          - Enchytraeids
      - Repellency
        - Fungal
        - Chemical
    - Chemistry
      - pH
      - NH4
      - PNR
    - Biodiversity
      - Bacteria
        - Methane oxidisers
        - Denitrifiers
        - Nitrifiers
      - Microbes
        - Eubacteria
        - Fungi
      - Fauna
        - Nematode spp
        - Earthworm spp
  - Function
    - Losses
      - Leaching
        - NO3
        - TEN
        - DOC
      - Gas flux
        - CO2
          - FieldCO2
          - Decomposition
        - N2O
          - FieldN2O
          - PDR
    - Decomposition
      - Comminution
        - Earthworms
        - Enchytraeids
        - Detritivores
          - Collembola
          - Oribatids
      - Mineralisation
        - Bact:Fung
          - B:F ELFA
          - B:F nematodes
        - Microbivores
          - Microbivore-nematodes
          - Protozoa
          - Microbivore-arthropods
        - Predators
          - Omnivore-nematodes
          - Predator-nematodes
          - Mesostigmatids

Decomposition

Organic matter constituents:

10%

- Simple sugars: small molecules, energy-rich bonds (e.g., glucose)
- Starches: simple sugars, but longer chains; storage of carbohydrates

40-80%

- Hemicellulose: polymers of basic sugars in straight or branched chains
- Cellulose: polymers with polymers with 3-d structure, structural function; external enzyme required to decompose

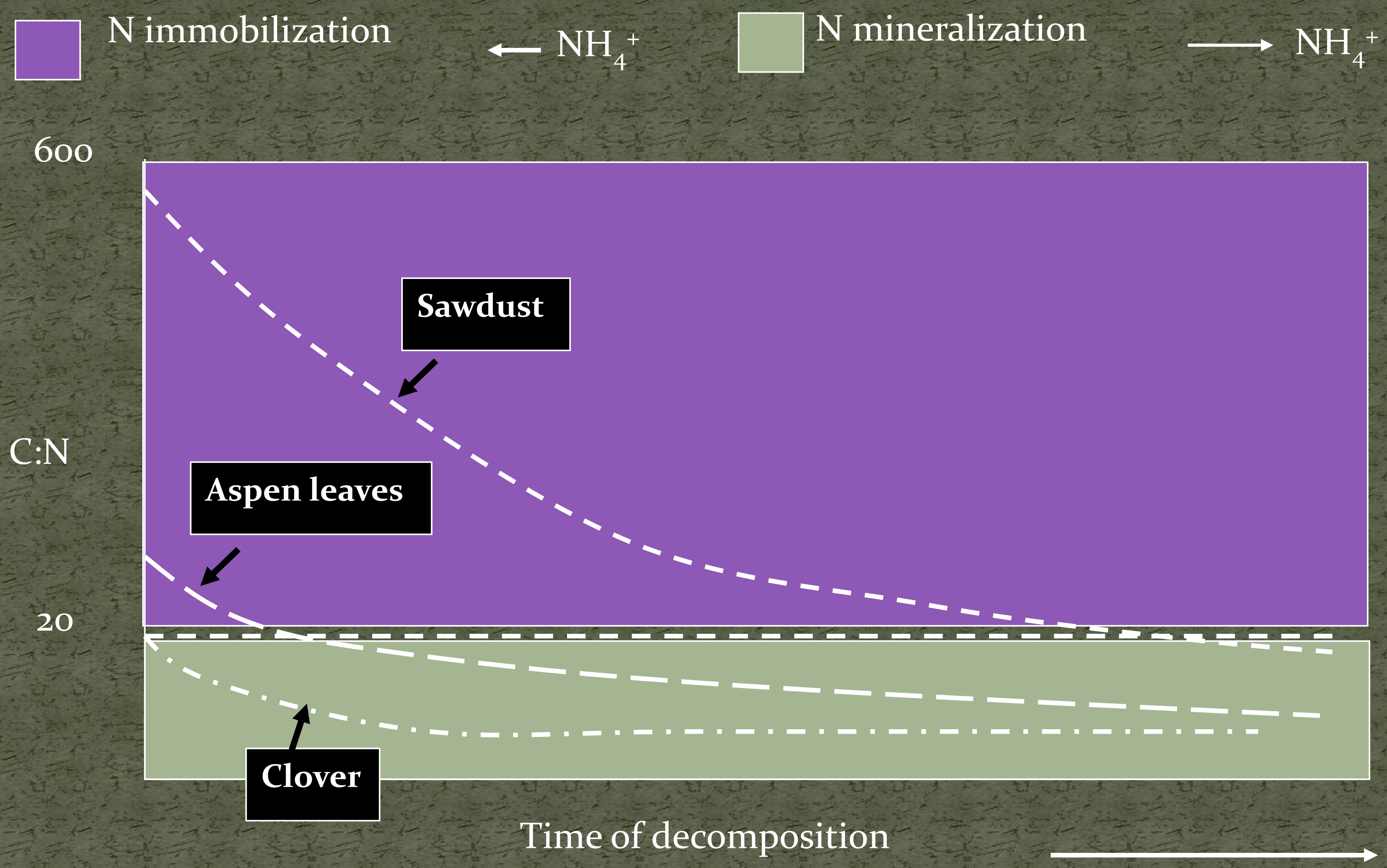
5-40%

- Lignin: polyphenol (ring structure), resistant to decay

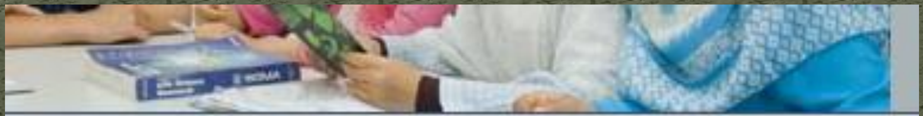
Stages of Decomposition

1. Fragmentation: Physical breakdown; macroinvertebrates involved.
2. Leaching: soluble constituents, esp. K
3. Chemical breakdown
    a. Enzymatic breakdown of C compounds:
        - Easily degradable: proteins, sugars, starches
        - Cellulose and bug bodies
        - More resistant (lignin)
    b. Formation and release of by-products (gases, soluble elements, partially oxidized litter)
    c. Humus formation: material resistant microorganisms modification of lignin, synthesis by microorgs

Material	C/N ratio
Soil Microbes	
Bacteria	6:1
Actinomycetes	6:1
Fungi	12:1
Litter Types	
Alfalfa	13:1
Clover	20:1
Straw	80:1
Deciduous litter	40:1 to 80:1
Coniferous litter	60:1 to 130:1
Woody litter	250:1 to 600:1
Soil Organic Matter	12:1 to 50:1


N immobilization
$\leftarrow NH_4^+$
N mineralization
$\rightarrow NH_4^+$
600
C:N
20
Sawdust
Aspen leaves
Clover
Time of decomposition

GERABAH ORGANIK



Rilis

Teliti Kotoran Sapi, Syammahfuz Chazali Raih Juara I Bisnis Plan Pemuda Tingkat Nasional

BATA ORGANIK

http://www.gsvc.org/finalists_winners/

Congratulations to the 2009 Winner: EcoFaeBrick!

EcoFaeBrick, in conjunction with Faerumnesia, produces high quality and low price bricks by utilizing the abundant cow dung in Godean and Sayegan, Jogjakarta. The utilization of the cow dung will not only solve the hygiene problem but also reduce the exploitation of the un-renewable clay. The

The Global Social Venture Competition
UC Berkeley. USA. $45,000