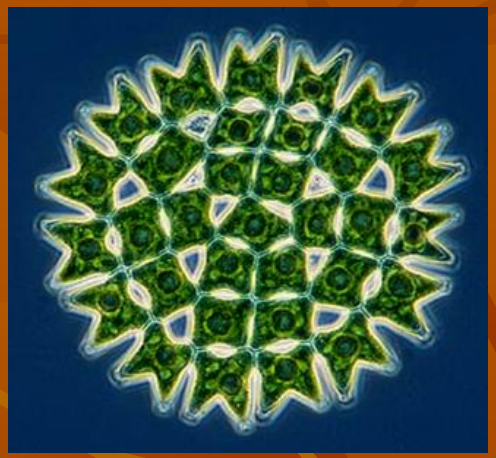
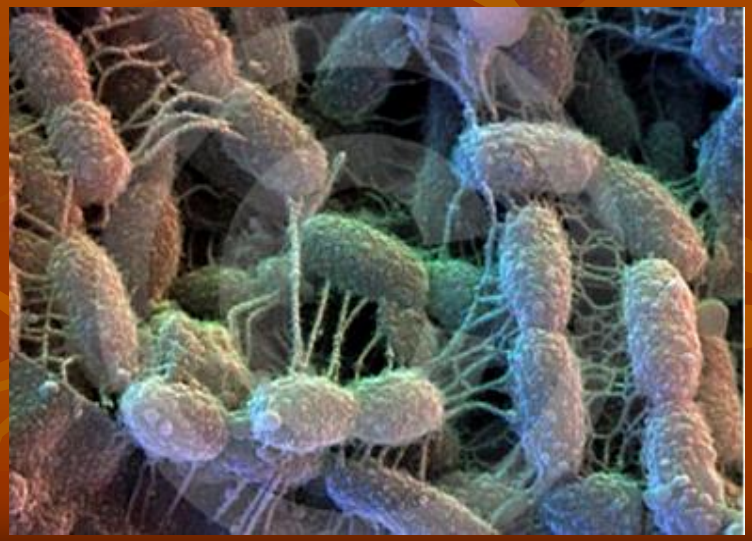
SOIL MICROBES

ORGANISMS AND THEIR RESIDUES

KINGDOMS OF LIVING ORGANISMS

- **Kingdom Monera**
  - Bacteria, actinomycetes, cyanobacteria
- **Kingdom Protista**
  - Heterotrophs, protozoa, amoeba, algae
- **Kingdom Fungi**
  - Perfect and imperfect fungi





KINGDOMS OF LIVING ORGANISMS

- **Kingdom Plantae**
  - Mosses, ferns, and vascular plants

- **Kingdom Animalia**
  - Earthworms, nematodes, arthropods, mollusks, and vertebrates

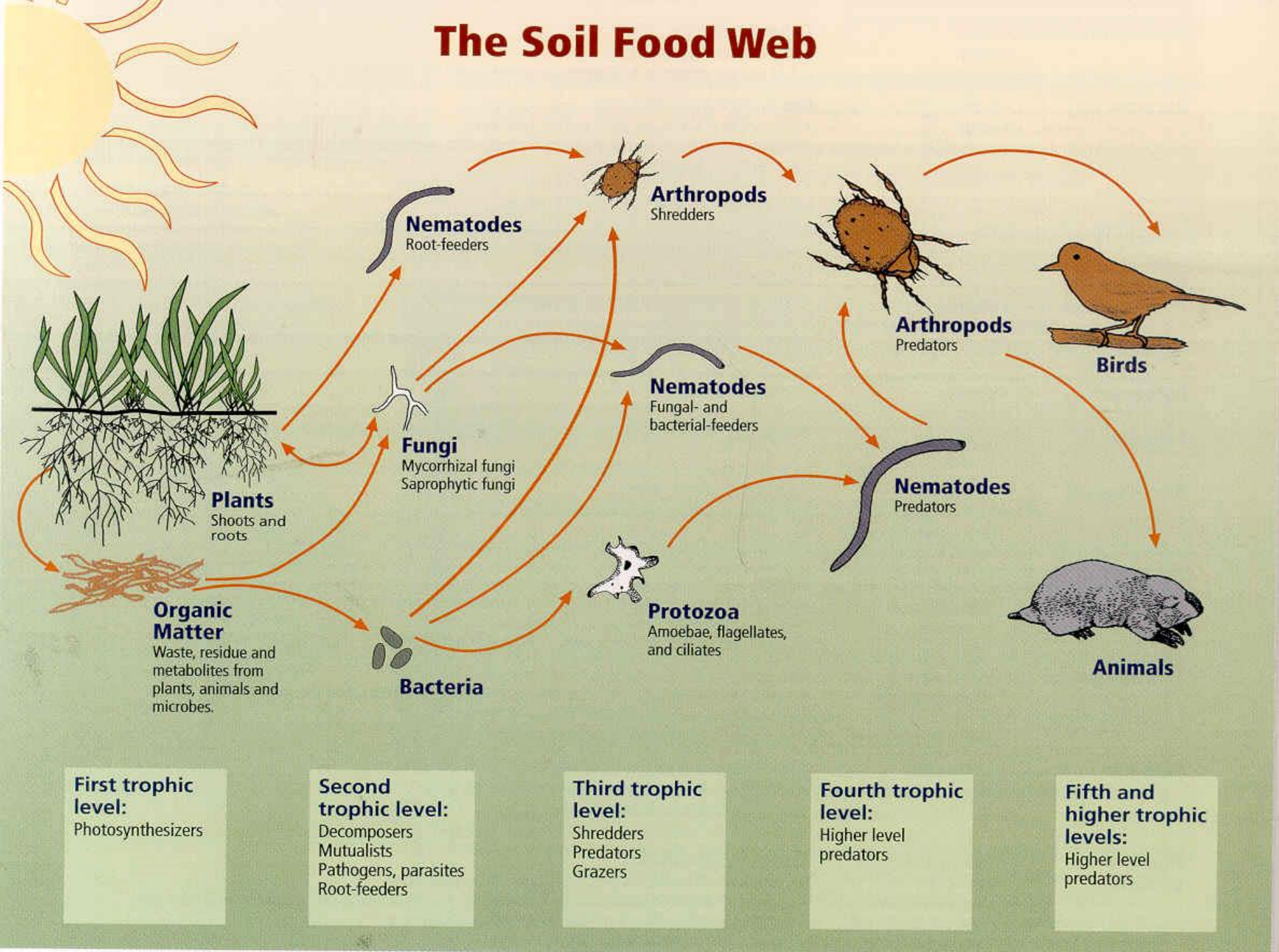
SIZES OF SOIL ORGANISMS

- **Fauna** – animals of the soil
- **Macrofauna** – mammals, earthworms, millipedes
- **Mesofauna** – springtails and mites
- **Microfauna** – nematodes and protozoan
- **Flora** – roots of plants, algae, diatoms
- **Microorganisms** – fungi and bacteria

TYPES OF DIVERSITY

- **Species diversity –** even distribution of species among a large number of species
- **Functional diversity** – capacity to utilize a wide variety of substrates and carry out a wide array of processes
- **Functional redundancy –** presence of several organisms to carry out the same task
  - Leads to ecosystem stability
- **Keystone species** – organisms responsible for certain soil processes
  - Nitrifying bacteria and earthworms

The Soil Food Web



First trophic level:
Photosynthesizers

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

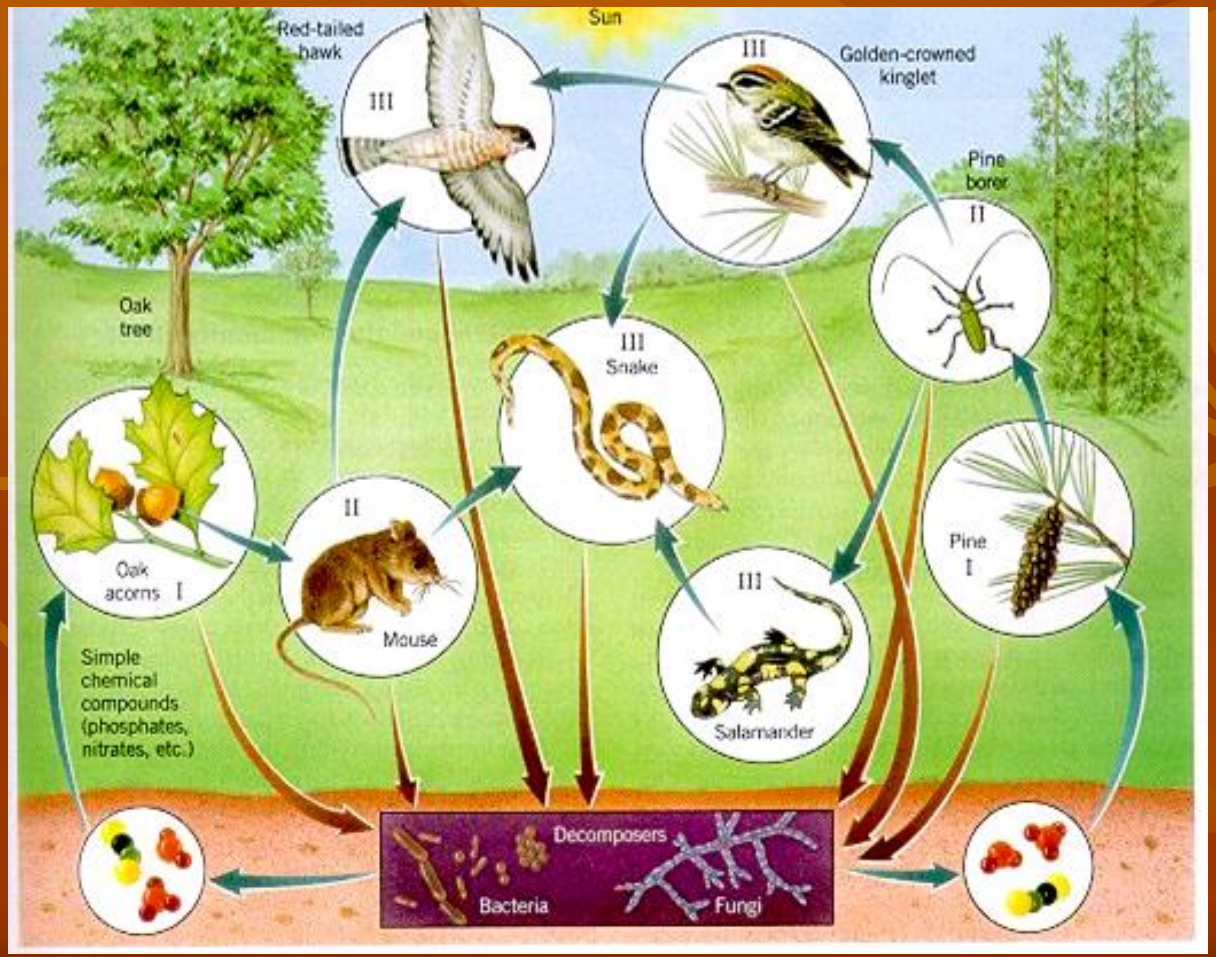
Third trophic level:
Shredders
Predators
Grazers

Fourth trophic level:
Higher level predators

Fifth and higher trophic levels:
Higher level predators

FOOD CHAINS OR FOOD WEBS

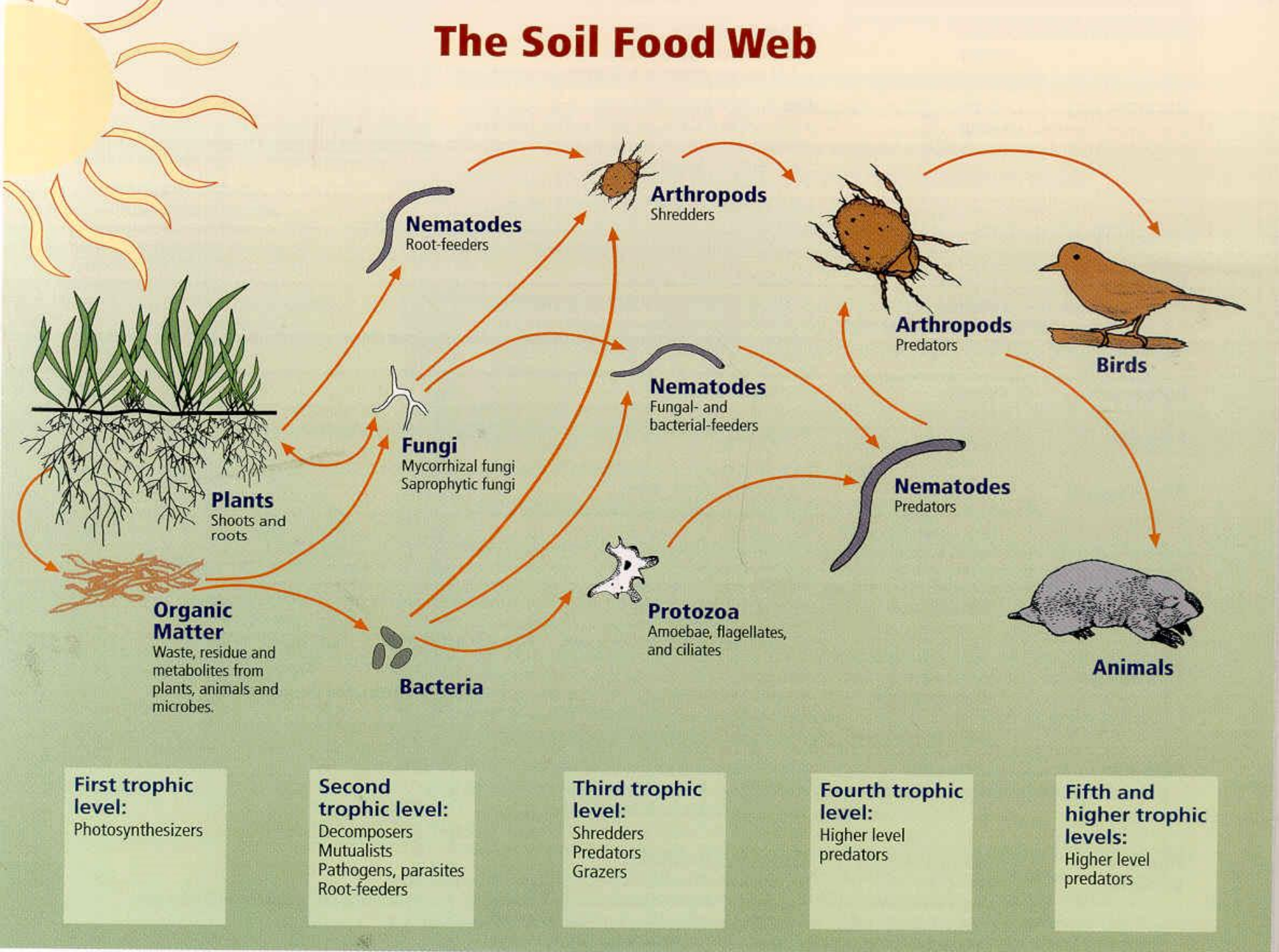
- **Activities of soil flora and fauna**



SOIL ORGANISMS IN ACTION

- **Trophic levels** **(Levels 1-4)**
  - **Primary producers:** vascular plants/algae
  - **Primary consumers:** herbivores
  - **Predators:** animals that eat primary consumers
  - **Predators:** animals that eat other predators

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

PRIMARY CONSUMERS

- **Detritivores –** feed on debris of dead plants tissues (**detritus**)

- **Saprophytes –** fungi and bacteria that feeding on dead tissue

SECONDARY CONSUMERS

- **Carnivores –** consumers of other animals
  - Centipedes and mites
  - Involved in both **physical** and **chemical** activities and reactions

- **Microflora –** bacteria, fungi, and actinomycetes
  - Involved in **biochemical** activities and reactions

TERTIARY CONSUMERS

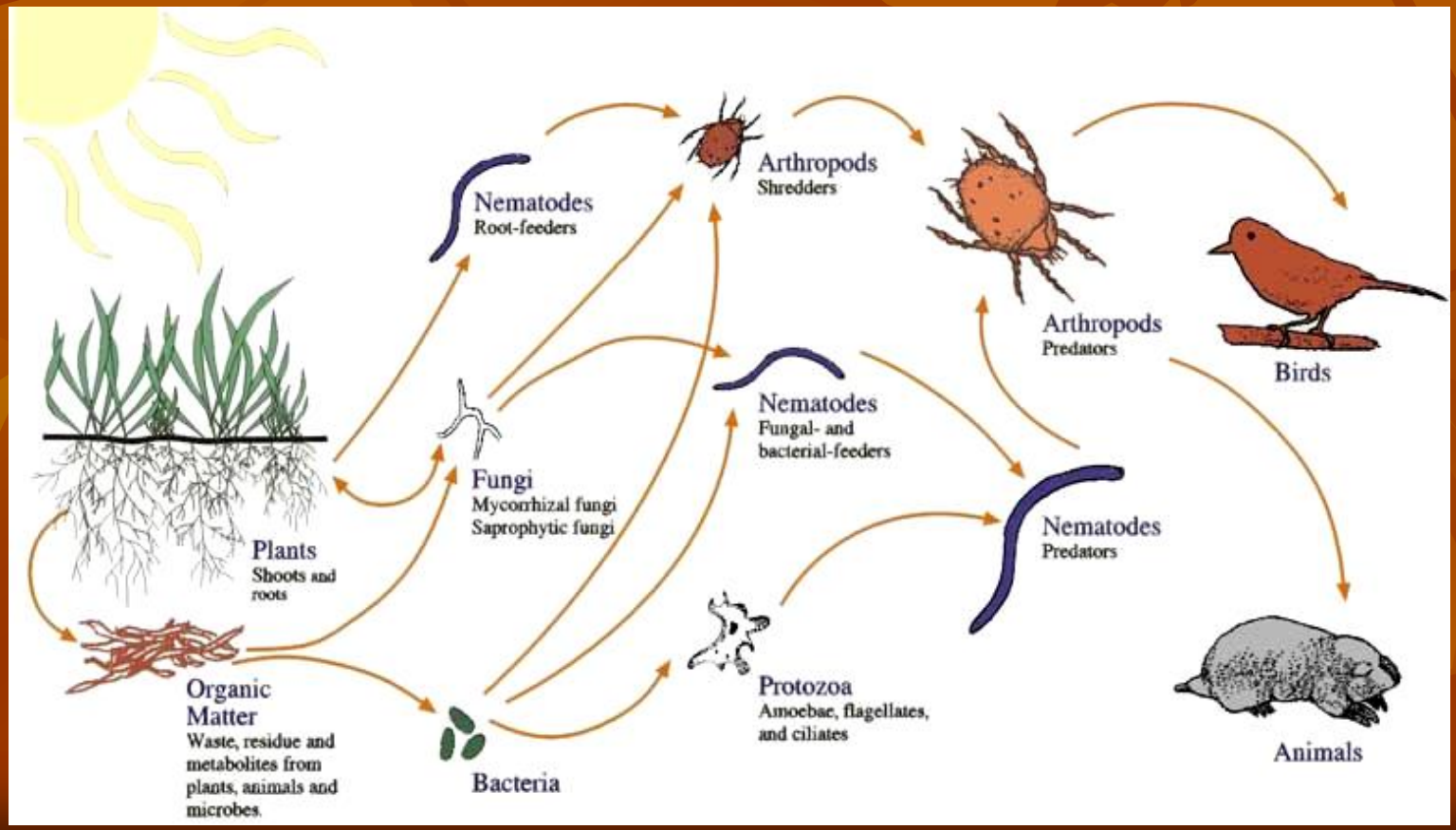
- **Predators** such as:
  - Birds
  - Insects
  - Earthworms
  - Arthropods (spiders, mites and scorpions)

“ECOSYSTEM ENGINEERS”

- Create **impervious surfaces** in deserts
- **Burrowing** by earthworms
- **Soil inversion** by termites
- **Nutrient enhancement** by dung beetles

SOIL BIOMASS, AND METABOLIC ACTIVTY

- Living fraction of the soil and is related to the amount of OM present



EARTHWORMS

- **Most important macro animals in soils**
  - Eat detritus, soil organic matter and microorganisms
  - Do not eat living plant or plant roots
  - Non-pests

EARTHWORMS

- **Influence soil fertility and productivity**
  - Ingest soil 2 to 30 times their weight/day
  - Create extensive burrows
  - Ingested soil is expelled as **casts** (“soil globs”)

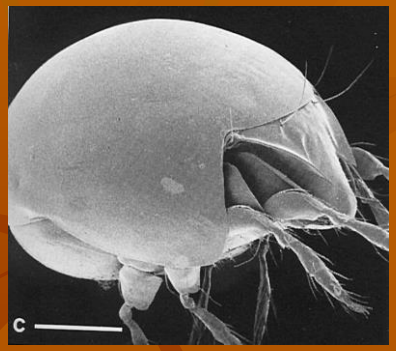
- **Influence soil fertility and productivity**
  - Alter physical and chemical soil properties
  - Help increase aeration, drainage, water infiltration

EARTHWORM ACTIVITY

- Prefer moist, well-aerated, warm (70^{o}F) soils
- pH between 5.0 – 8.4
- Abundant supply of calcium (Ca)
- Sensitive to salinity
- Maximum activity in spring and autumn
- Vulnerable to moles, mice, Arthropods
- Inhibited by sandy soils
- Affected by **ammonia fertilizers**
- Affected by **carbamate** insecticides

ARTHROPODS AND THEIR ACTIVITY

- **Mites, millipedes, centipedes, and insects**



- Feed on decaying vegetation and help aerate the soil

- Can be beneficial or pestiferous (pests)

GASTROPODS AND THEIR ACTIVITY

- **Slugs and snails**
- Feed on decaying vegetation
- Can be beneficial or pestiferous (pests)

NEMATODES AND THEIR ACTIVITY

- Found in most all soils in large numbers
- **Un-segmented roundworms**
- Seen only with magnification
- High populations in moist, sandy soils
- Survive adversity in **cryptobiotic** or "resting state"
- Some are **predators** and/or **plant**

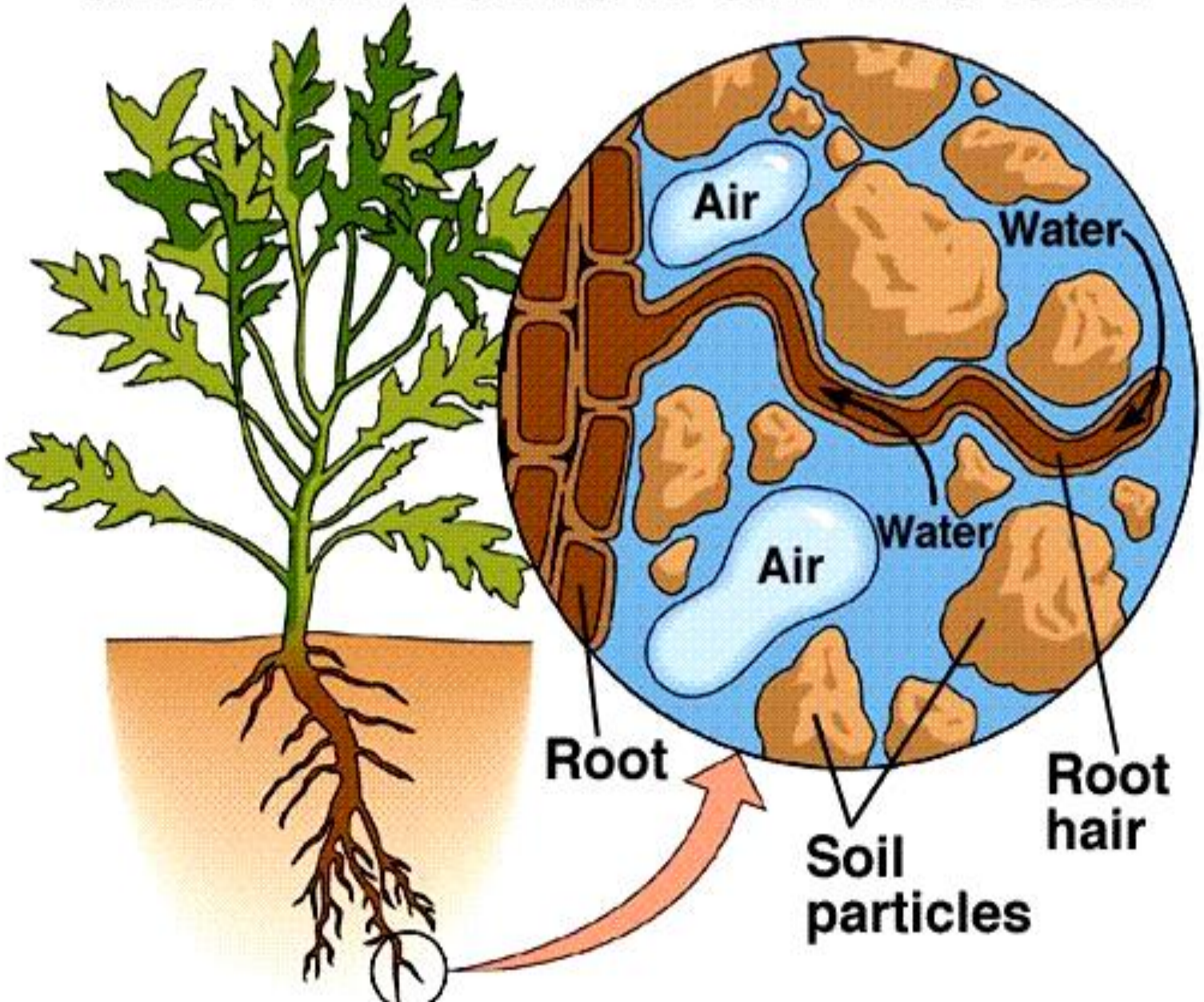
PLANT ROOTS AND THEIR ACTIVITY

- Occupy about 1% of soil volume
- Account for 25%-33% of soil respiration
- Compete for oxygen
- Produce carbon and energy

ROOT HAIRS

- **Elongated, protuberances of single cells of the outer (epidermal) layer**
  - Anchors the root
  - Increase root surface area
  - Assist in uptake of water and nutrients
  - Formation is stimulated by contact with soil particles and low nutrient supply

Root Hairs Absorb Water and Nutrients from the Soil

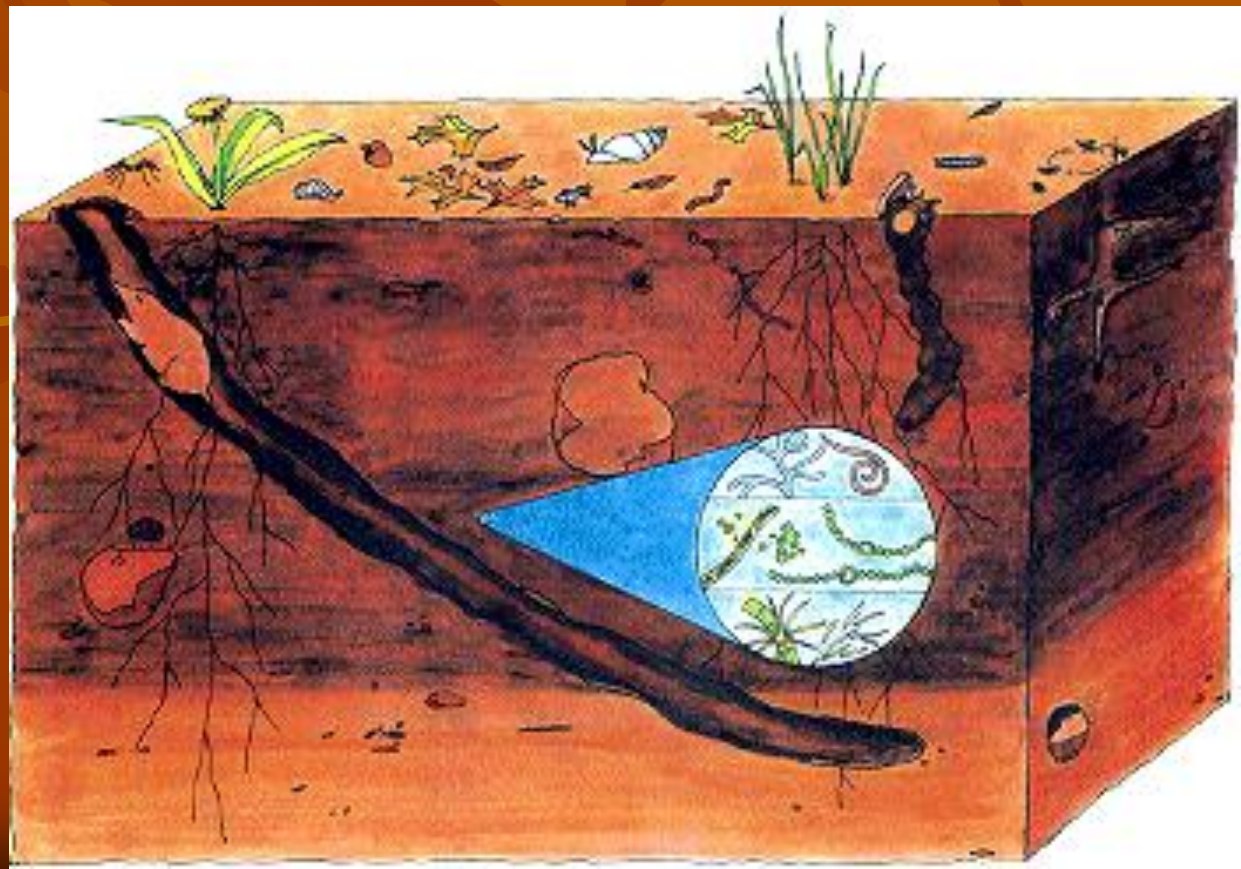


PLANT ROOTS AND THEIR ACTIVITIES

- Physically modify the soil
- Increase stable **soil aggregation**
- **Root exudates** for microorganisms
- Add **humus** and organic matter

RHIZOSPHERE

- Soil immediately around the root up to about 2 mm

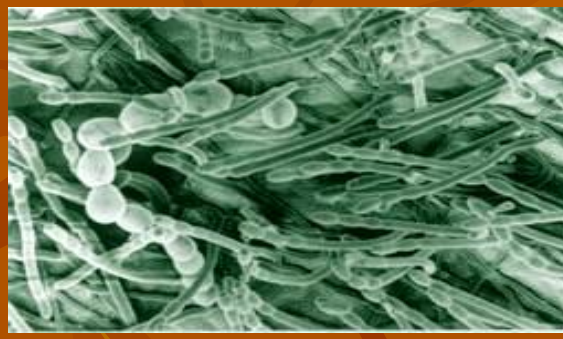


SOIL FUNGI AND THEIR ACTIVITIES

- One million soil-dwelling species still unidentified
- **Heterotrophs -** depend on living or dead organic materials for carbon and energy
- **Aerobic** organisms

SOIL FUNGI AND THEIR ACTIVITIES

- **Hyphae** - fungal filaments
- **Mycelia** – woven strands of hyphae
- **Yeasts**
  - Live in anaerobic, waterlogged soils
- **Molds**
  - Filamentous fungi
  - Important in organic matter breakdown
  - ***Penicillium, Fusarium, Aspergillus***



SOIL FUNGI AND THEIR ACTIVITIES

- Decompose organic matter
  Important in humus formation
- More efficient than bacteria
- Important in soil fertility
- Some produce **mycotoxins**
  - **Aflatoxins** on corn and peanuts

MYCORRHIZAE

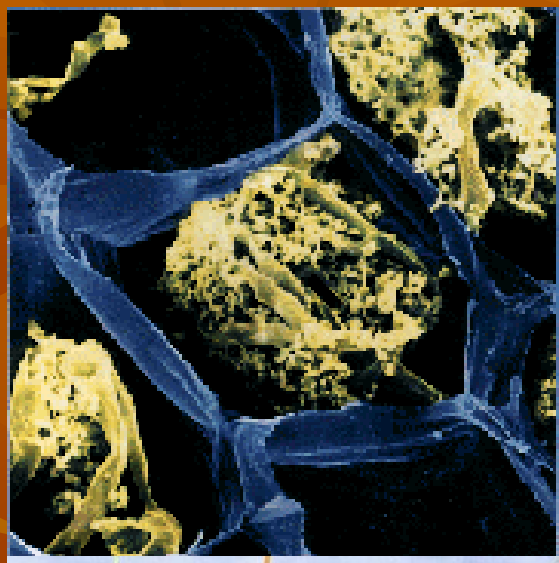
- Means "***fungus root***"
- Form **symbiotic relationships** with plant roots

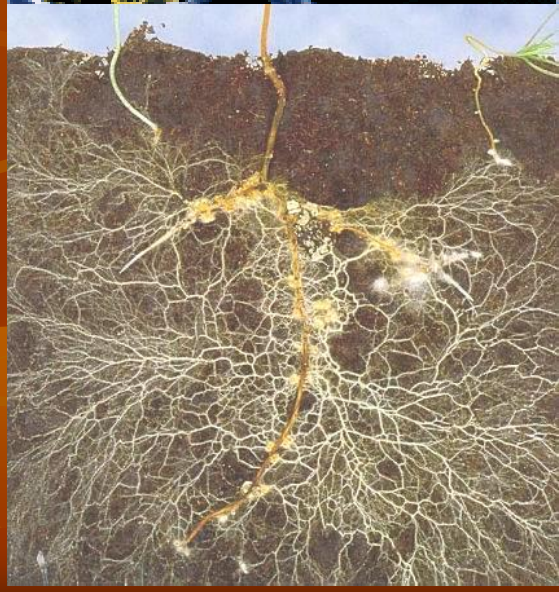
BENEFITS OF MYCORRHIZAE

- Enhance water and nutrient uptake
- Protect plant roots from:
  - Pathogens
  - Heavy metals and salts

ECTOMYCORRHIZA

- Associated with temperate trees and shrubs
- Cover the surface of feeder roots
- Do not penetrate root cortex cells walls
- Root system consists of stubby, white rootlets with ‘Y” shape



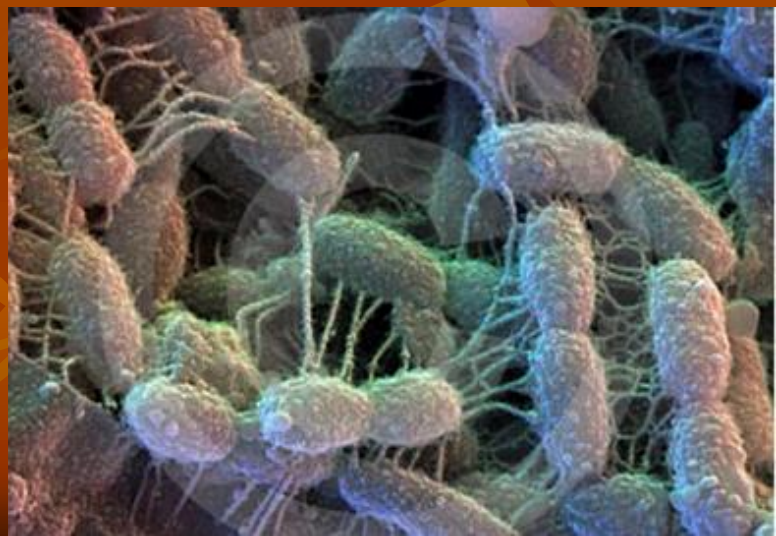


ENDOMYCORRHIZA

- Penetrate the root cortex cell walls
- Form small highly branched structures called **arbuscules**
  - Transfer mineral nutrients from fungus to plant and sugars from plant to fungus
- Storage organs called **vesicles** are formed

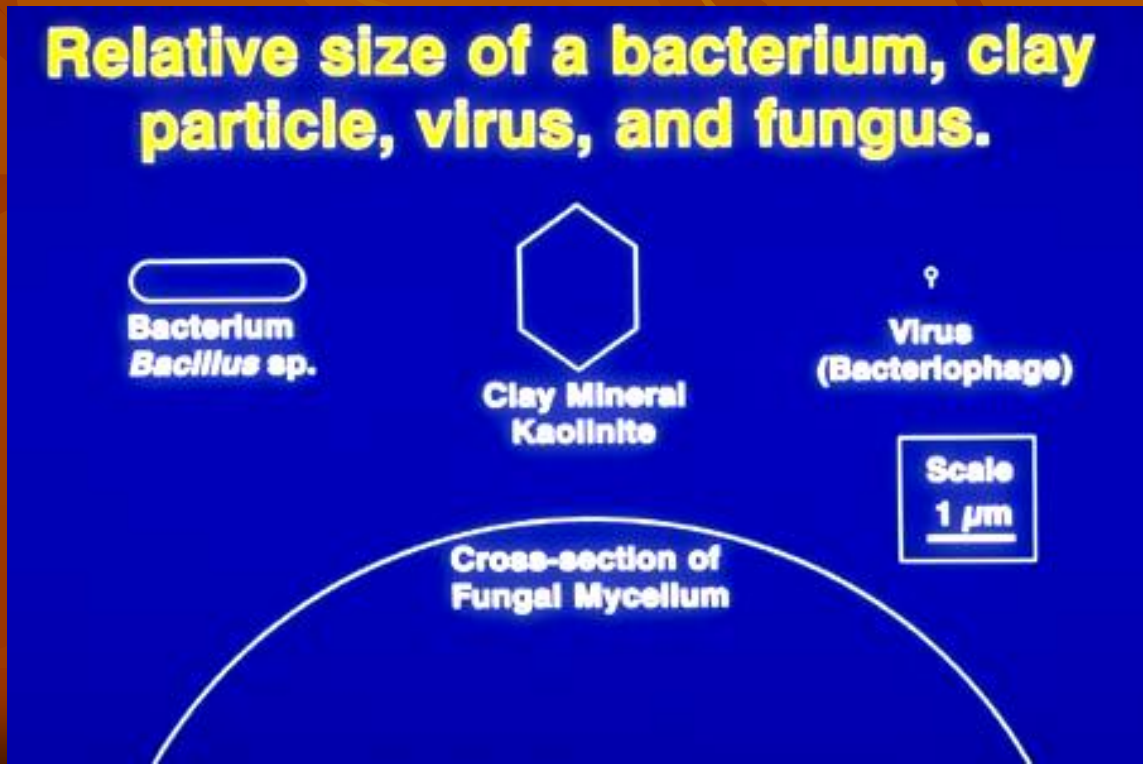
BACTERIA

- **Rod-shaped** organisms lacking a nucleus
- **Motile**, swimming by means of **cilia** and **flagella**
- Rapid reproduction



BACTERIA

- Participate in virtually all soil organic transactions

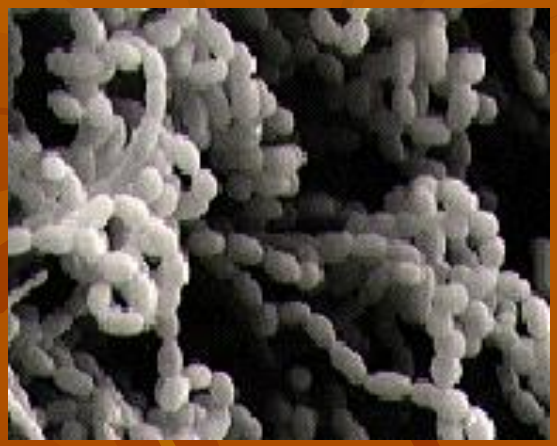


BACTERIA

- Important in **soil remediation** for removal of:
  - Crude oil
  - Organic toxins
  - Gasoline
  - Pesticides
  - Diesel fuel

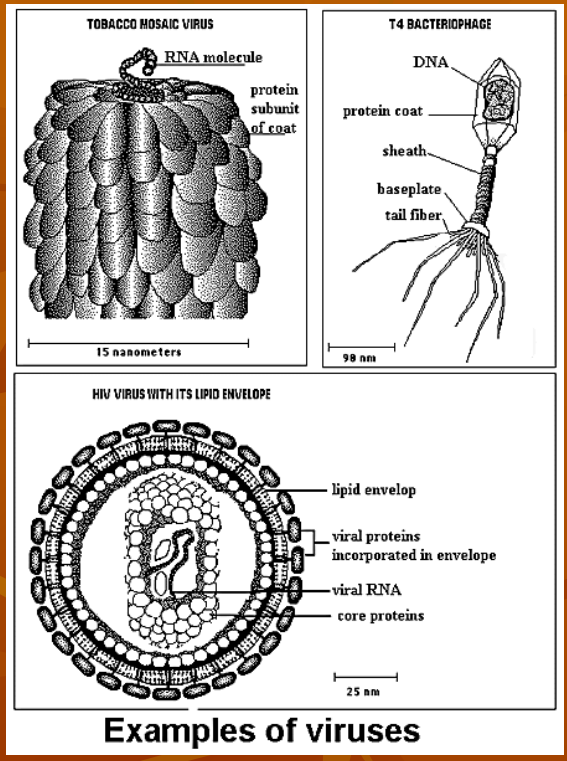
SOIL ACTINOMYCYCETES

- Filamentous and profusely branched
- "Bacteria-like"
- Classified as bacteria
- Live on decaying OM
- Produce **antibiotic compounds**
  - Used as insecticides (i.e. Conserve™)
- **Antibiotics:** Actinomycin, Neomycin, Streptomycin
- Fix atmospheric N gas into ammonium
- Prefer moist, warm, well-aerated soils
- Prefer pH's of 6.0 – 7.5



SOIL VIRUSES AND VIROIDS

- Virus (Roman word for ***poison venom or secretion)***
- Non-living nucleic acids surrounded by a protein coat
- Considered **acellular organisms**
- Capable of only a few life functions
- ***Cause serious plant and animal diseases***



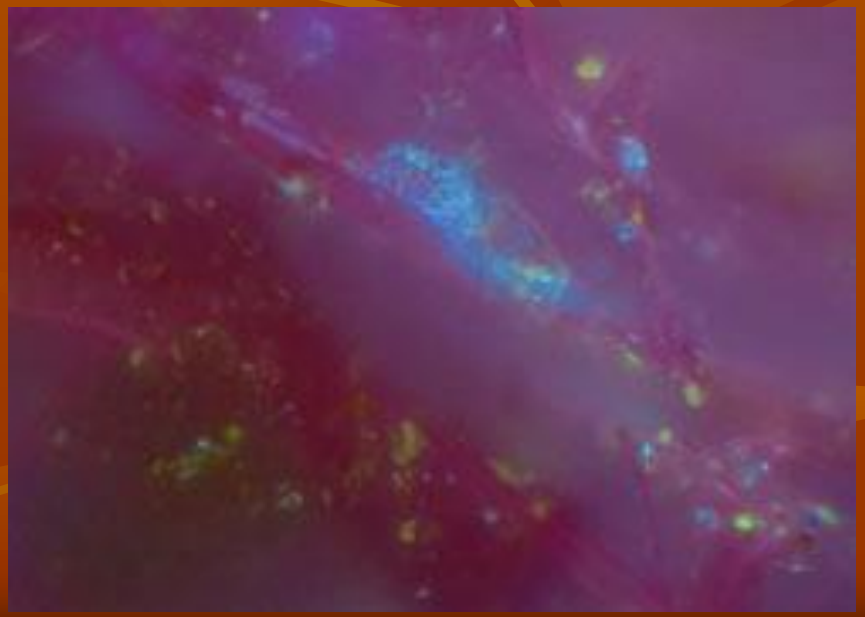
Examples of viruses

OPTIMUM CONDITIONS MICROBIAL ACTIVITY

- **OM requirements**
  - Additions stimulate microbial activity
- **Oxygen requirements**
  - Most are aerobic
  - Some anaerobic
  - High Ca and neutral pH favors bacteria
  - Lower pH's favor fungi
    - ***Fungi are more prevalent in forest soils***
    - ***Bacteria more prevalent in prairie soils***

BENEFICIAL ASPECTS OF SOIL ORGANISMS

- OM decomposition
- Breakdown of toxic compounds
- Inorganic transformations
- N fixation
- **Rhizobacteria**
- Plant protection



PLANT DISEASE CONTROL AND SOIL MANAGEMENT

- Prevention
- Soil pH
- Air and temperature

EFFECTS OF MANAGEMENT PRACTICES ON MICROBES

- **Monocultures** reduce diversity
- Pesticides can be detrimental or enhance organisms
- Addition of OM can be helpful

END OF PRESENTATION