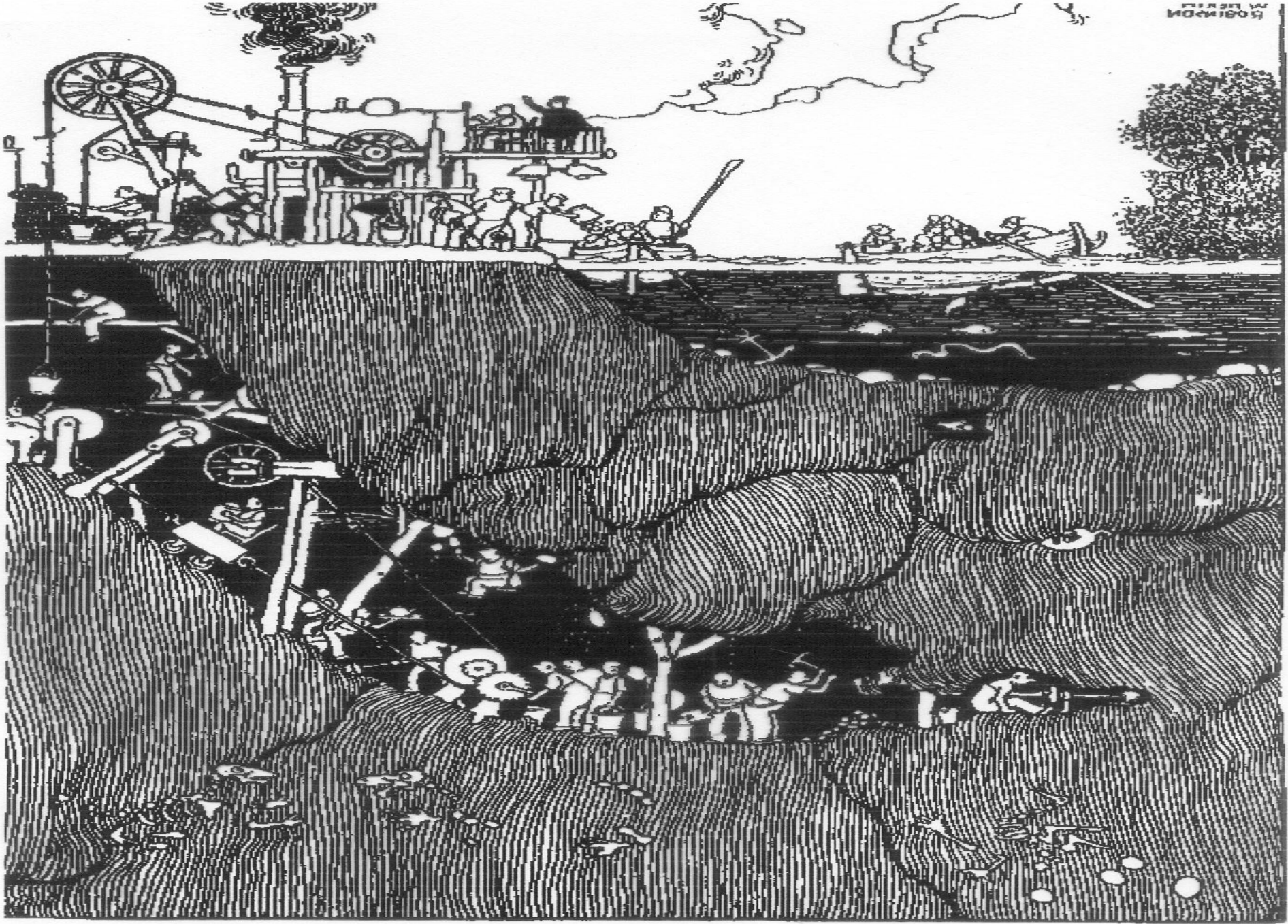
LECTURE IN SOIL SCIENCE

Soil Biological Characteristics

KONYA FOOD AND AGRICULTURE UNIVERSITY
2019 SPRING SEMESTER

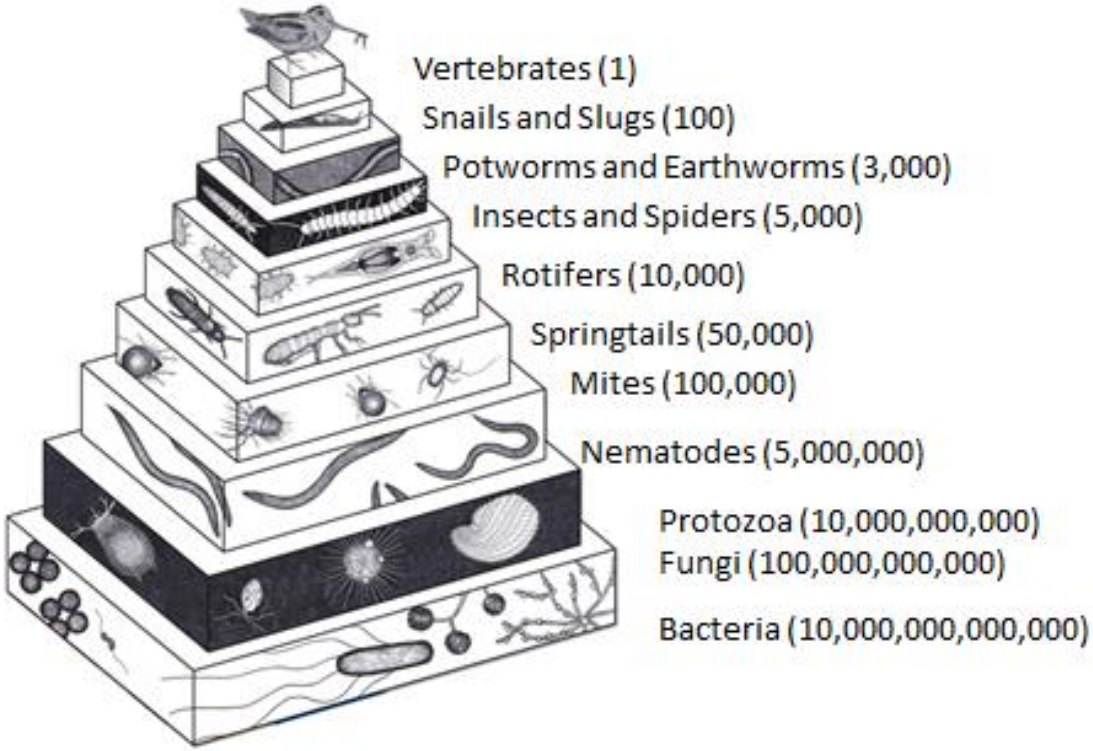
Prof. Dr. Oğuz Can TURGAY
Soil Science Department
Faculty of Agriculture, Ankara University



Soil biology is the subsection of soil science mainly focused on microbial and faunal activity and ecology in **soil**.

Soil life, **soil** biota, **soil** fauna, or edaphon is a collective term including all organisms that spend a significant portion of their life cycle within a **soil** profile, or at the **soil**-litter interface

Biology Pyramid



This pyramid represents a food chain showing the diversity of living organisms found in most soils. The base has lots of organisms, which tend to be small and support life for organisms above. Upward through each level, fewer organisms remain until you get to the top with a single bird. The smallest organisms, it turns out, are the most abundant.

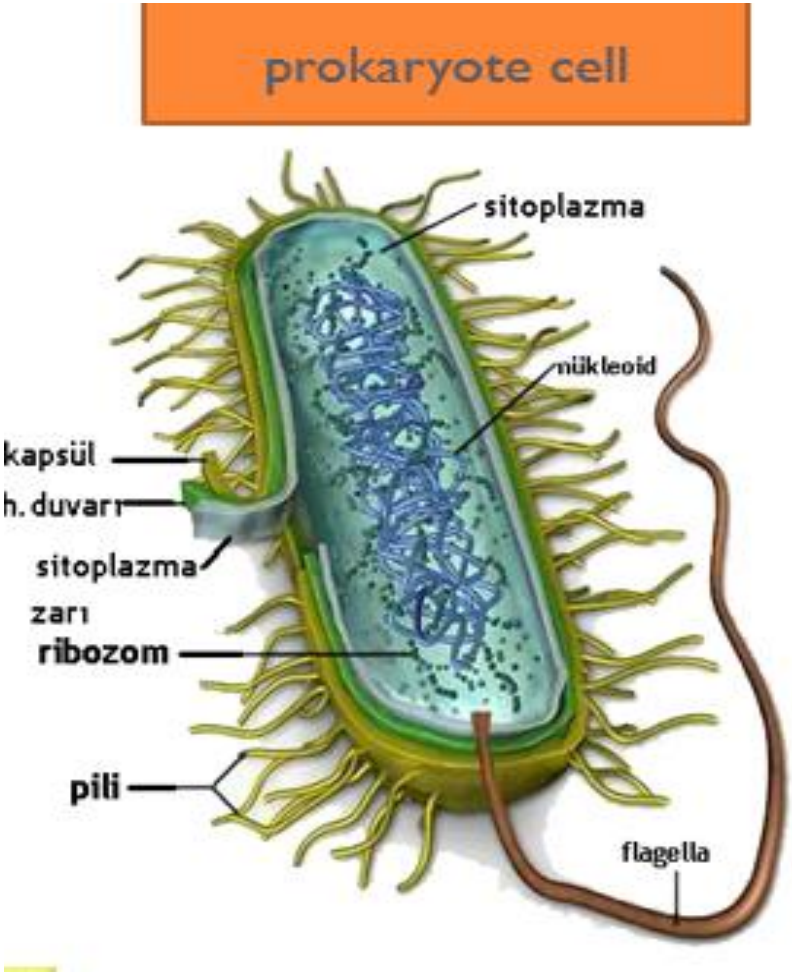
- Most of the microorganisms in the terrestrial ecosystem are found in the soil and their relationships with non-living environment (mineral soil) is widely regarded as **soil ecology**.

All living organisms can be classified into two major groups, mainly **eukaryotes** and **prokaryotes**, according to their cell structure differences

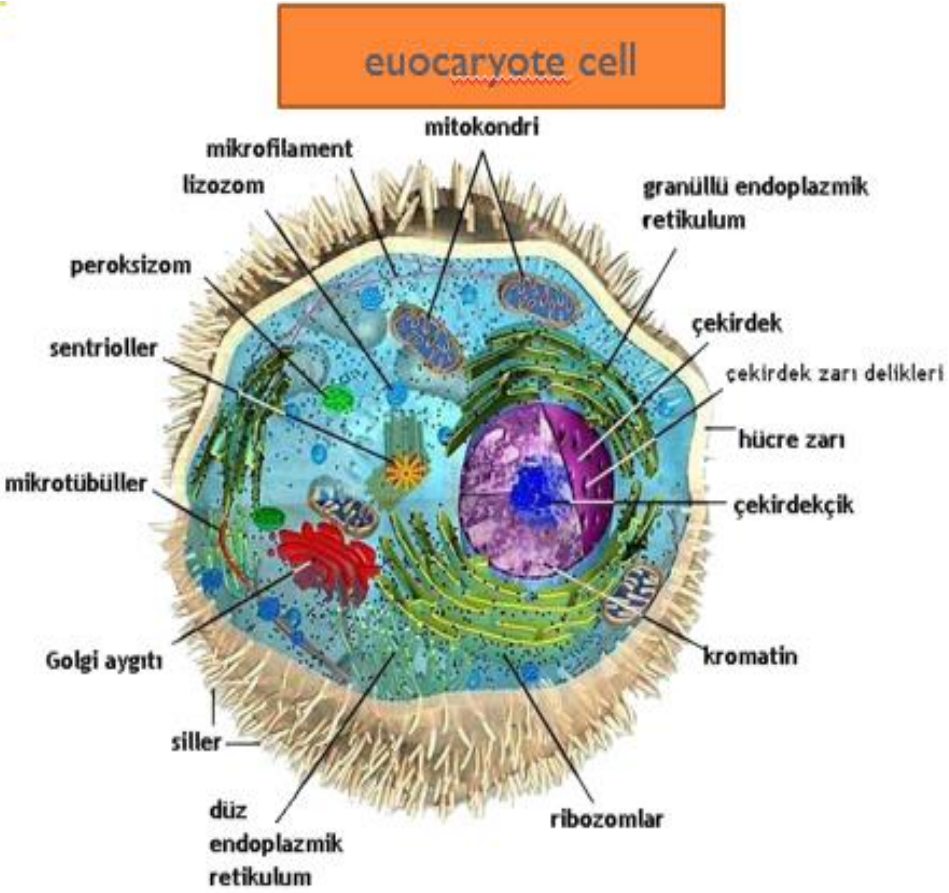
Substructural structural differences between eukaryotes and prokaryotes are important.

The names "eukaryotes" and "prokaryotes" are Greek originated word.

karyo nucleus
pro prior
Eu good or right

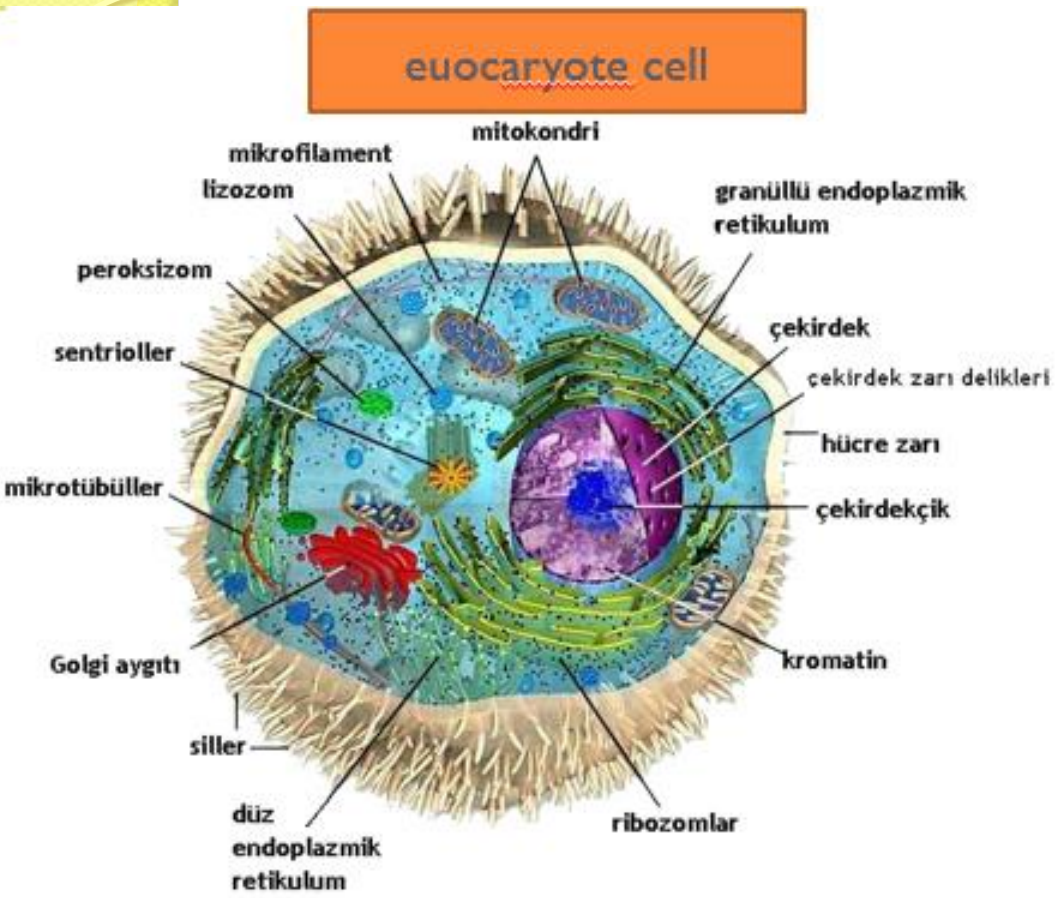


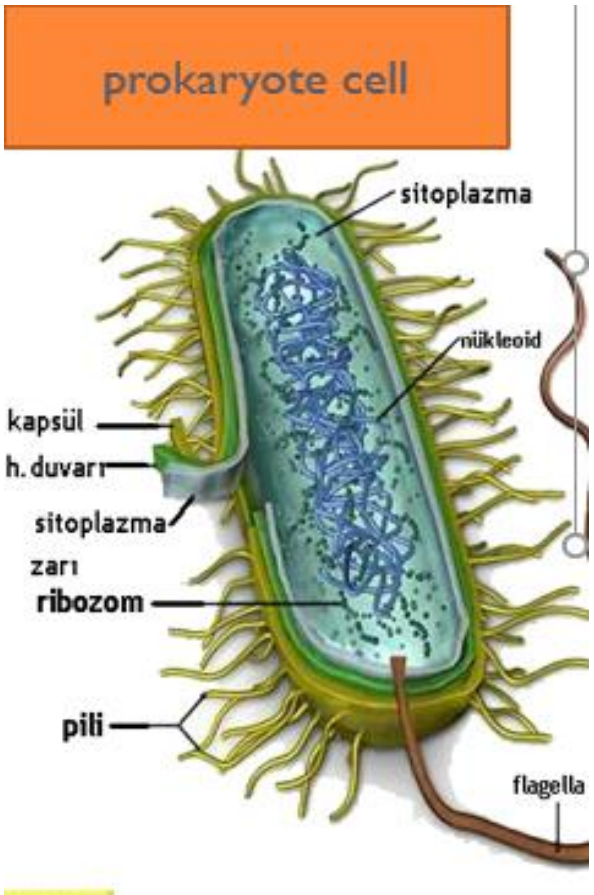
- The prokaryote cell contains simple DNA molecules and a nuclear region surrounded by membranes **(Bacteria and Archaea)**
- No real cell nucleus
- Mitochondria and plastids are absent
- The cell contains a heteropolymer substance called murein



The eukaryotic cell contains well-defined nucleus with nuclear membrane that protects the DNA molecules forming genetic material (fungi, algae and protozoa)

- They have a certain cell nucleus, contain no mureid
They have mitochondria in the cytoplasm and plastids in the plant cells



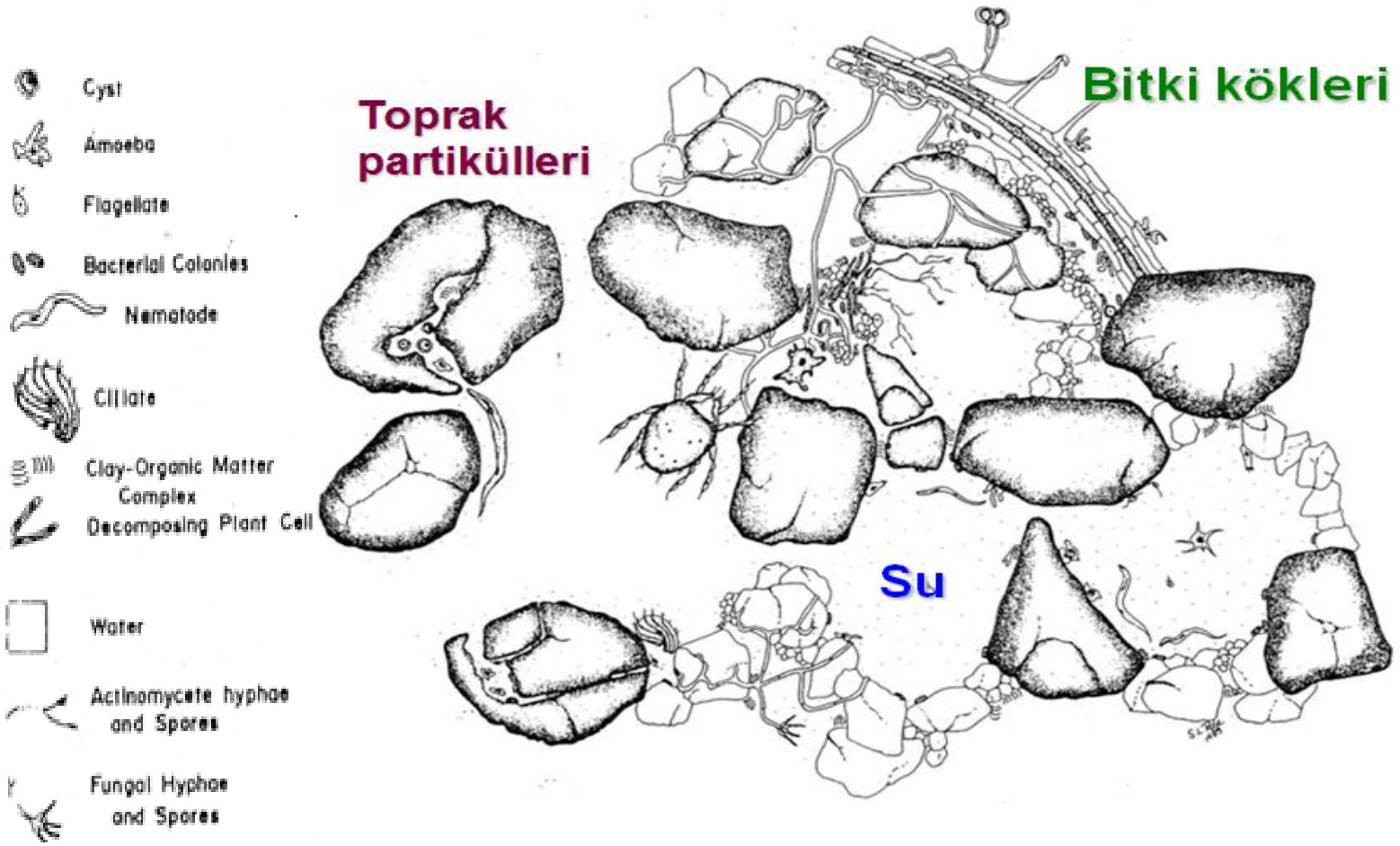


Eukaryotes are divided into 2 main groups

1) multicellular organisms with cells having specific tasks

2) Unicellular organisms with cells having same properties

Soil as a habitate



1cm^2 of soil microzone indicating relationships between living organisms and their access to life resources

Classification of Microorganisms (according to their size)

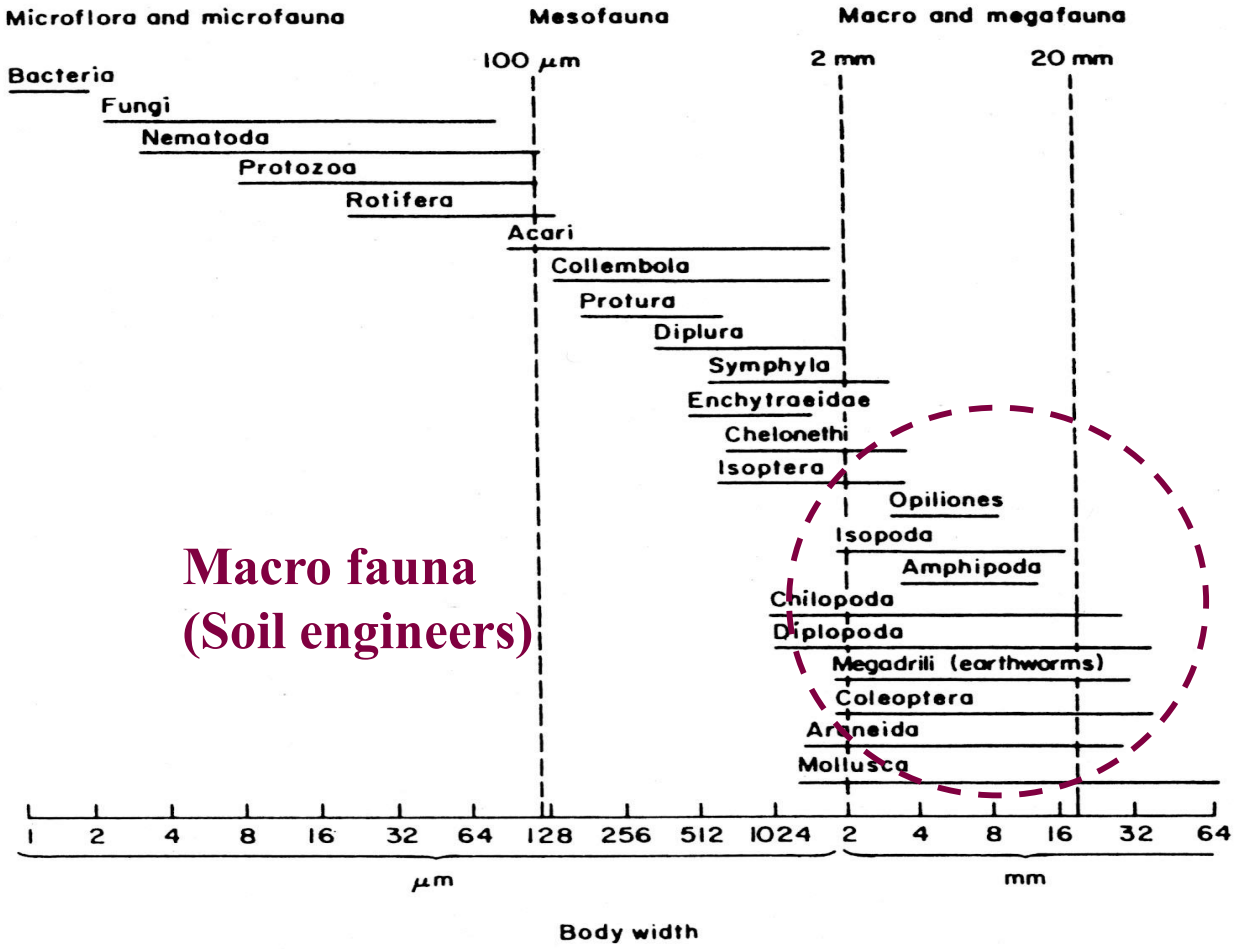


FIGURE 4.3 Size classification of organisms in decomposer food webs by body width (Swift *et al.*, 1979).

Mesofauna:
predators
pathogenes

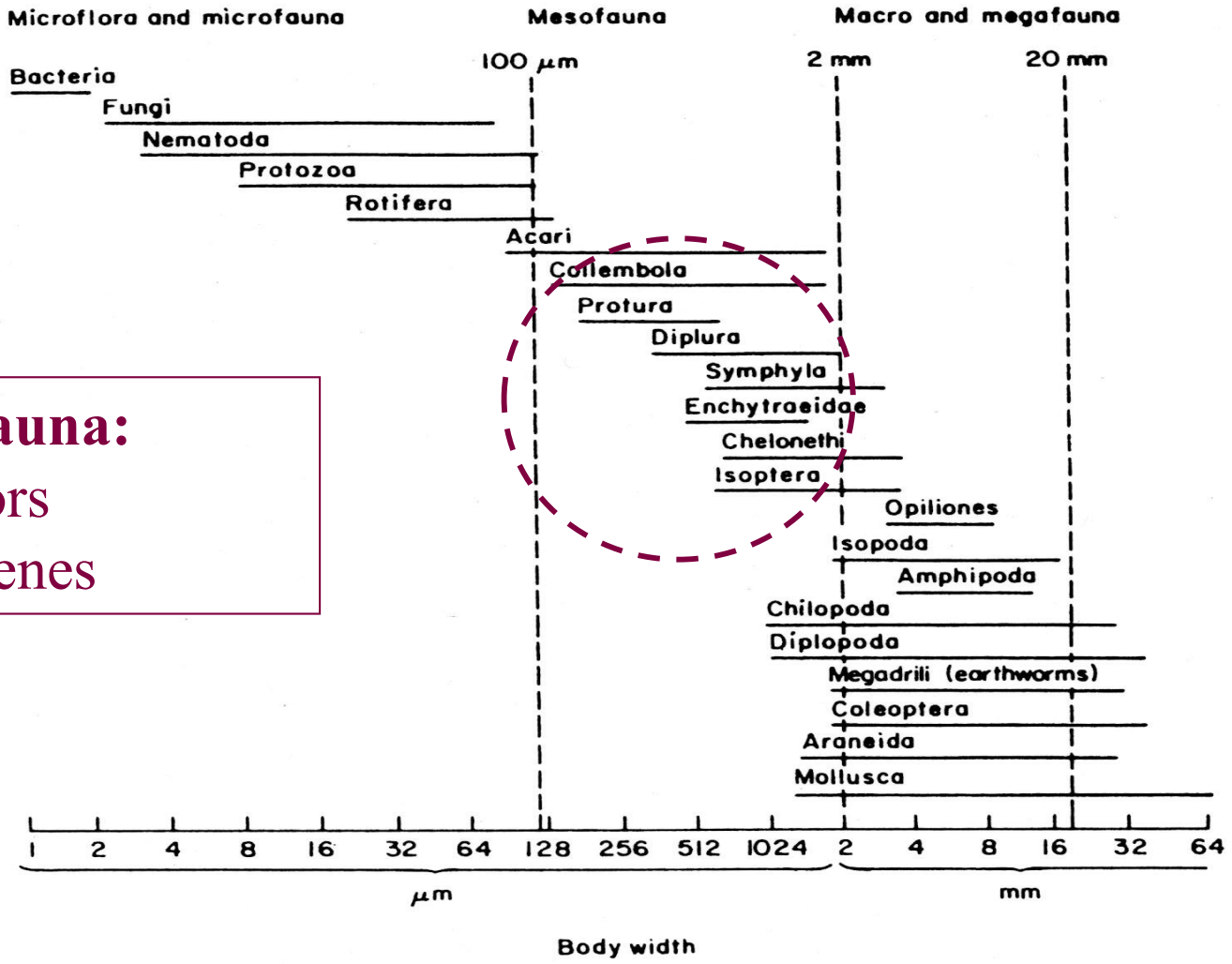


FIGURE 4.3 Size classification of organisms in decomposer food webs by body width (Swift *et al.*, 1979).

Microorganisms (responsible for many nutrient processes in the soil)

C, N, S, P

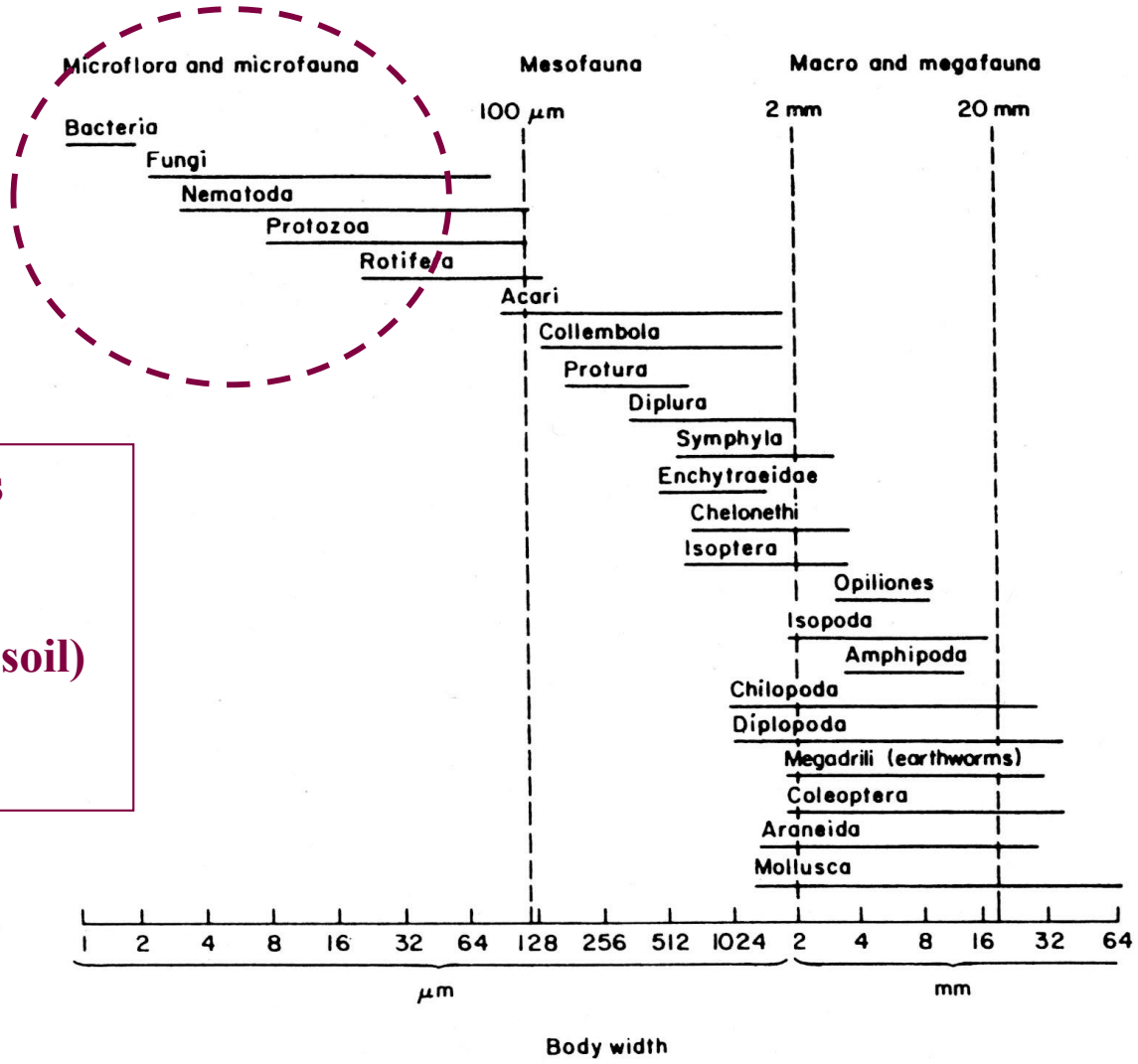
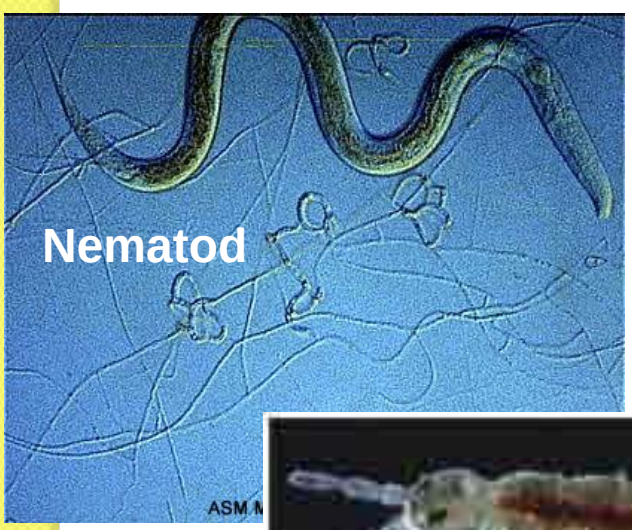


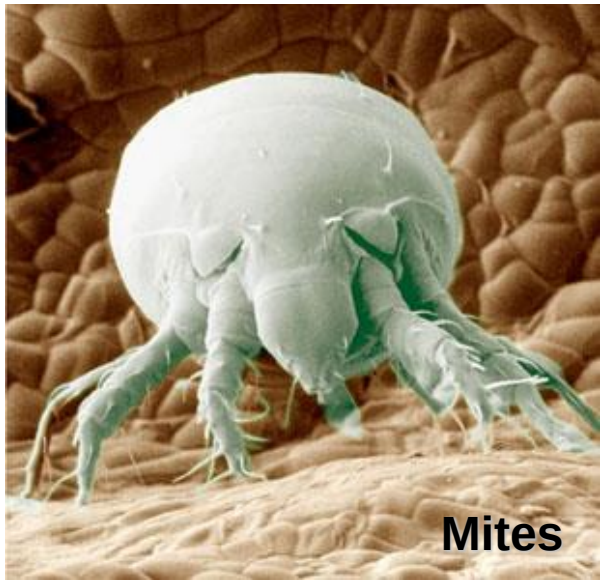
FIGURE 4.3 Size classification of organisms in decomposer food webs by body width (Swift *et al.*, 1979).

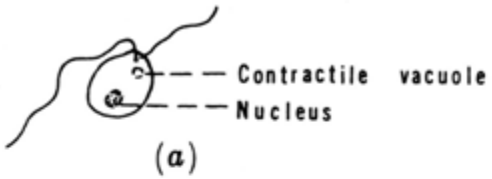
Soil Macrofauna

Macrofauna is important because they're responible for organic matter decomposition, predation and bioturbation (mixing of mineral soil by living microorganisms)

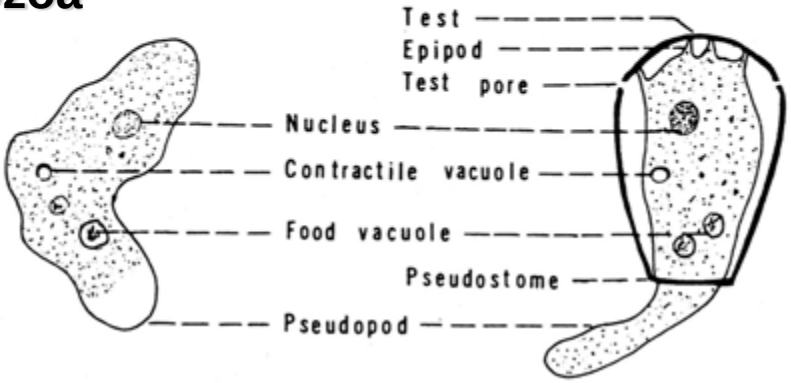
Soil Mesofauna





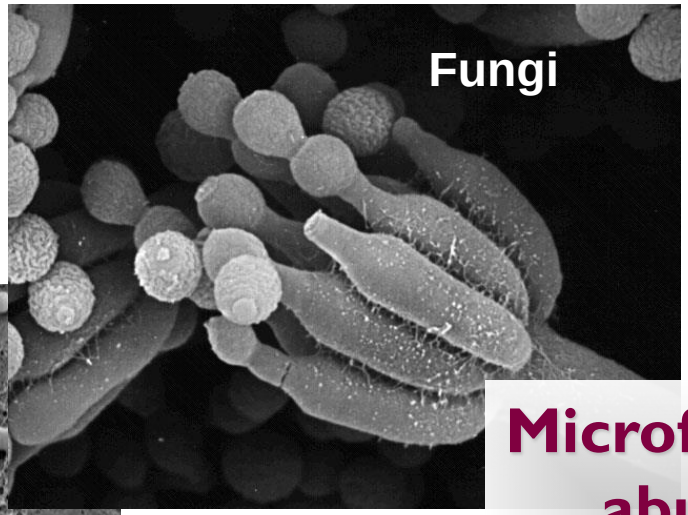


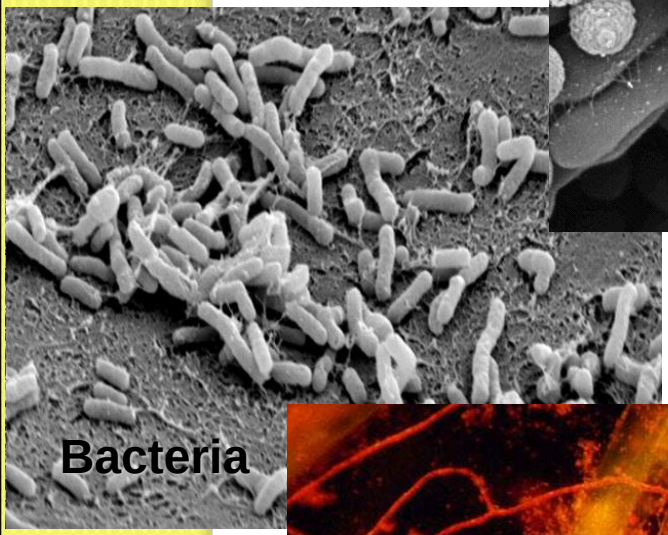
Protozoa

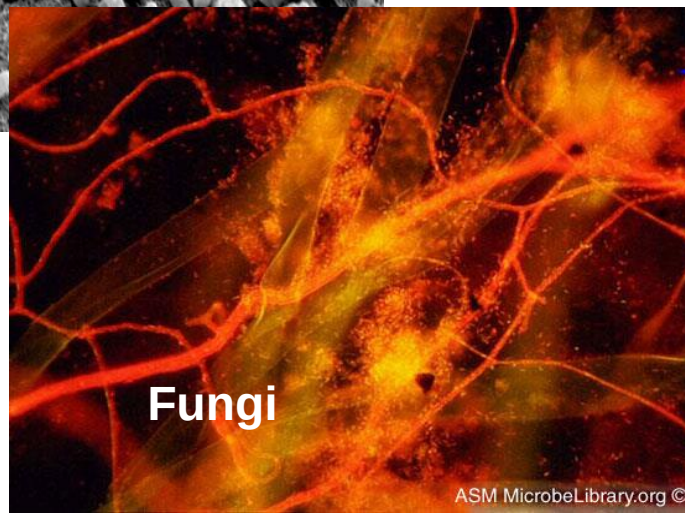


Mesofauna is important because responible for organic matter decomposition, predation and controlling pathogenes in soils

Soil microfauna







Microfauna is the most abundant in the soil and mainly responsible for the decay of organic matter, nutrient transformations and cycles, "carbon sequestration" and disease suppression as well .Therefore it is regarded as living part of soil organic matter.

Classification of soil bacteria according to their energy and carbon Needs

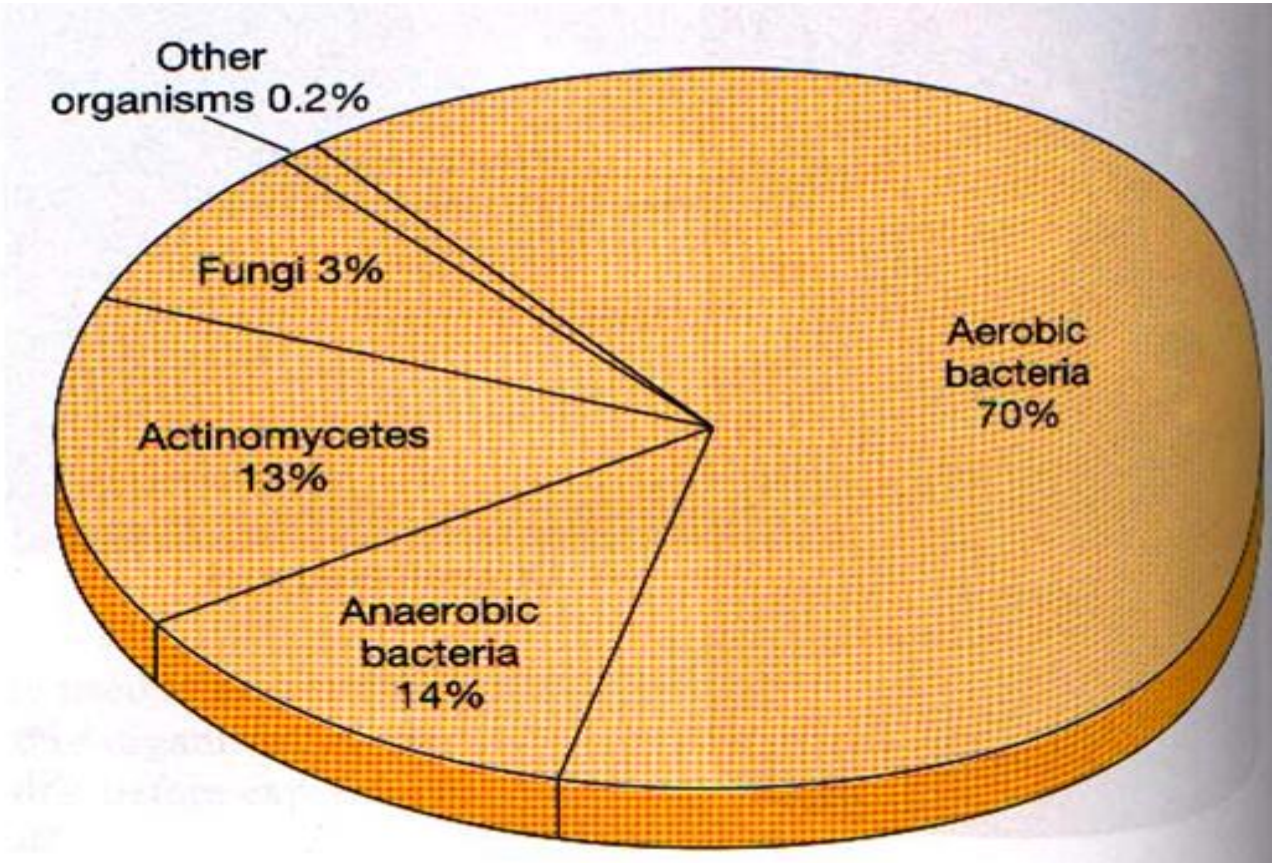
1) **Heterotrophic microorganisms**: Organisms using organic nutrients as energy and carbon sources (fungi, protozoa, bacteria, animals).

2) **Ototrophic microorganisms**: Organisms obtaining their energy from the oxidation of solar energy or inorganic compounds, and carbon from assimilation of CO_2

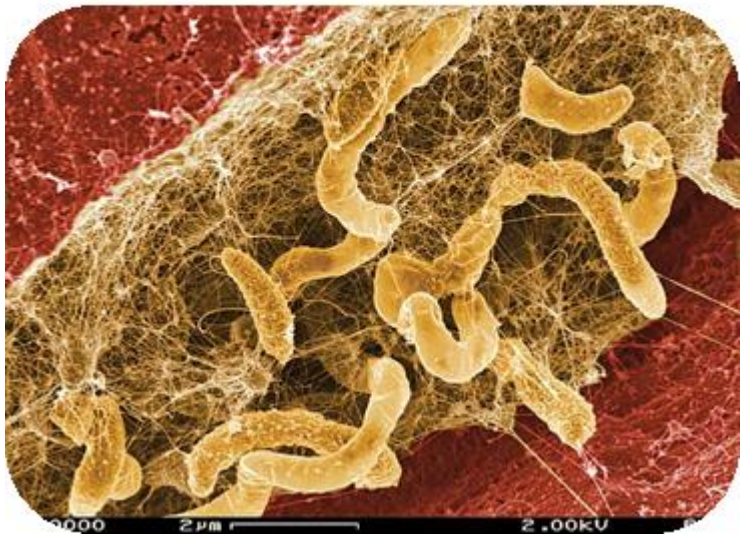
   a. **Photoototrophs** (photolithotrophs), energy derived from sunlight, algae, bacteria, high plants.

   b. **Kemoototrophs** (chemolithotrophs) are energy derived from the oxidation of inorganic substances bacteria.

Different soil microorganisms in numbers



Bacteria

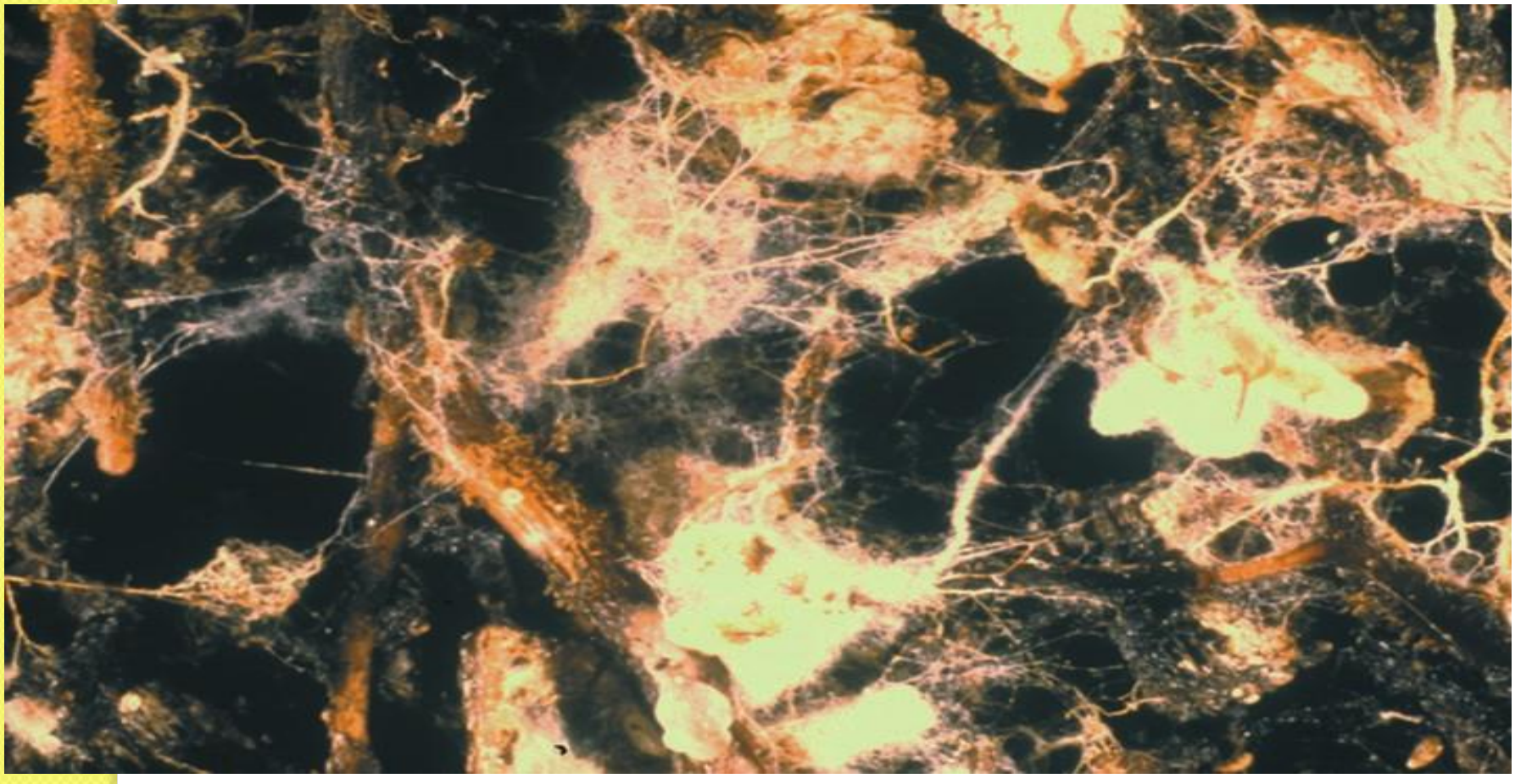


Bacteria are some of the smallest of life forms, normally just 1 to 3 micrometers in length. They are rather complex, however, because each cell contains everything needed for life. **Plants need bacteria to convert elements in the soil and air into nutrients that plants require for growth.**

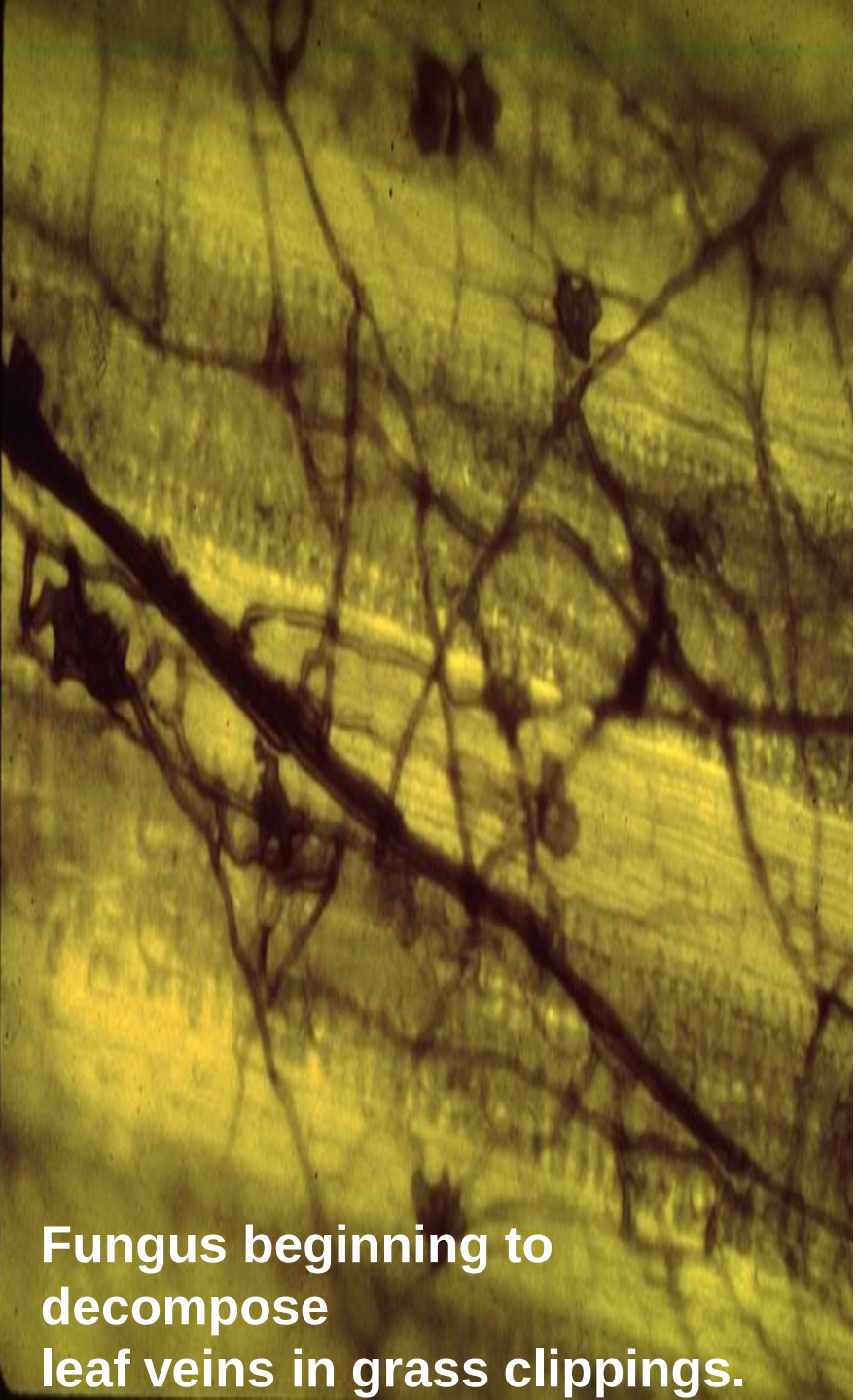
What effects soil bacteria??

- Soil environment and temperature
- Organic matter quantity and quality
- Amount of inorganic nutrients
- pH
- Moisture
- Soil depth
- Seasonality
- Human being (agriculture, urbanization)

Soil fungi



Fungi are microscopic organisms that develop along the soil particles, plant roots and rock surfaces on their paths in the form of long thin strands called hyphae. The fungal hyphae is a few micrometers in diameter. A single hyphae with several cell lengths has a length of several hundred meters.



Fungus beginning to decompose
leaf veins in grass clippings.

...Functions of Soil Fungi

- nutrient cycle
- disease control
- humus formation
- soil aggregation

Fungi-1: Decomposers (saprophytic-decaying fungi convert dead organic matter into fungal biomass, CO2 and organic acids)

Fungi-2: Mutualists (i.e. mycorrhizal fungi colonize the plant roots and make phosphorus and other nutrients in the soil useful for the plant)

Fungi-3: Pathogens and parasites (fungi that cause proliferation and death in plants and other organisms if they multiply)

Fungi

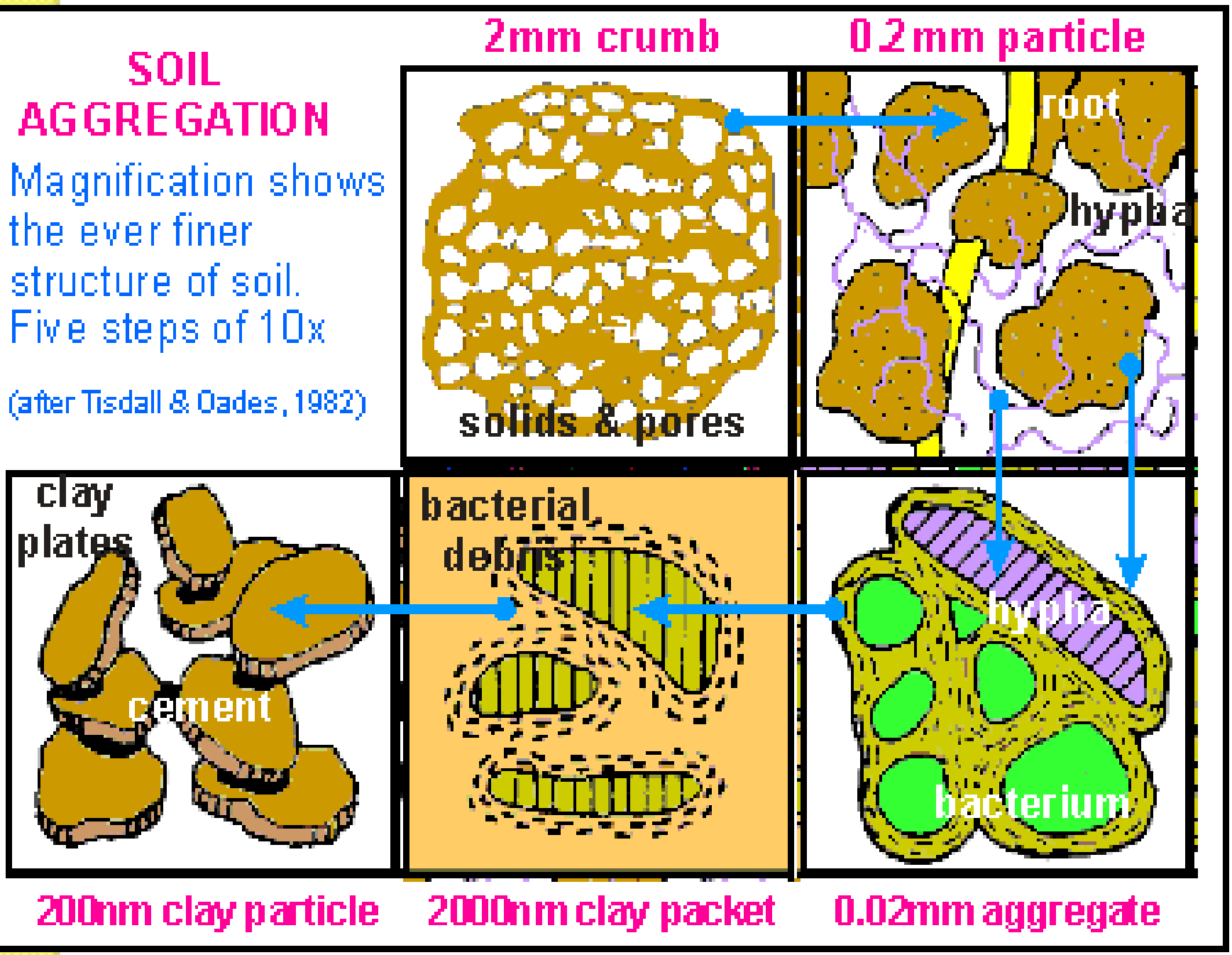
Soil Fungi play an active role in the biodegradation of plant / animal residues and organic pollutants.

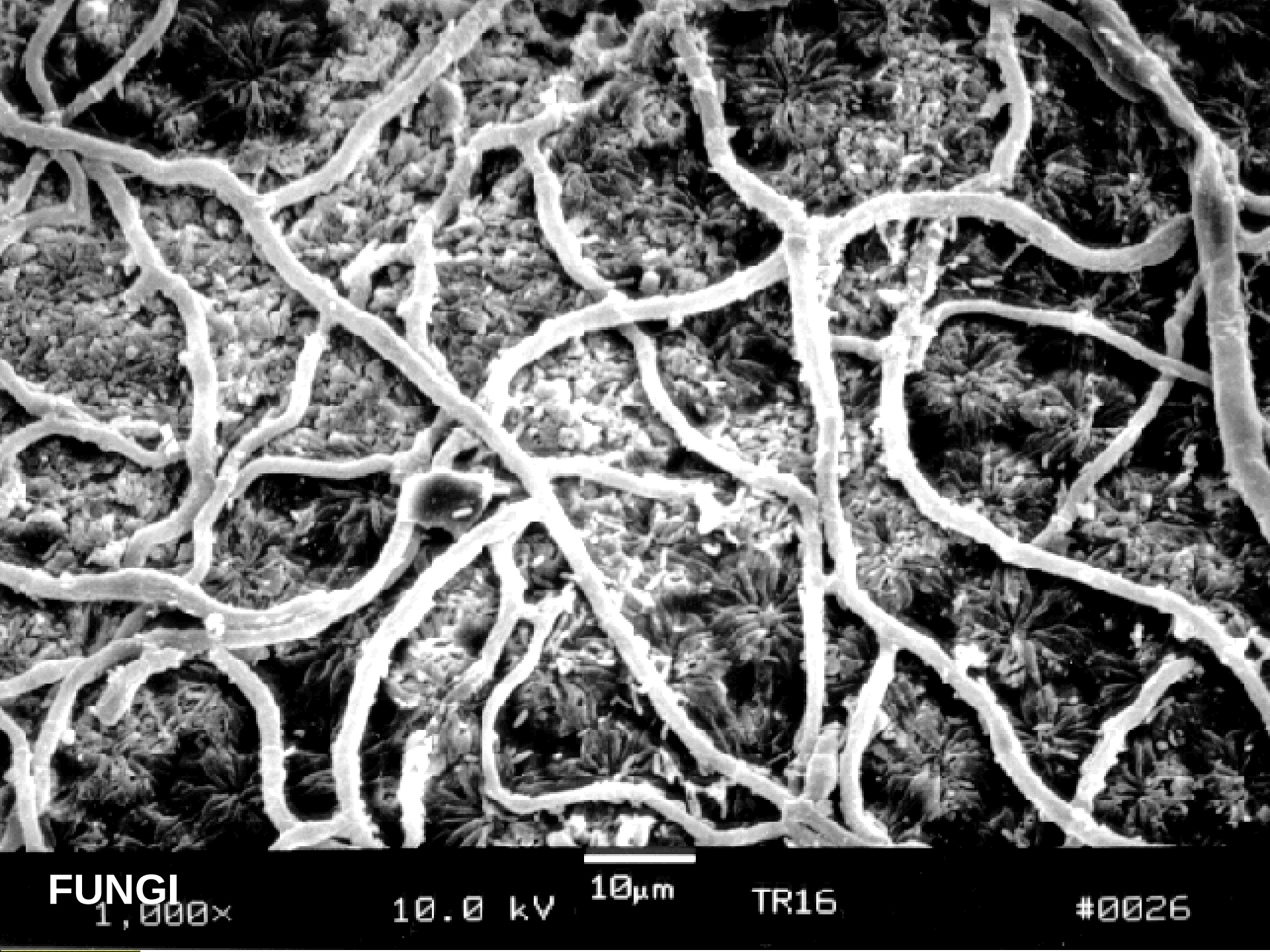
Soil fungal network is responsible for soil formation (aggregation), water and nutrient transfer and communication between

SOIL AGGREGATION

Magnification shows the ever finer structure of soil. Five steps of 10x

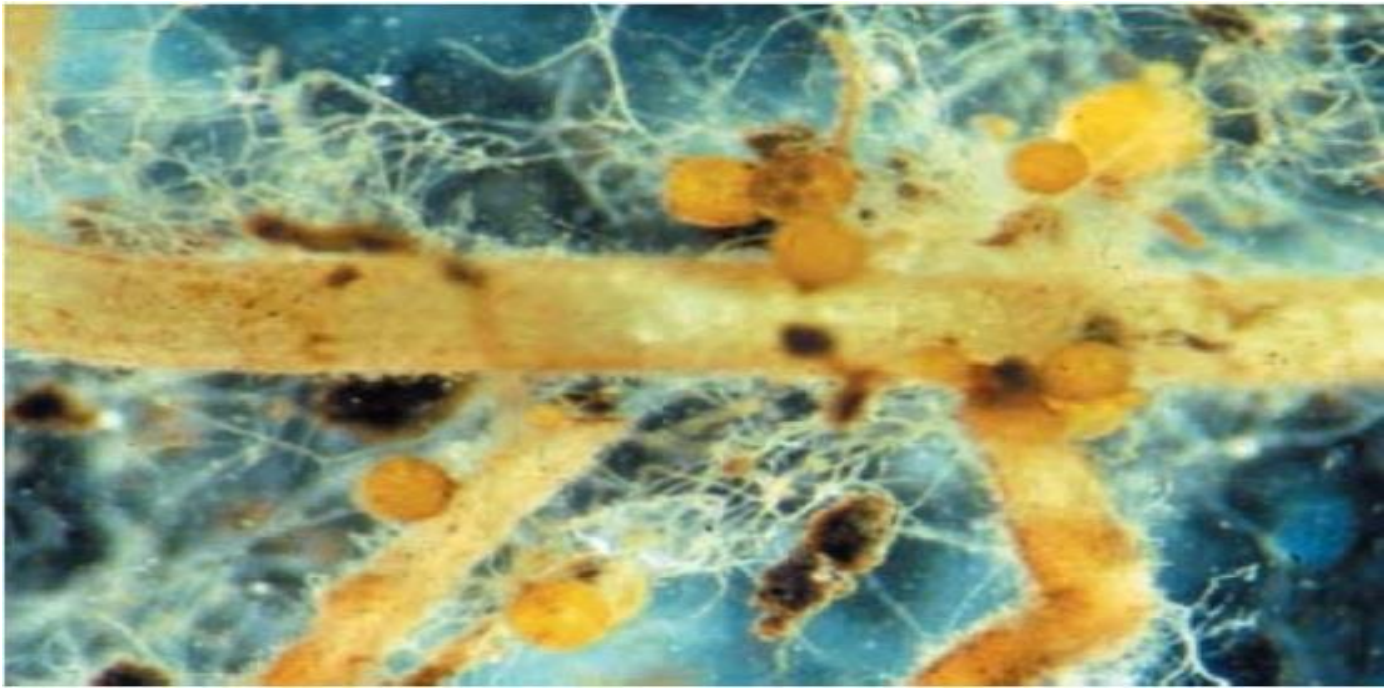
(after Tisdall & Oades, 1982)




FUNGI
1,000×
10.0 kV
10µm
TR16
#0026

Mycorrhiza (symbiotic)

- In greek “mykes” (fungi) ve “rhiza” (root)
- Mutualistic symbiosis common in 80-90% of plants in the world
- Critical role in plant-soil relationships



What is "Mycorrhiza"?

Mycorrhizae are symbiotic associations that form between the roots of most plant species and fungi.

In this symbiosis, carbon flows to the fungus and inorganic nutrients (mainly phosphorus) move to the plant, thereby providing a critical linkage between the plant root and soil.

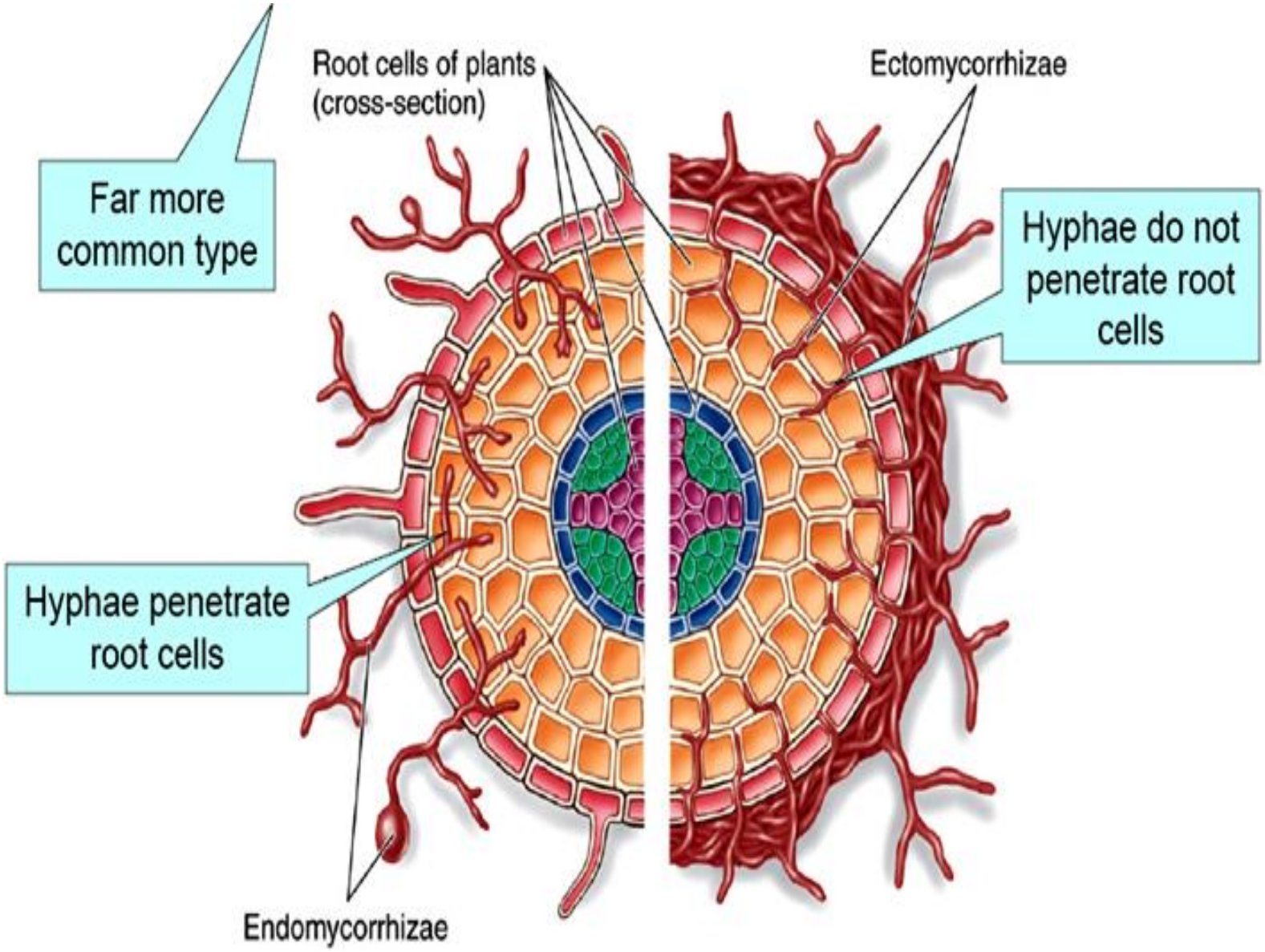
Ectomycorrhizal fungi are mostly basidiomycetes that grow between root cortical cells of many tree species, forming a Hartig net.

Arbuscular mycorrhizal fungi (AMF) belong to the order Glomales and form highly branched structures called arbuscules, within root cortical cells of many herbaceous and woody plant species

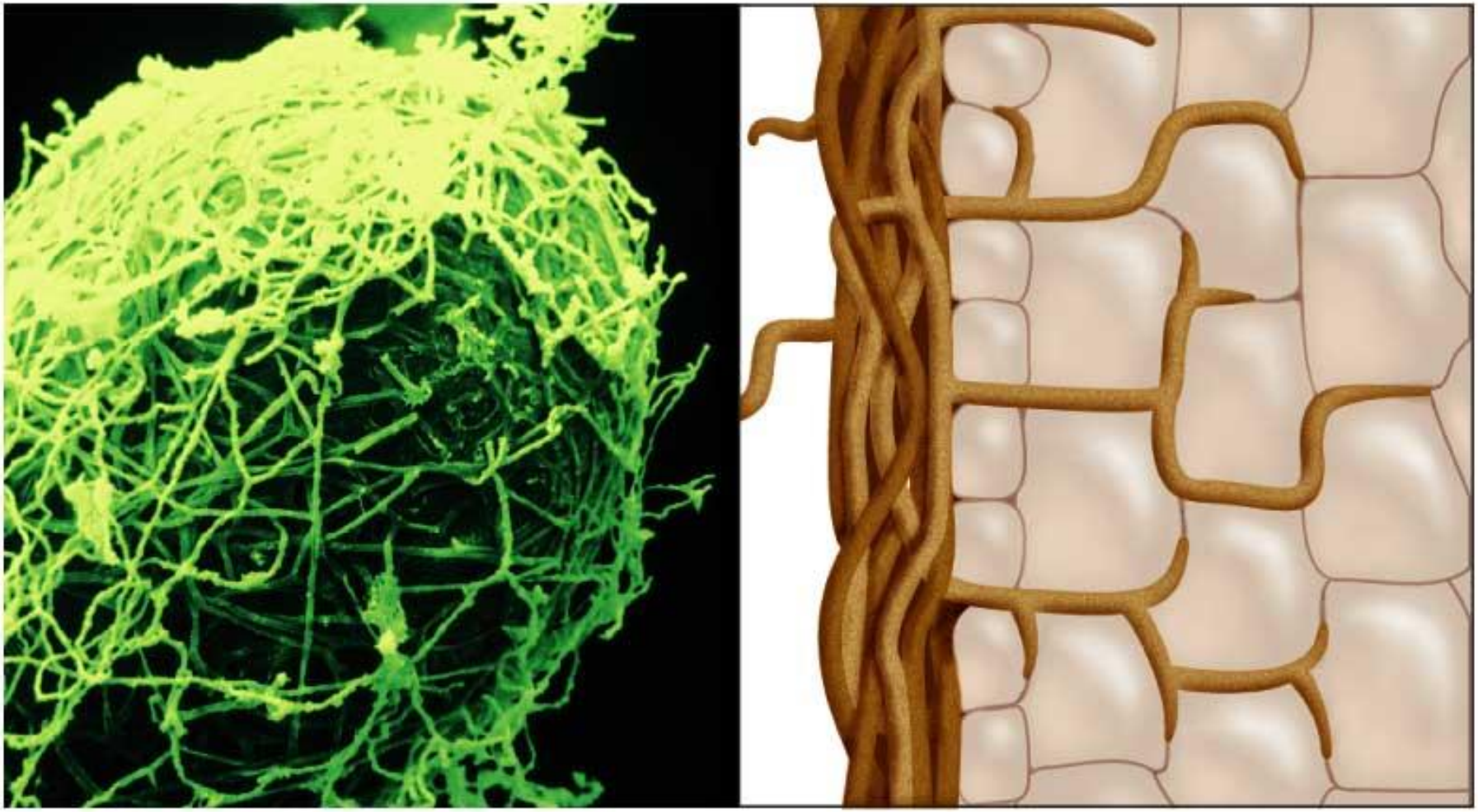
Mycorrhizal connections

The appearance of hyphae in the soil structure of mycorrhizal infection in corn roots

Different types of Mycorrhiza



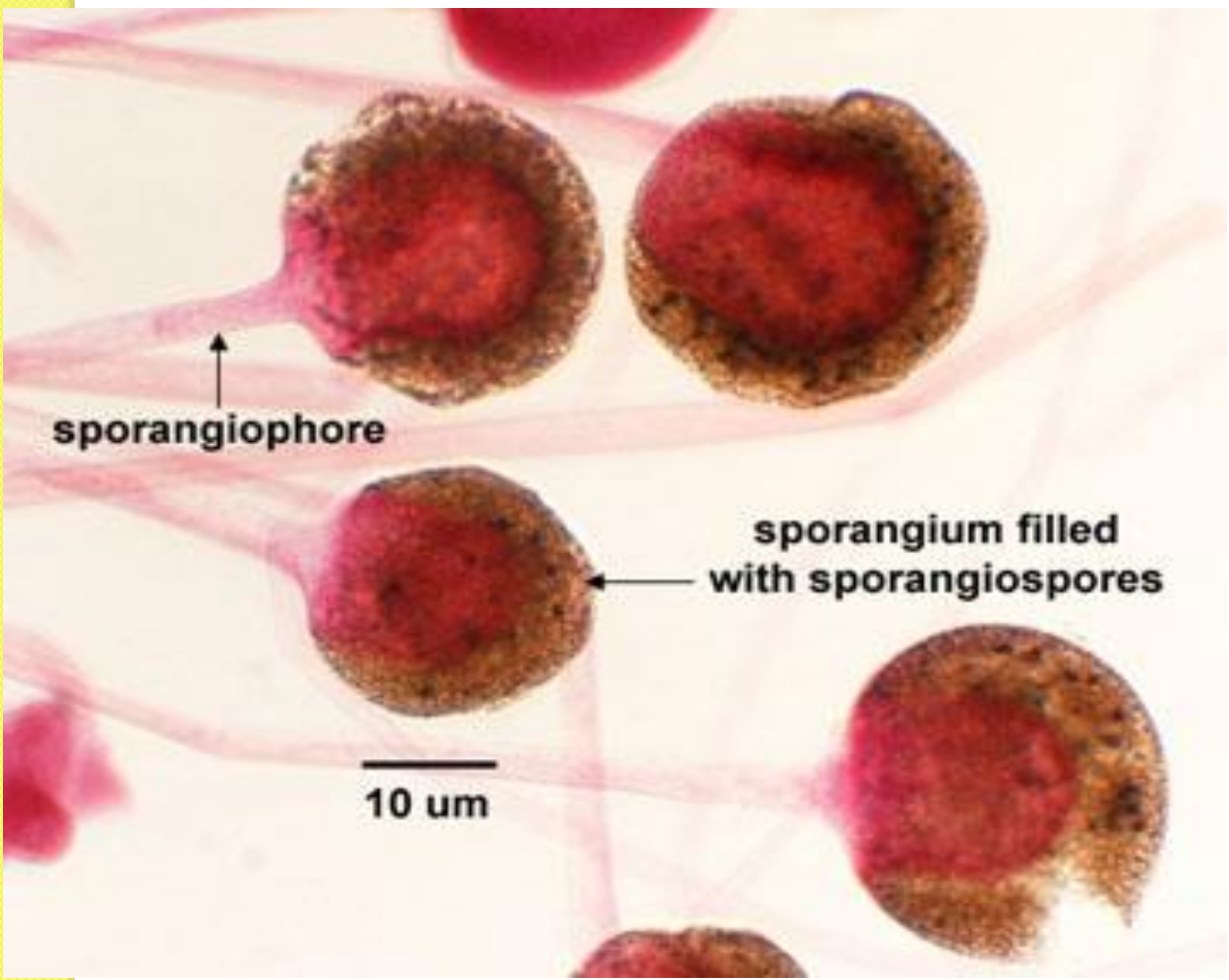
Ectomycorrhiza

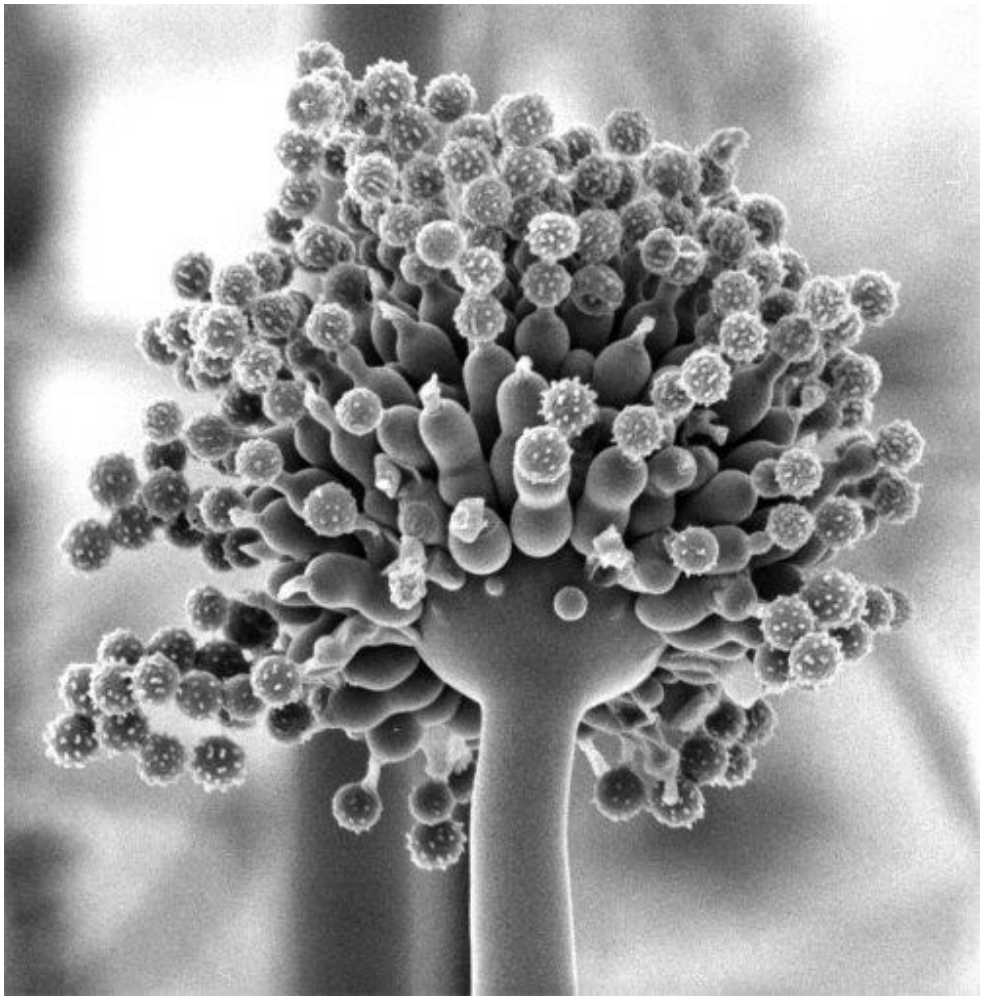


Functions of AMF

- Transfer of various nutrients (P, Zn, Cu, Mn, Fe, Ca, K ve N) to the plant
- Stimulation of plant metabolic activities
- Carbon storage (due to high lipid, aminoacid and carbohydrate contents in hyphae and spores)
- Supression of root disease
- Hyphae growth + hydrophobic stickng → soil aggregation
- Supporting plant growth under stress (drought-pollution-salinity)
- Potential biological material for soil remediation

AMF is one of the most important components of soil ecosystem due to above mentioned facts


sporangiophore
sporangium filled
with sporangiospores
10 um



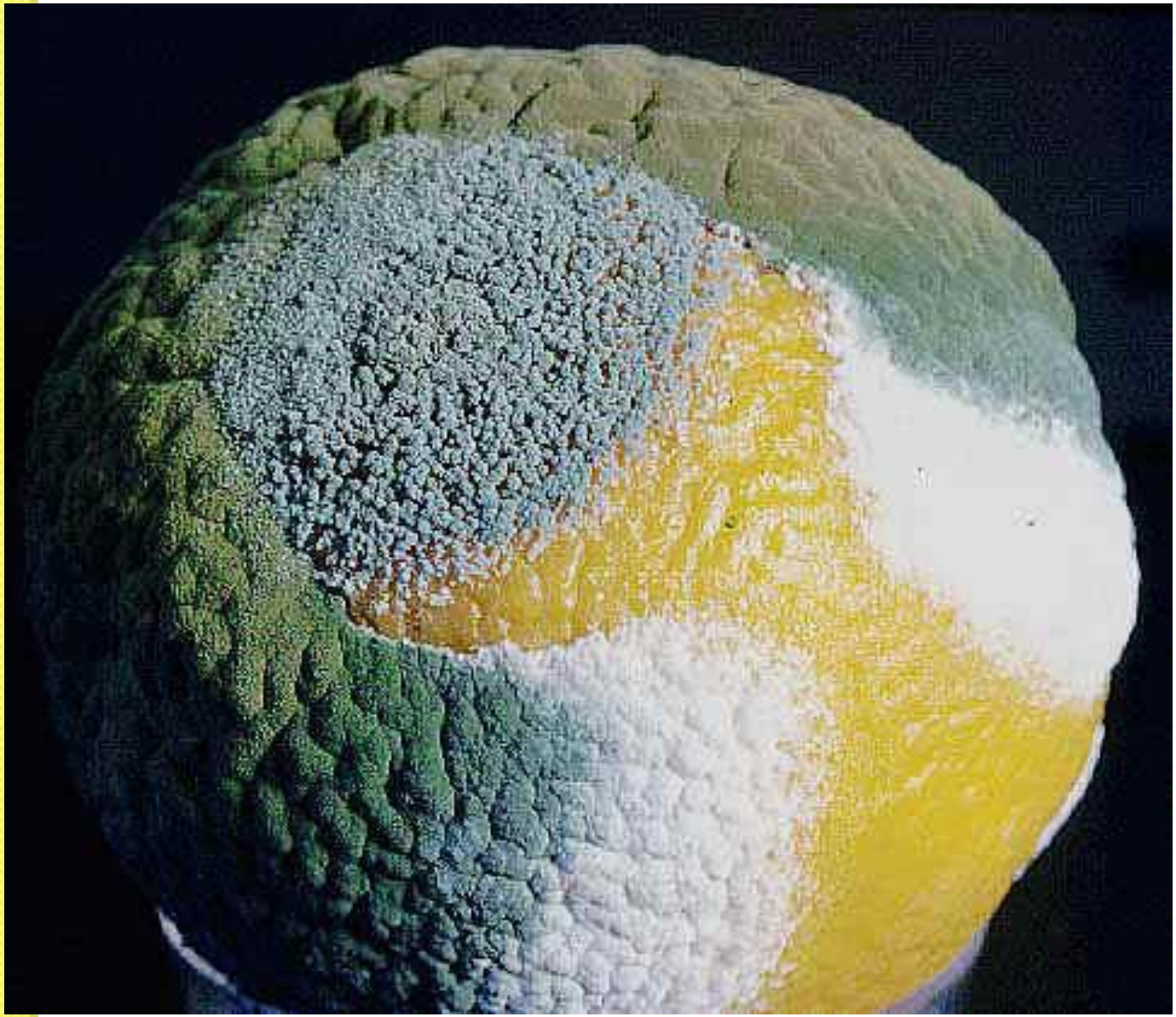
ASPERGILLUS NIGER-

ASPERGILLUS FLAVUS

Aspergillus niger

Siyah Çürüklük (Küf Hastalığı)

soğan, sarımsak, incir ve turunçgil meyvelerinde



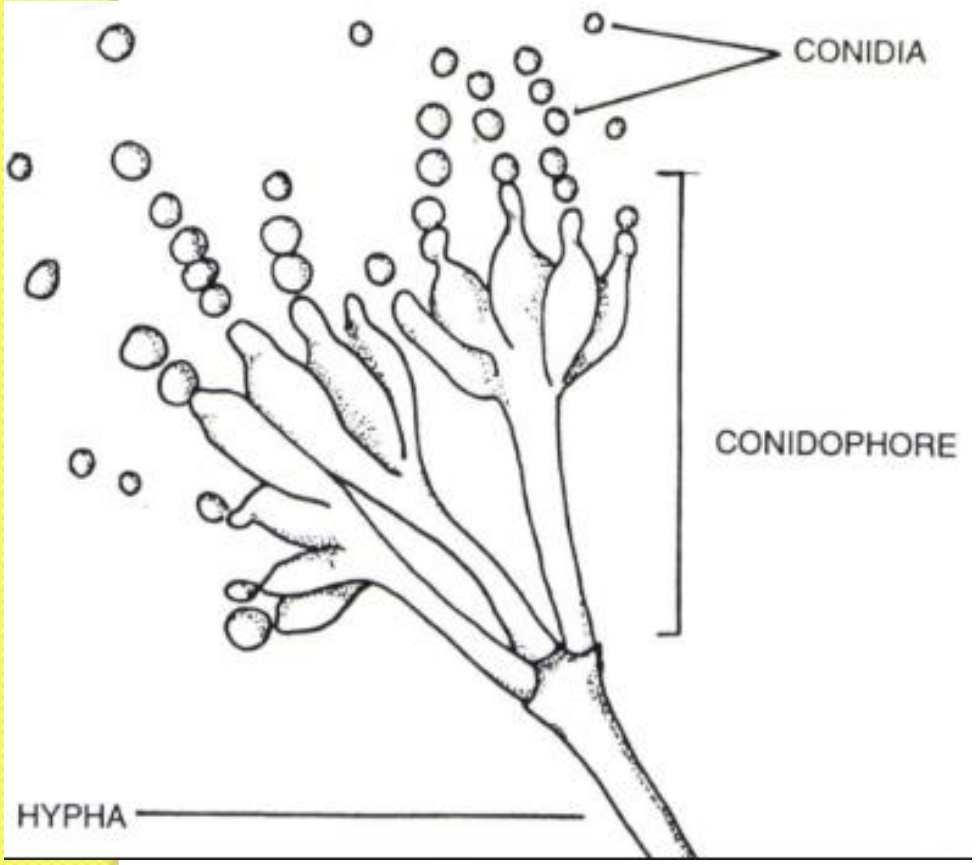
PENICILLIUM DIGITATUM

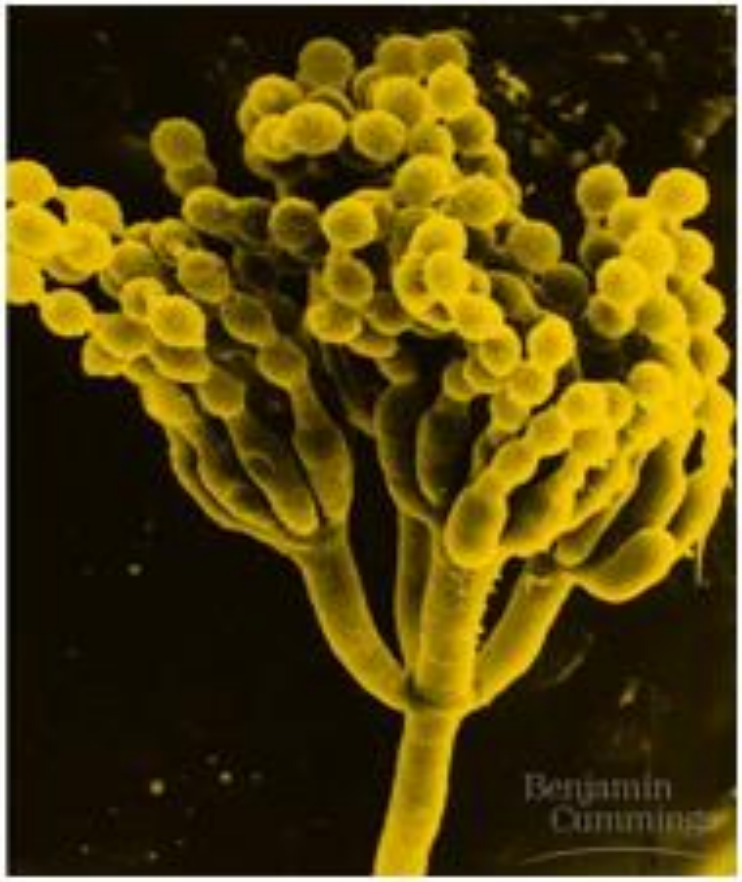
Penicillium roquefortii.

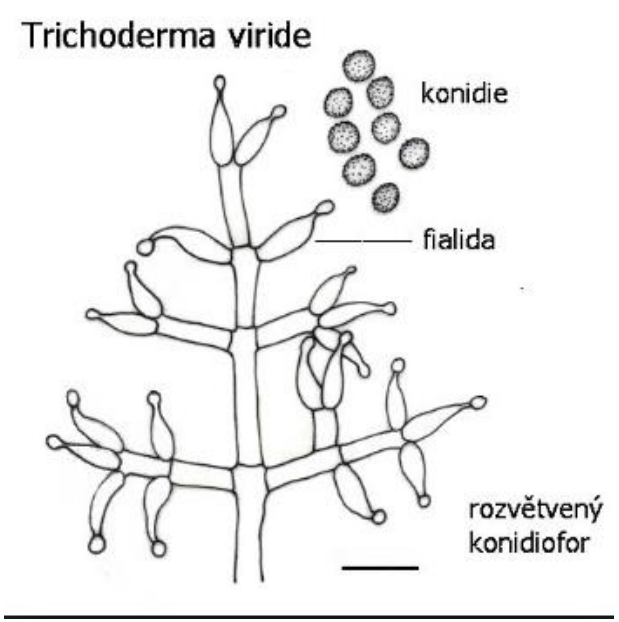
Actinomycetes

- Heterotrophic, prokaryotic, Gr^{+}, bacteria showing same characteristics with fungi.
- Having bacterial cell structure and mycelium development in soil (like fungi).
- Most actinomycetes form asexual spores known as conidia over their hyphae.
- Some others makes sporangium (special structure of spores)
- Core of decomposition (responsible for plant biomass degradation i.e chitin, lignocellulose and organic pollutants such as phenol, PAH, paraffin and other POPs)
- Microbial antagonism (supression of soil pathogens)
- Common species are Streptomyces, Nocardia and Micromonospora

Conidia, a Greek word for "fine dust






Trichoderma viride
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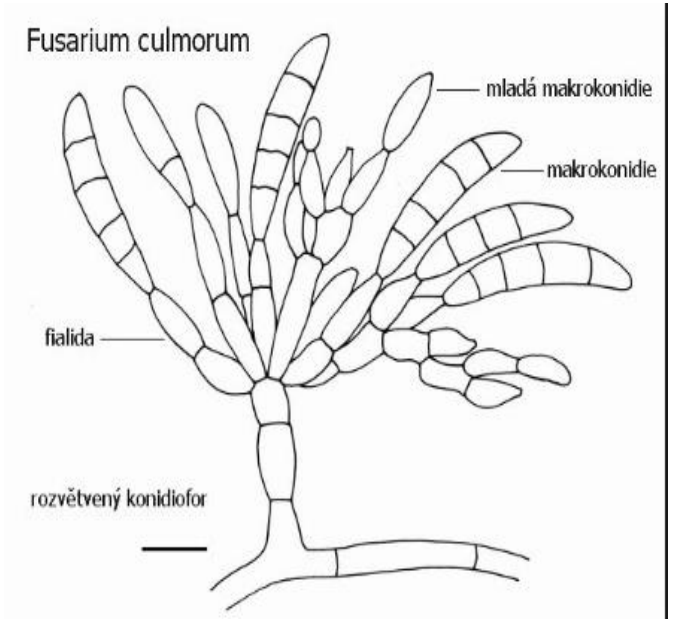
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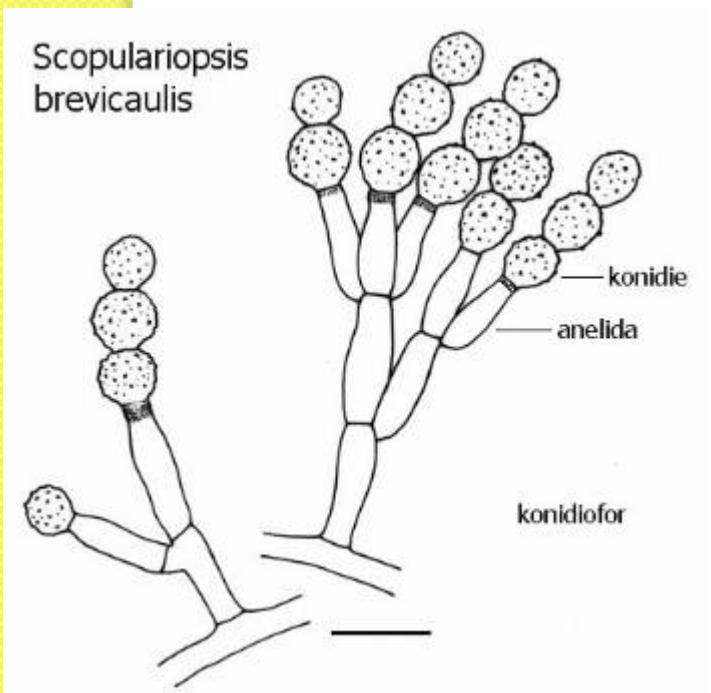
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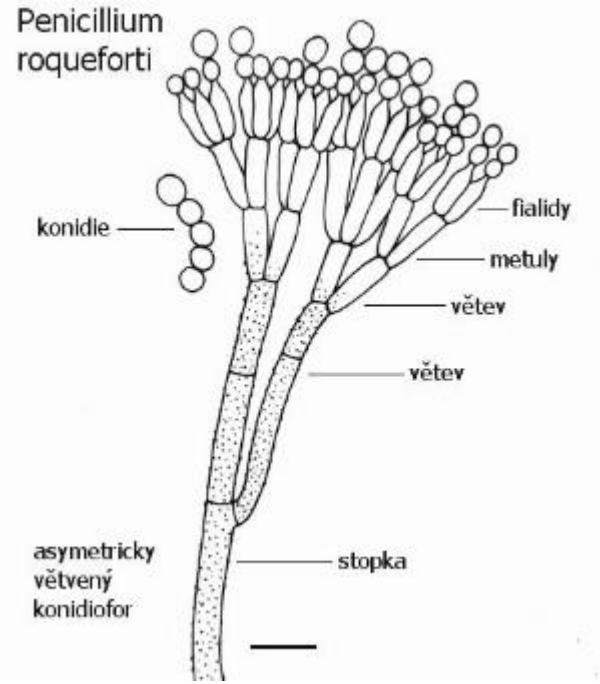
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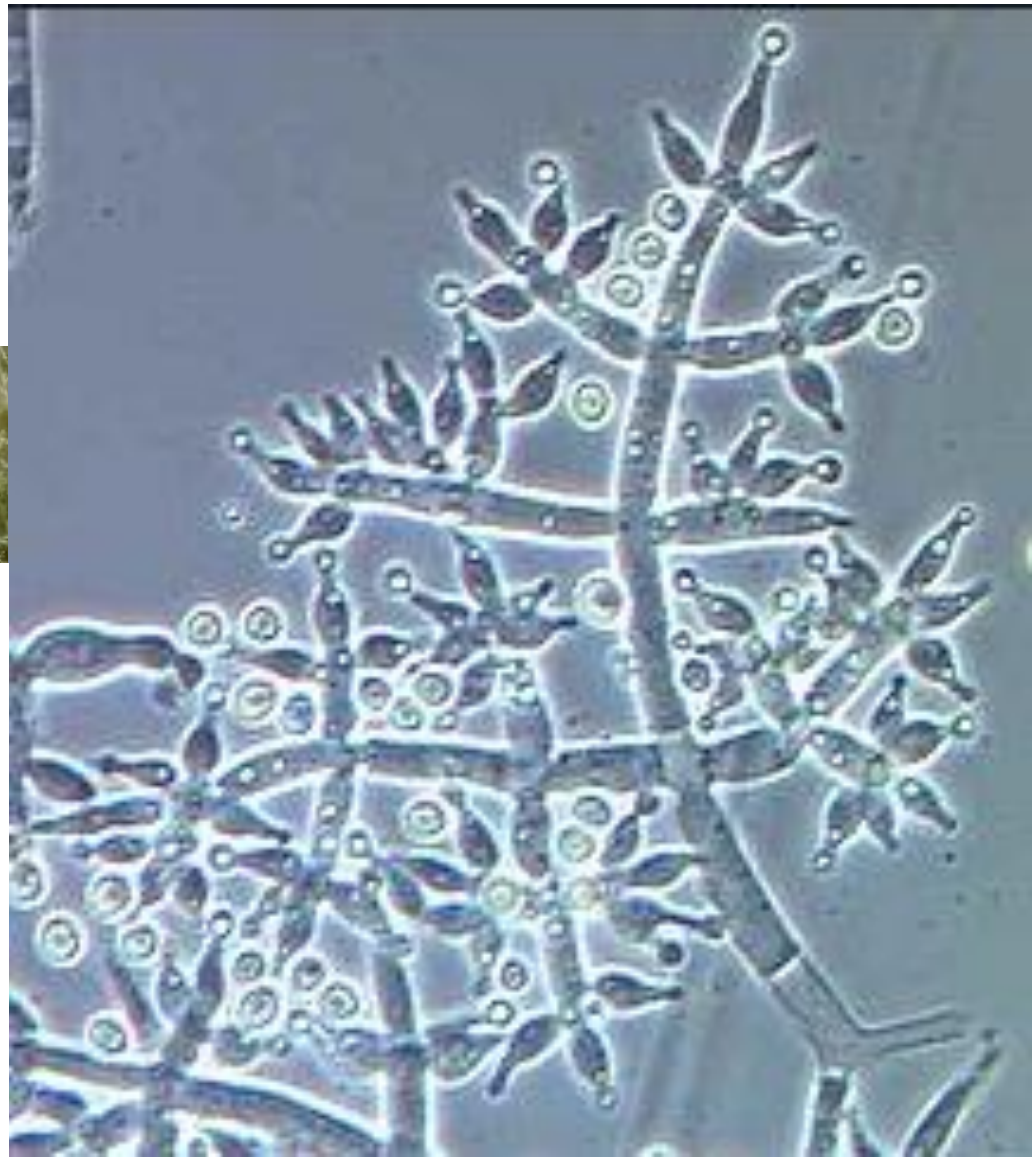
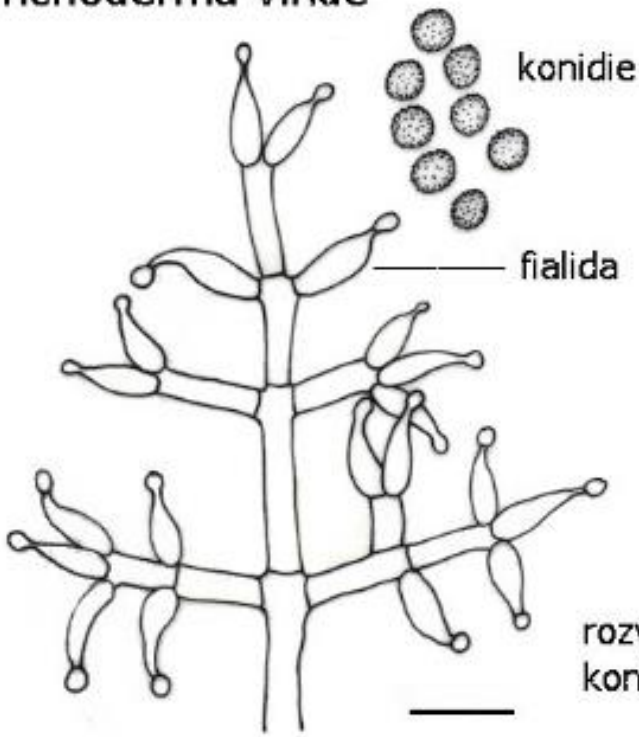
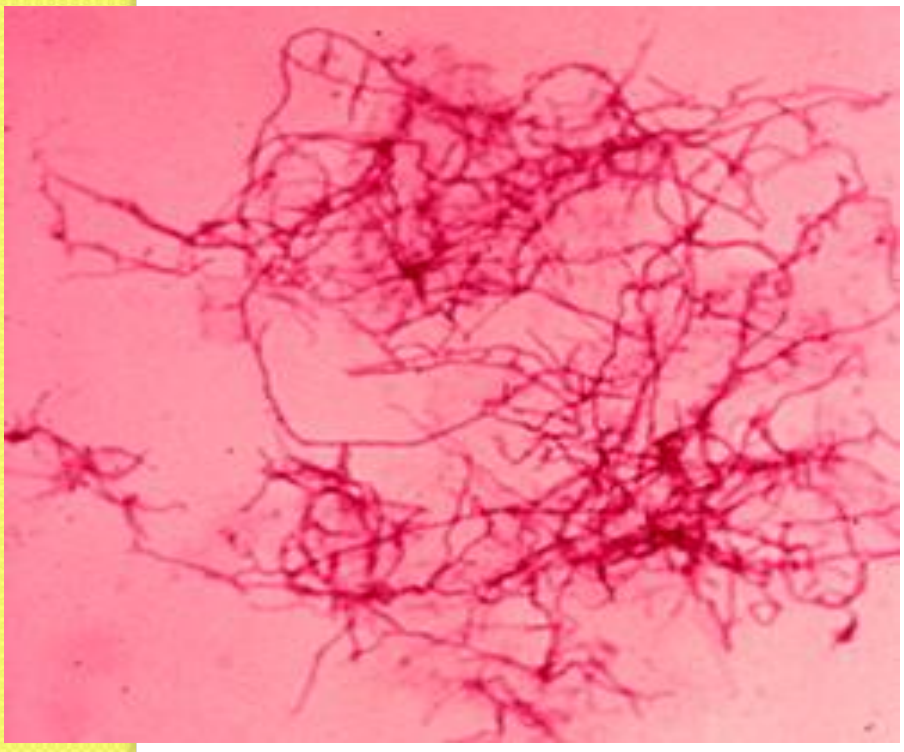
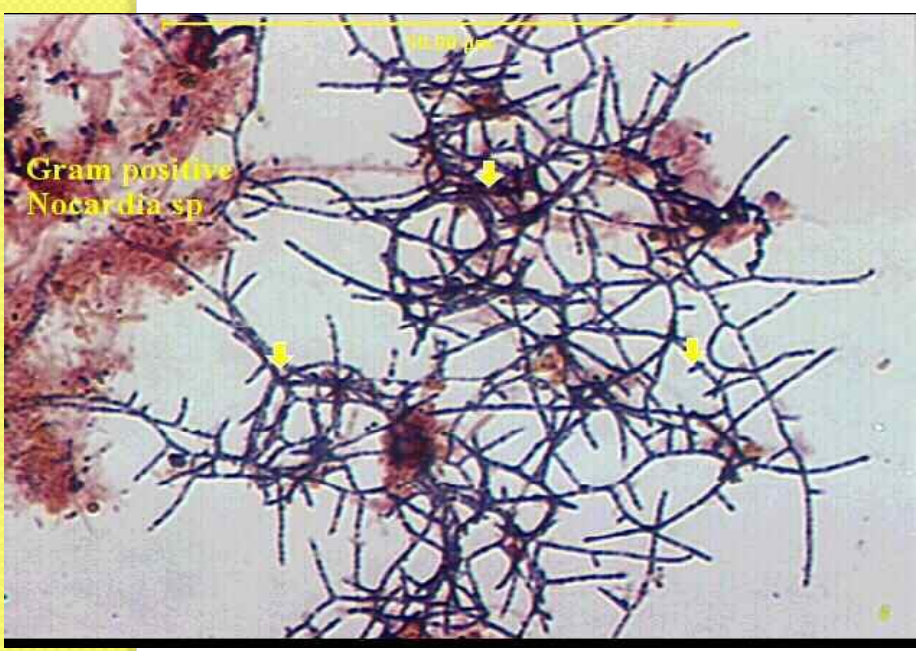
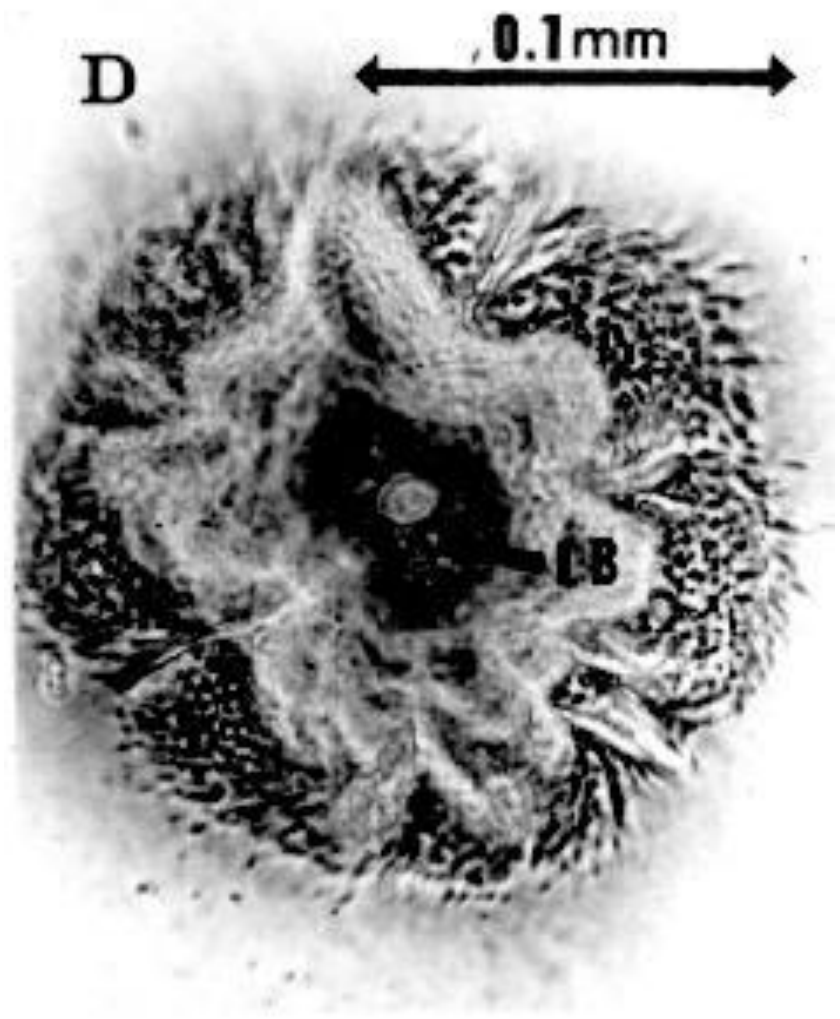


Trichoderma viride







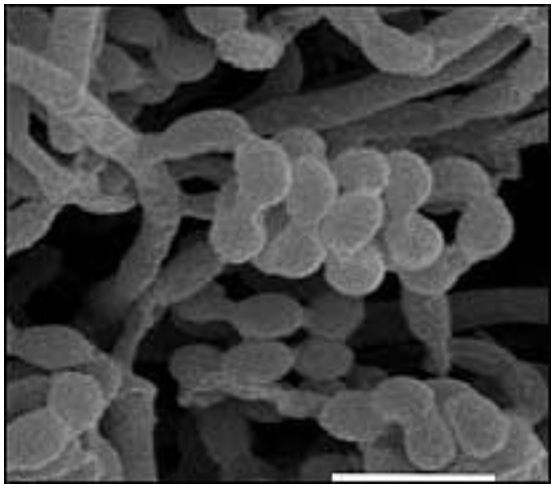


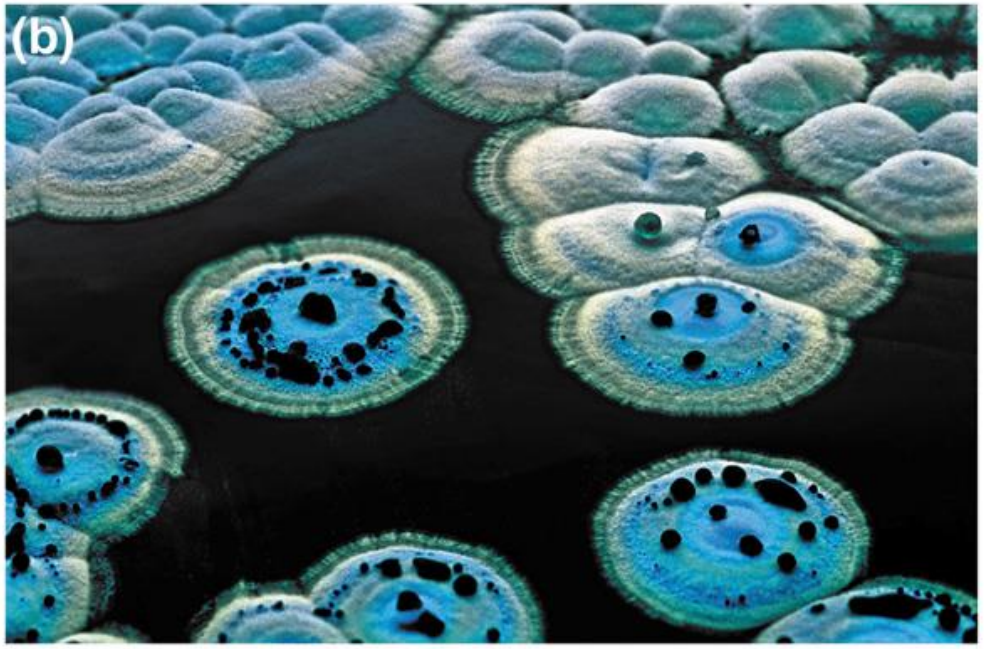
NOCARDIA/Nocardiaceae family

Streptomycetaceae familyası

- 500'ün üzerinde Streptomyces türü tanımlanmaktadır.
- Büyüme, ipliklerin uç noktalarında gerçekleşir ve buna genellikle dallanma eşlik eder.
- Sonuçta oluşan koloninin aldığı şekle mycelium denir.
- Streptomyces sporlarına konidya (**conidia**) adı verilir.
- Streptomyces türleri esas olarak toprakta yaşar. Hatta "**toprak kokusu**" dediğimiz kokunun sebebi bu canlıların **geosmin** adı verilen metabolik ürünleridir.

Streptomyces spp.





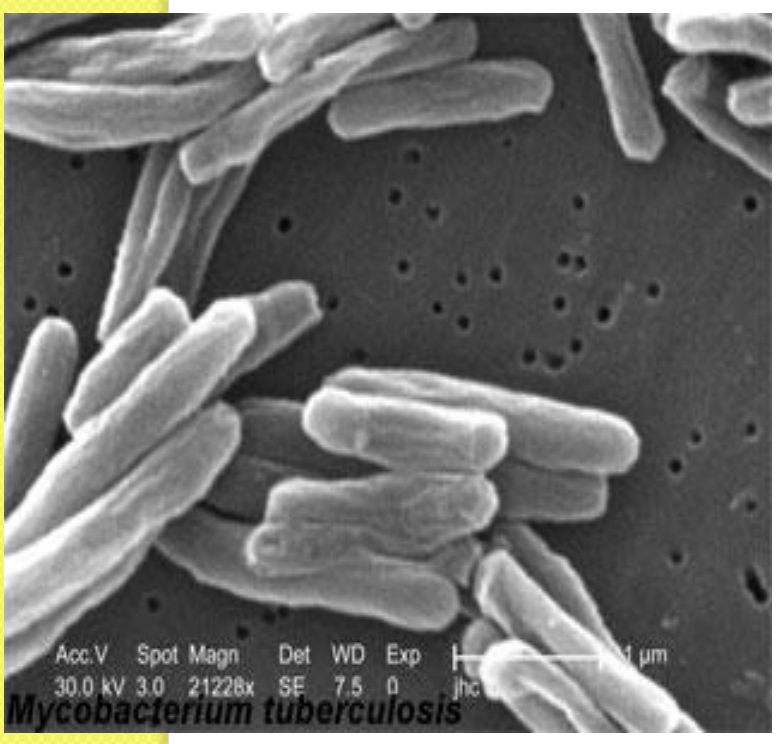
•Streptomyces cinsine ait türler zorunlu aerobiardır

•En önemli dikkat çekici özellik
• antibiyotik üretme

•KİTİN'i ayrıştırırlar

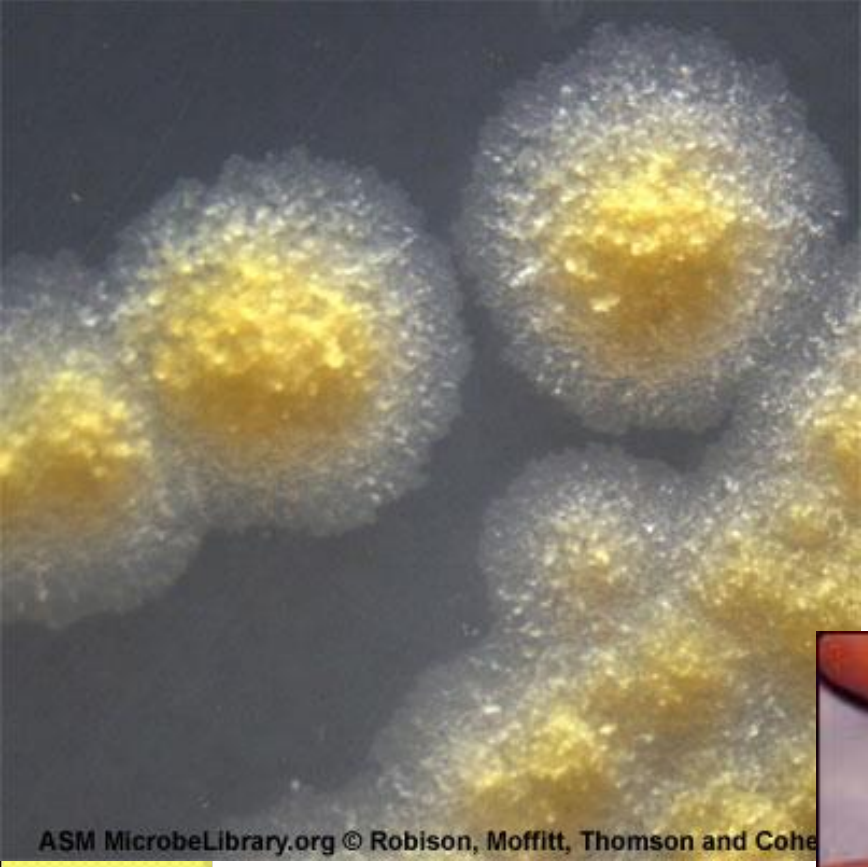
Streptomycetes

5 farklı Streptomycetes. Bu bakterilerin hepsi normalde toprakta yaşar ve antibiyotik üretirler. Bazıları örneğin *Streptomyces azureus*, plate de görüldüğü gibi renkli pigmentler verirler.

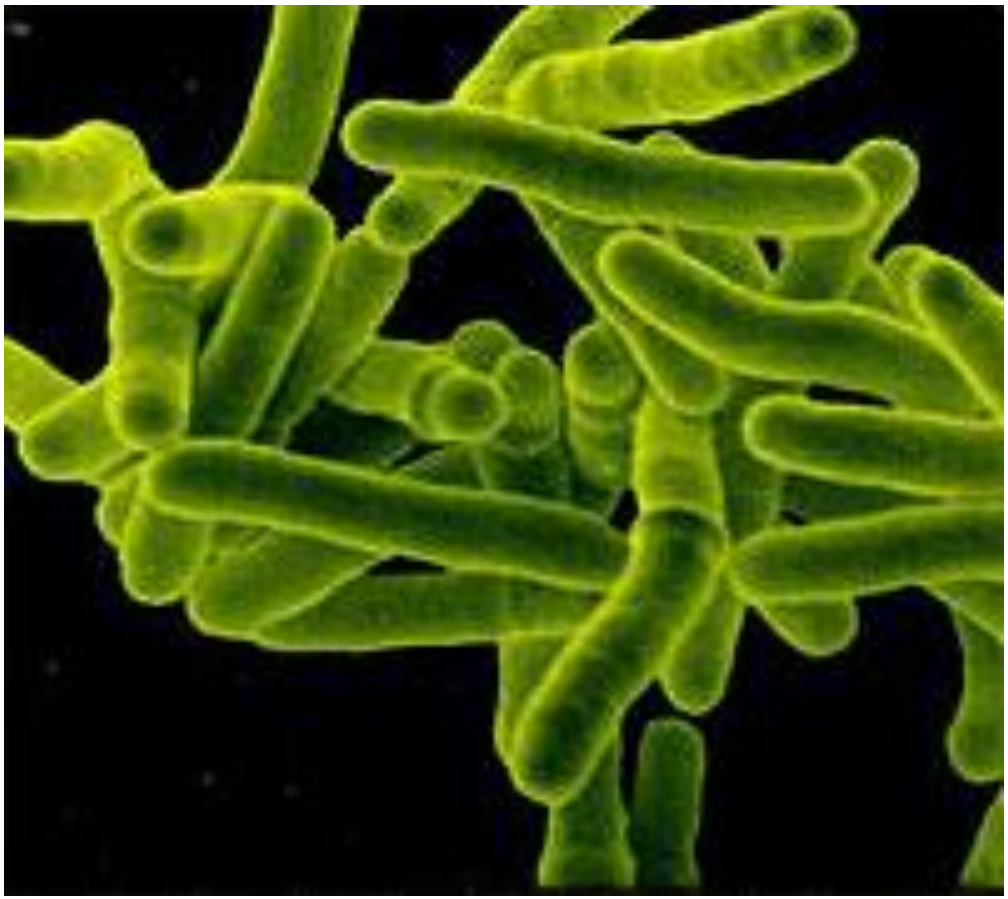


Mycobacterium
M. tuberculosis

Kingdom:	Bacteria
Phylum:	Actinobacteria
Takım:	Actinomycetales
Alttakım:	Corynebacterineae
Familya:	**Mycobacteriaceae**
Cins:	***Mycobacterium*** ***Mycococcus***



Mycobacterium marinum



Micobacterium tuberculosis

Microfauna

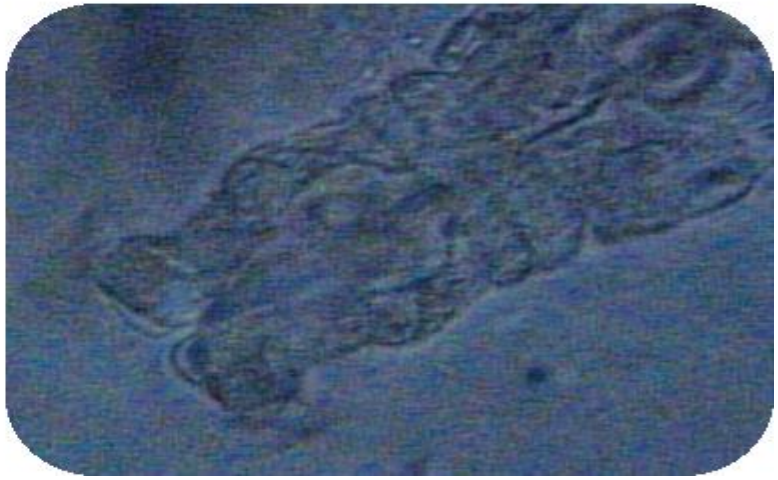
Soil microfauna consists of protozoa, worms and insects. Soil microfauna plays an indirect (but important role in the decomposition of organics residues on the surface.

These organisms can change the environment of the soil through "bioturbation" meaning mixing of soil or sediment by living organism

The soil surface is ventilated due to the mixing activities of these organisms and the concentrations of contaminants accumulating in surface layers are reduced.

Protozoa

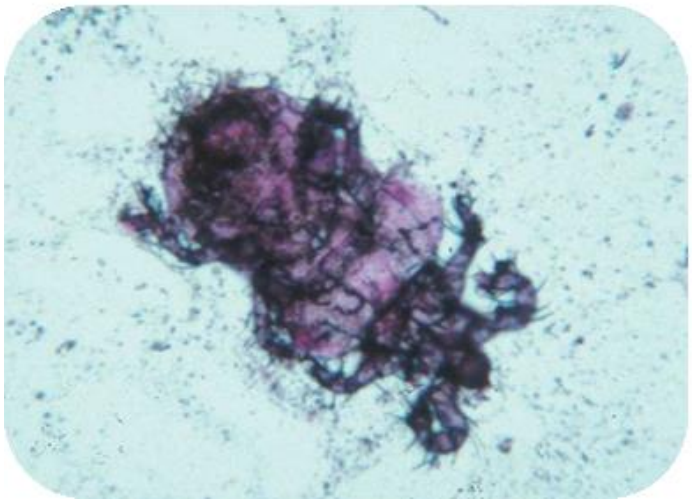
Rotifers



Protozoa are single-celled organisms that feed mainly on bacteria and organic debris. Protozoa swim through water films in the soil to collect their food. Notice the fine hairs around this organism that allow it to swim. The organism in this photograph is magnified 1000 times.

A little larger than the protozoa are the rotifers. By whirling hair-like cilia on their head, they move water into their mouths where the bacteria and other food particles can be digested. This is a fascinating group to watch under a microscope.

Mites

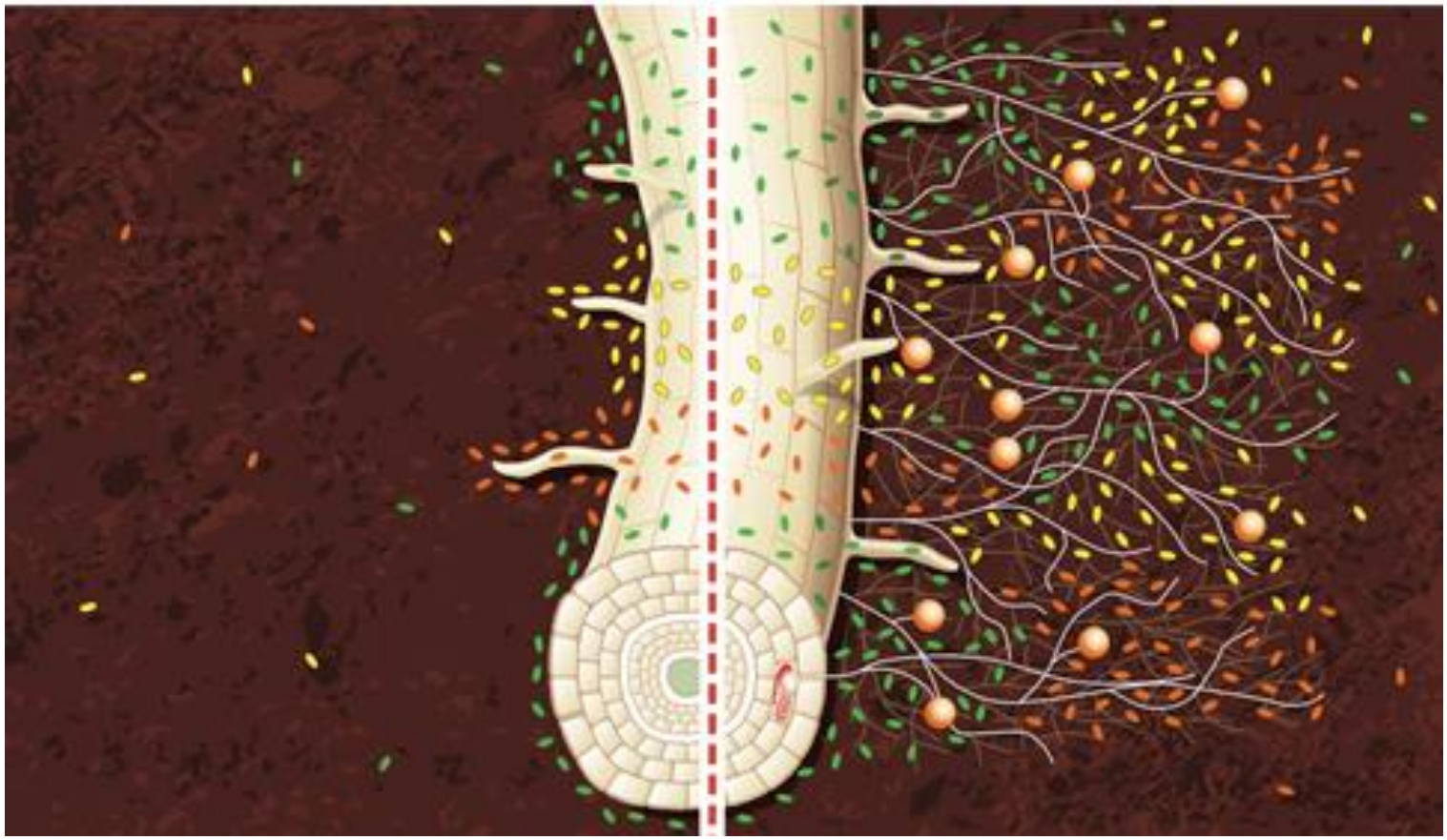


Spintails

Mites chew plant debris into small pieces, which makes the debris available to smaller organisms. Some also feed on other mites, living fungi, or other soil organisms. Mites have eight legs and are related to spiders.

These cute little organisms are springtails, which get their name because they have a mechanism under their abdomen that allows them to ‘spring’ away from predators. They eat organic materials and often graze on fungal tissue.

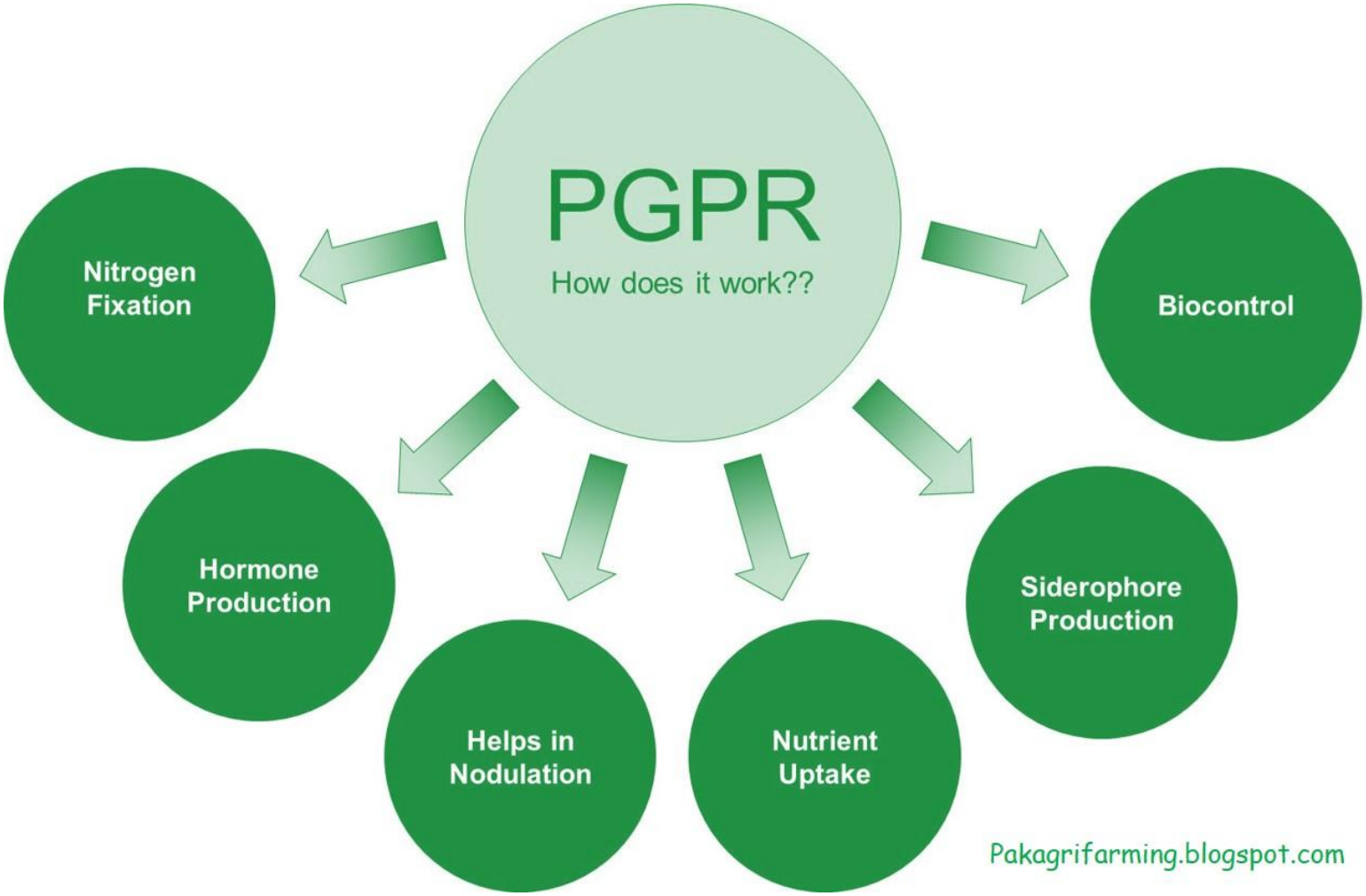
FUNCTIONALITY OF SOIL MICROBES



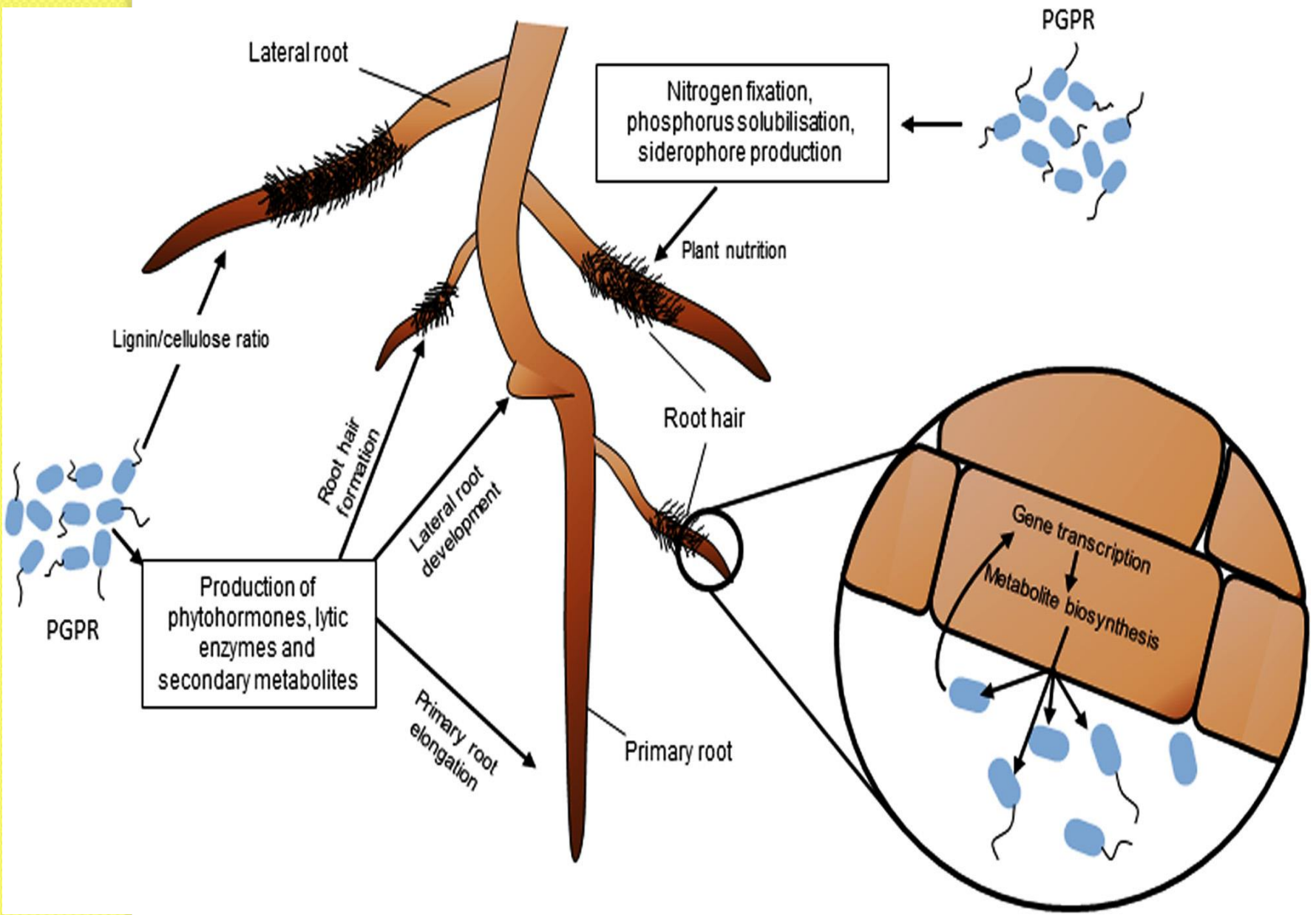
Non-rhizosphere

Rhizosphere zone + PGPR

Effective soil bacteria (Plant Growth Promoting Bacteria)



Nodulation of N_2 fixing bacteria


PGPR
Lateral root
Nitrogen fixation, phosphorus solubilisation, siderophore production
Plant nutrition
Lignin/cellulose ratio
Root hair
Root hair formation
Lateral root development
PGPR
Production of phytohormones, lytic enzymes and secondary metabolites
Primary root elongation
Primary root
Gene transcription
Metabolite biosynthesis

Microbial Density in Soil

Bacteria are dominant on the surface soil where plant debris are accumulated and decomposed into soil organic matter (humus).

Depending on soil conditions and depth, the number of bacteria in the soil varies between 10^7 and 10^{10} cfu (colony forming unit) / per gram soil.

In most cases the number of bacteria is higher than that of Protozoa, algae and fungi populations. High number of protozoa is usually associated with high number of bacterial populations.

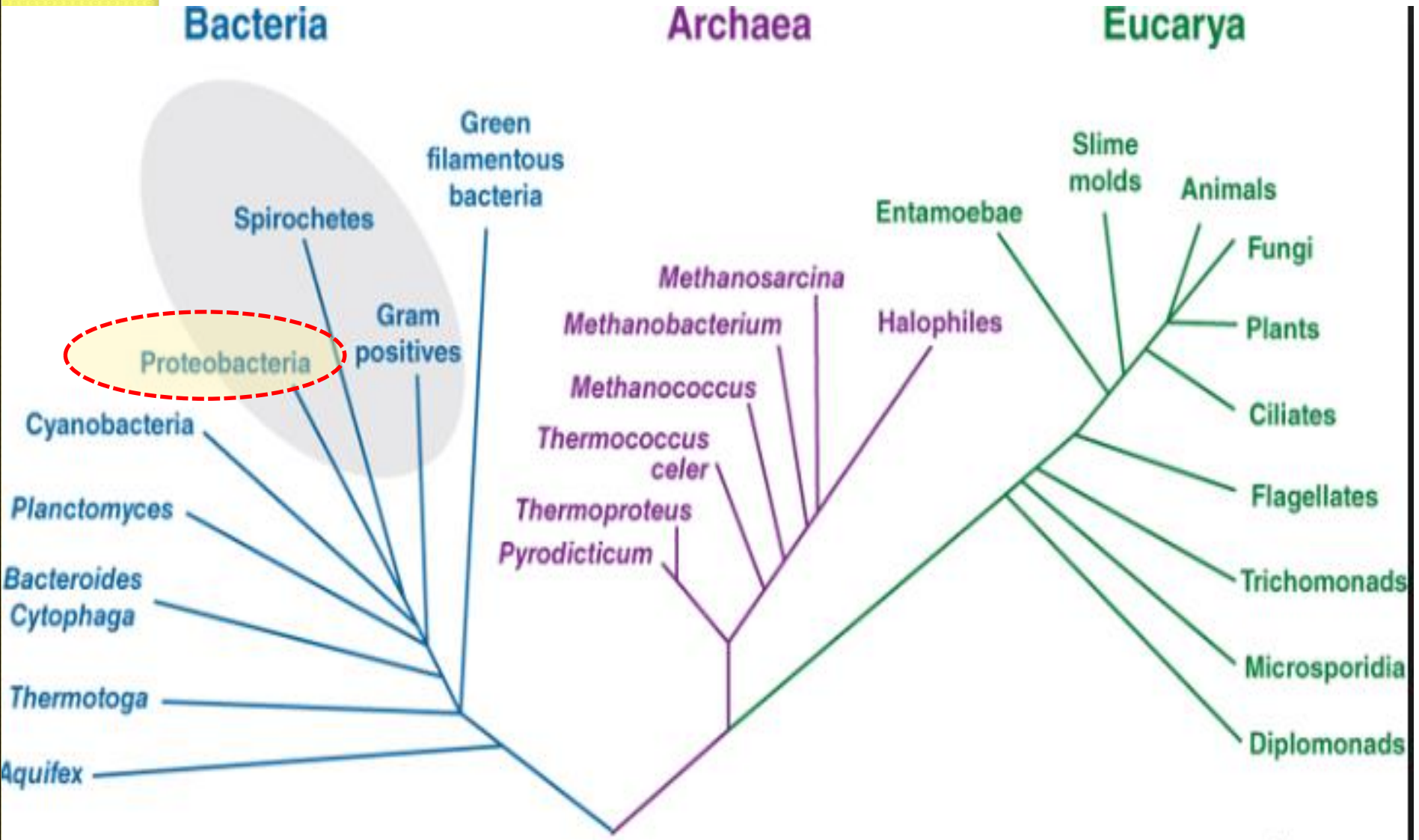
Soil algaE populations are largely related to solar energy (light and temperature) and the number of algae gradually decreases through deep layers of soil

In fact, the amount of organic nutrients decreases through deeper soil layers. This causes the decrease in soil microbial density .

HOW TO CLASSIFY SOIL BACTERIA?

- Systematic or taxonomic principles
- Physiological and metabolic differences
- Cell structure
- Energy requirements
- Functionality

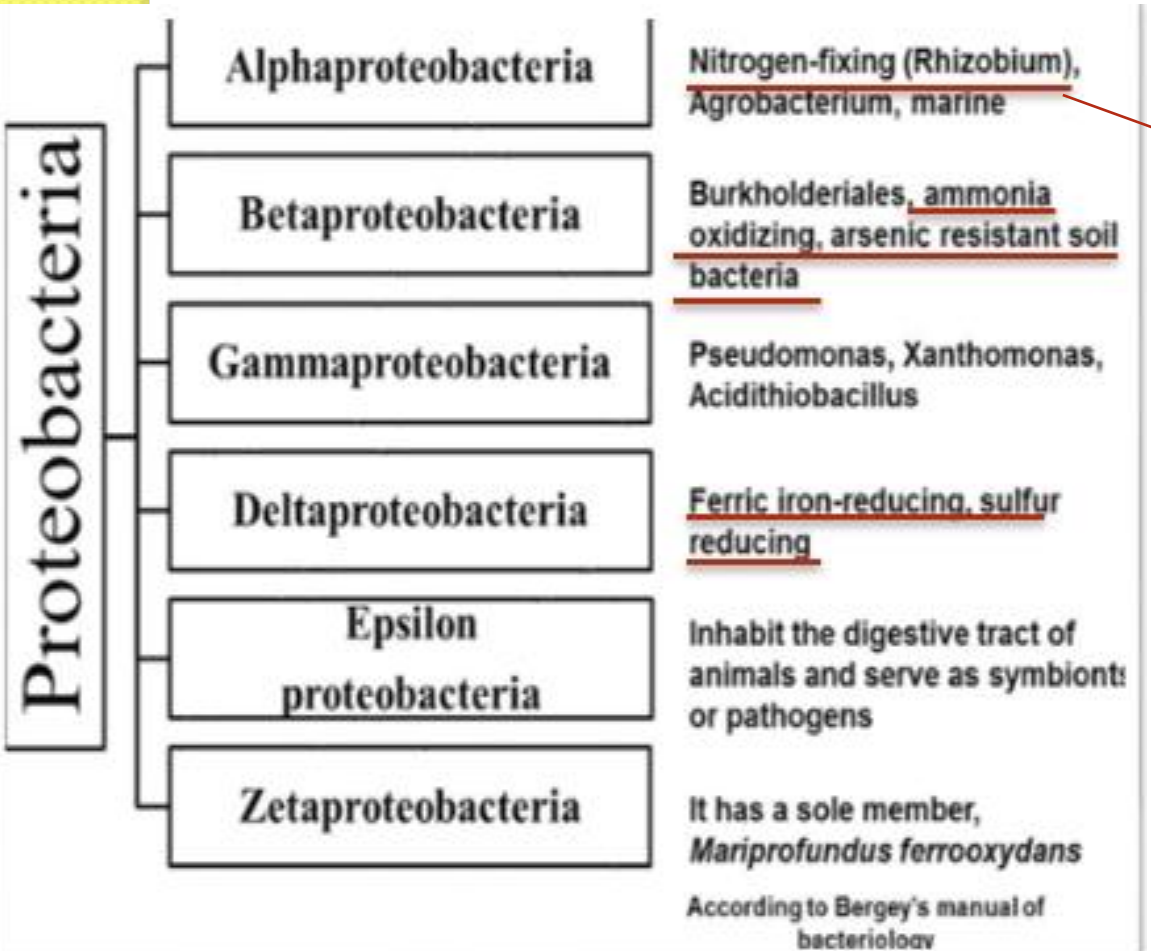
Phylogenetic Tree of Life!

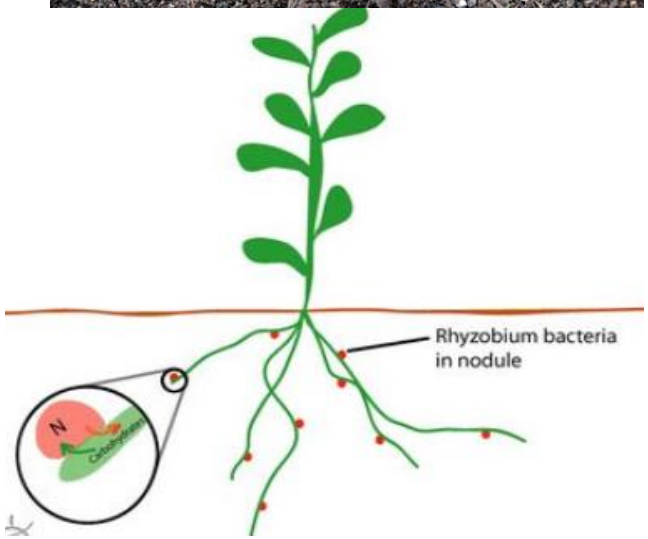


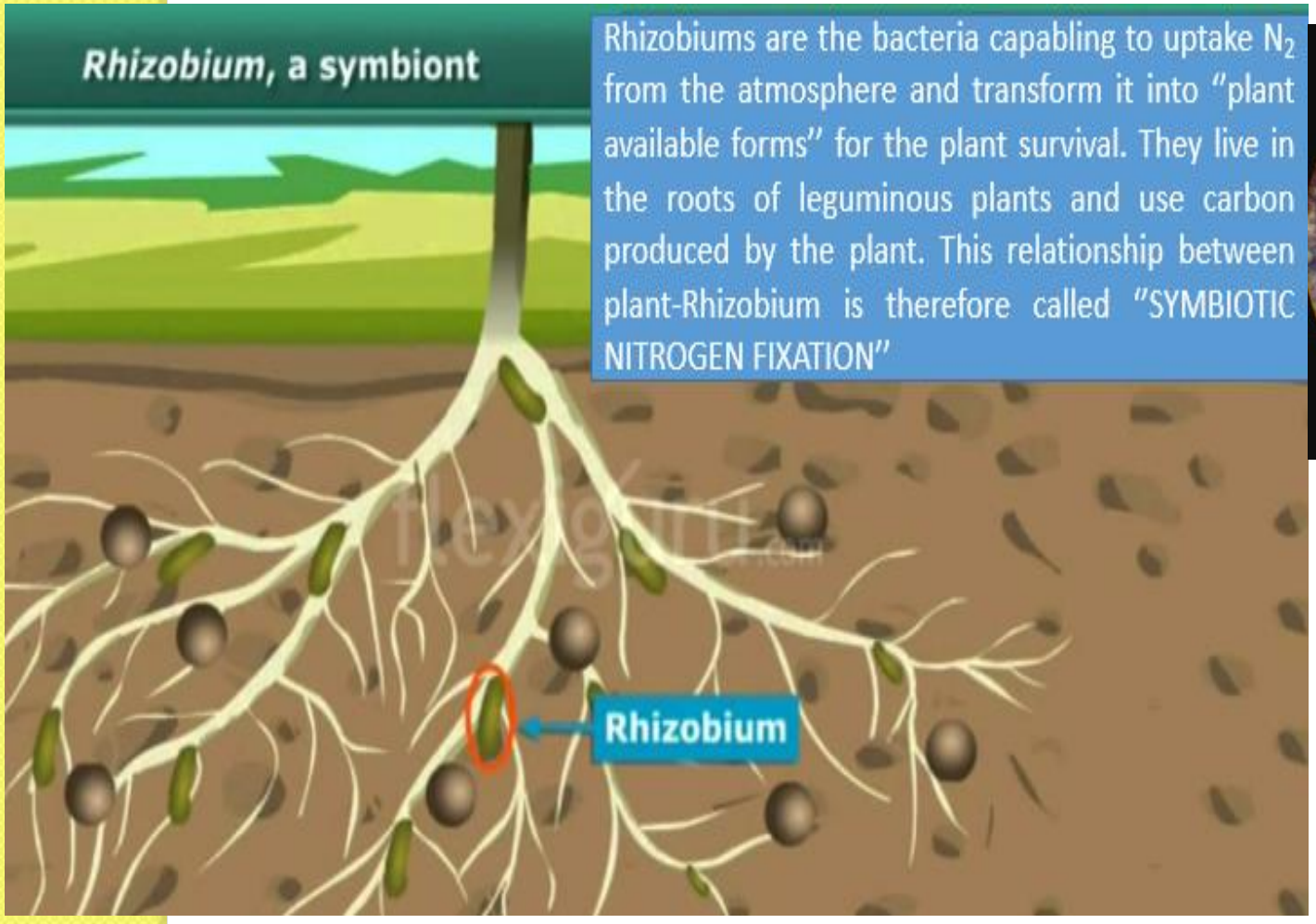
Source: Karen C. Carroll, Stephen A. Morse, Timothy Mietzner, Steve Miller: Jawetz, Melnick, & Adelberg's Medical Microbiology, 27th Edition.
www.accessmedicine.com

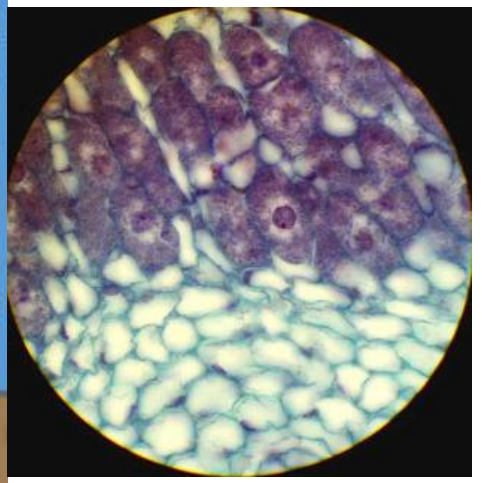
Phylogenetic Tree of Life

Proteobacteria is a major phylum of gram-negative bacteria including a wide variety of pathogens, such as *Escherichia*, *Salmonella*, *Vibrio*, *Helicobacter*, *Yersinia*, *Legionellales* and many other notable genera including ‘’free-living (non-parasitic) nitrogen fixing’’ bacteria









Taxonomy

Domain: Bacteria

Kingdom: Bacteria

Phylum: Proteobacteria

Class: Alphaproteobacteria

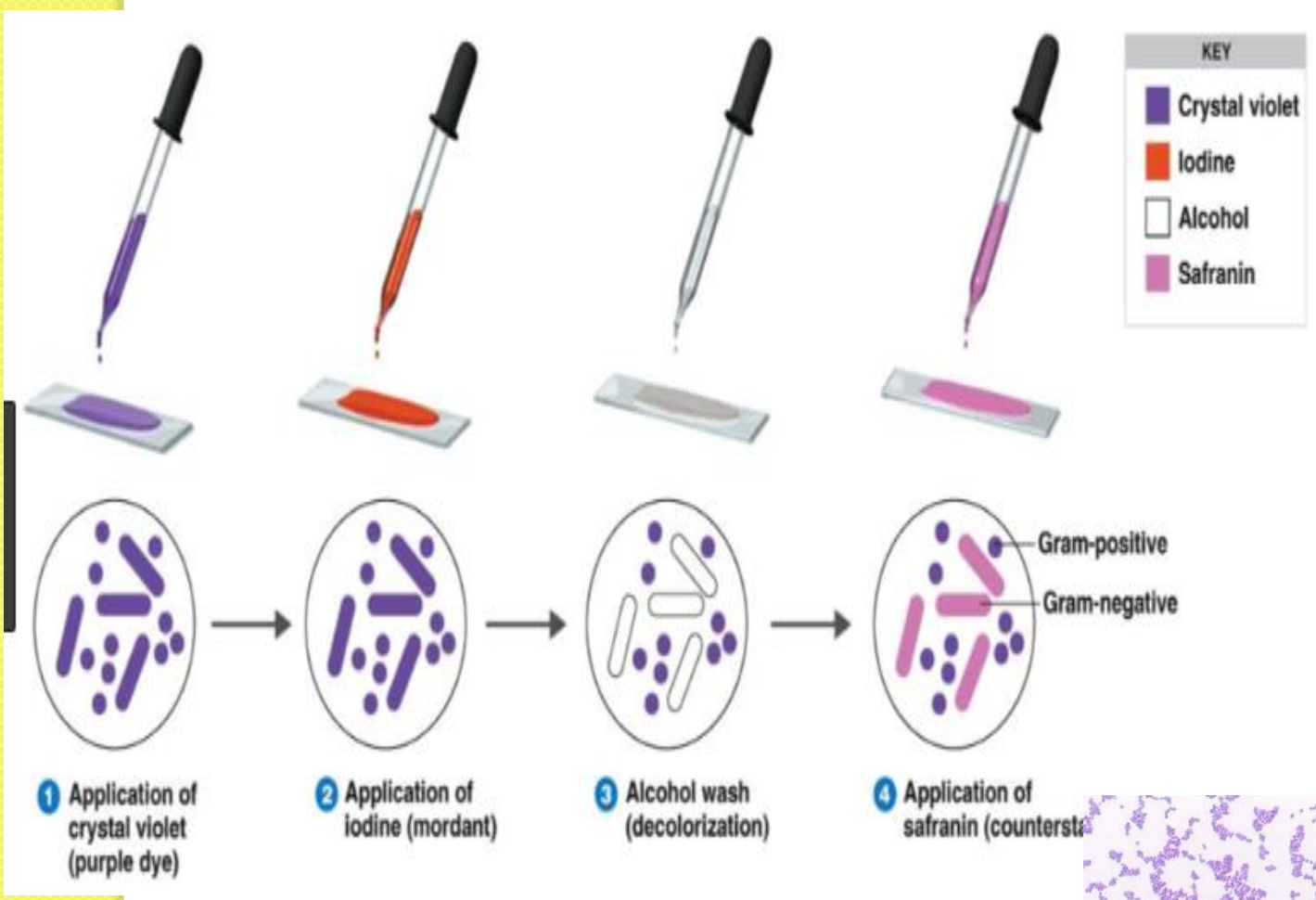
Order: Rhizobiales

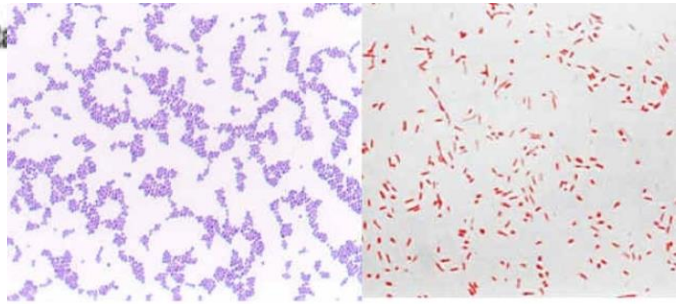
Family: Rhizobiaceae

Genus: *Rhizobium*

Species: *Rhizobium leguminosarum*

Bacterial Physiology and Metabolism concerns the life-supporting functions and processes of bacteria. Most common characterisation is ‘’Gram staining’’





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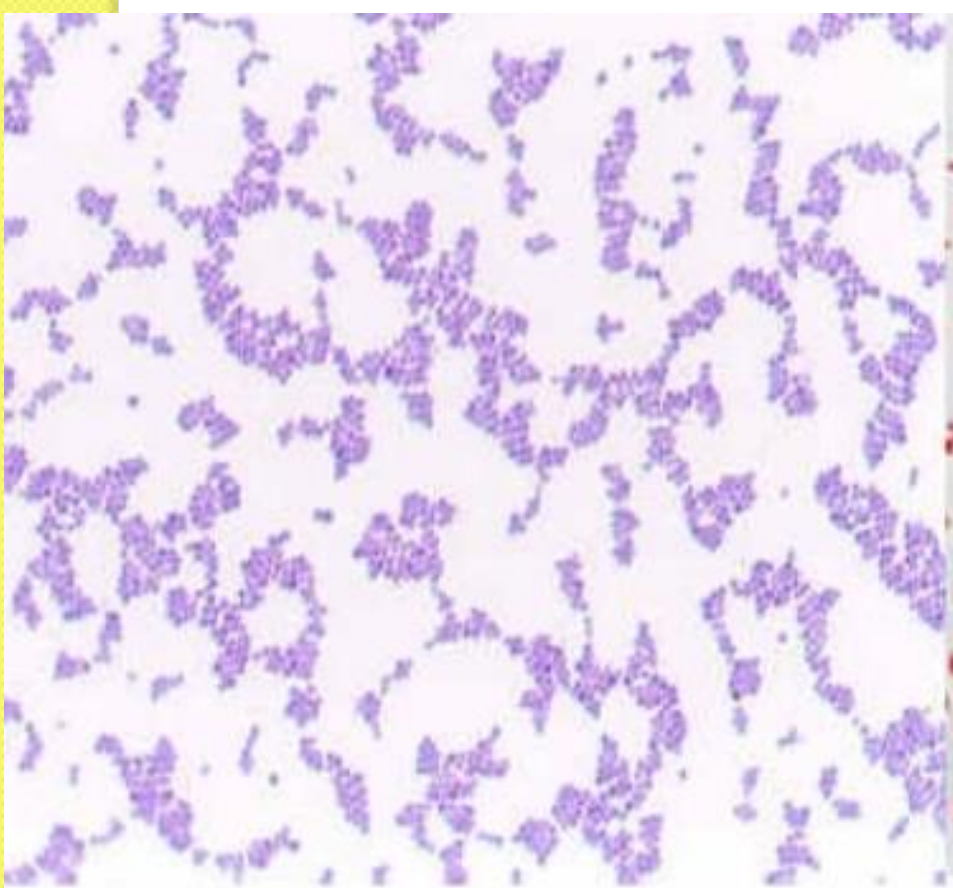
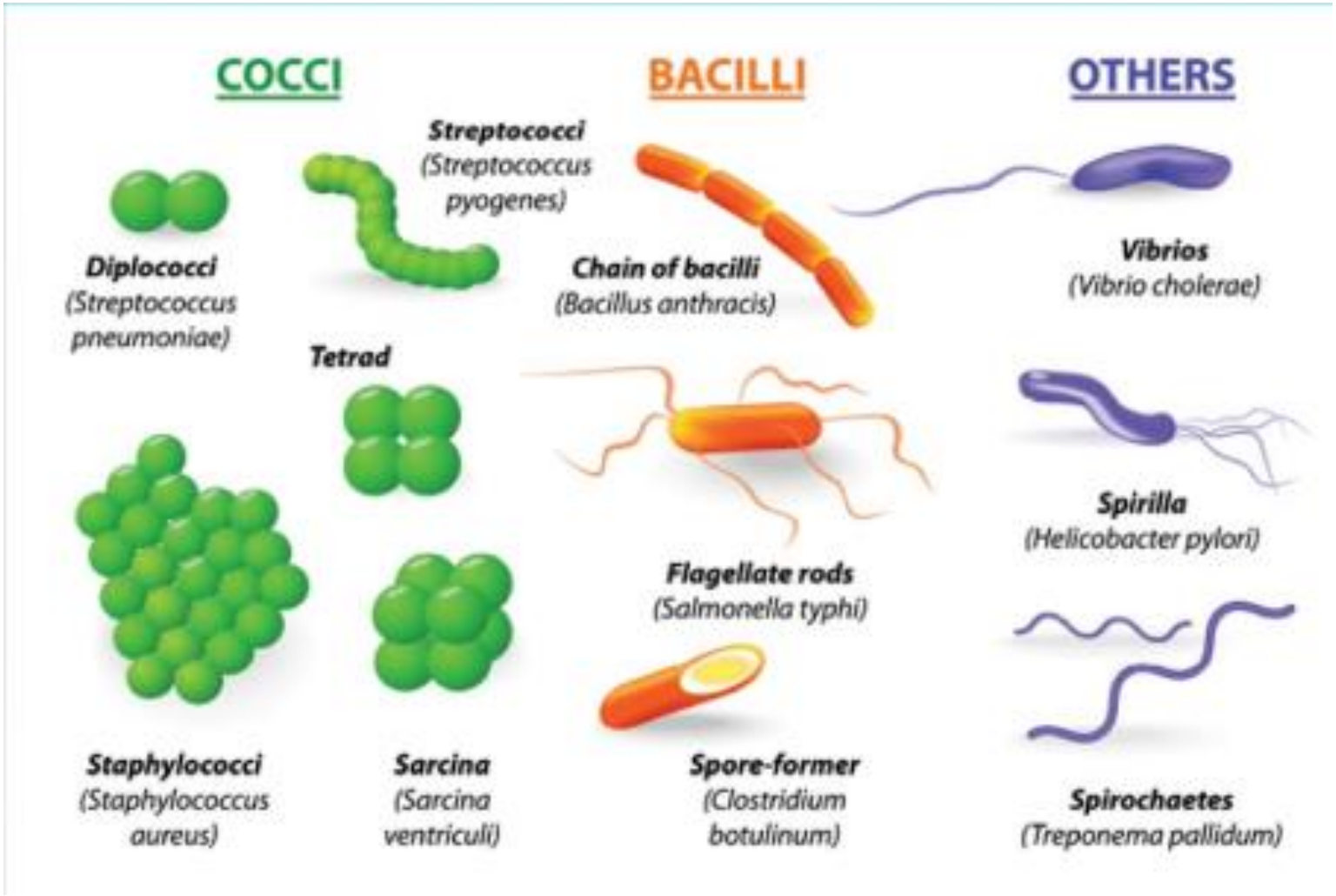


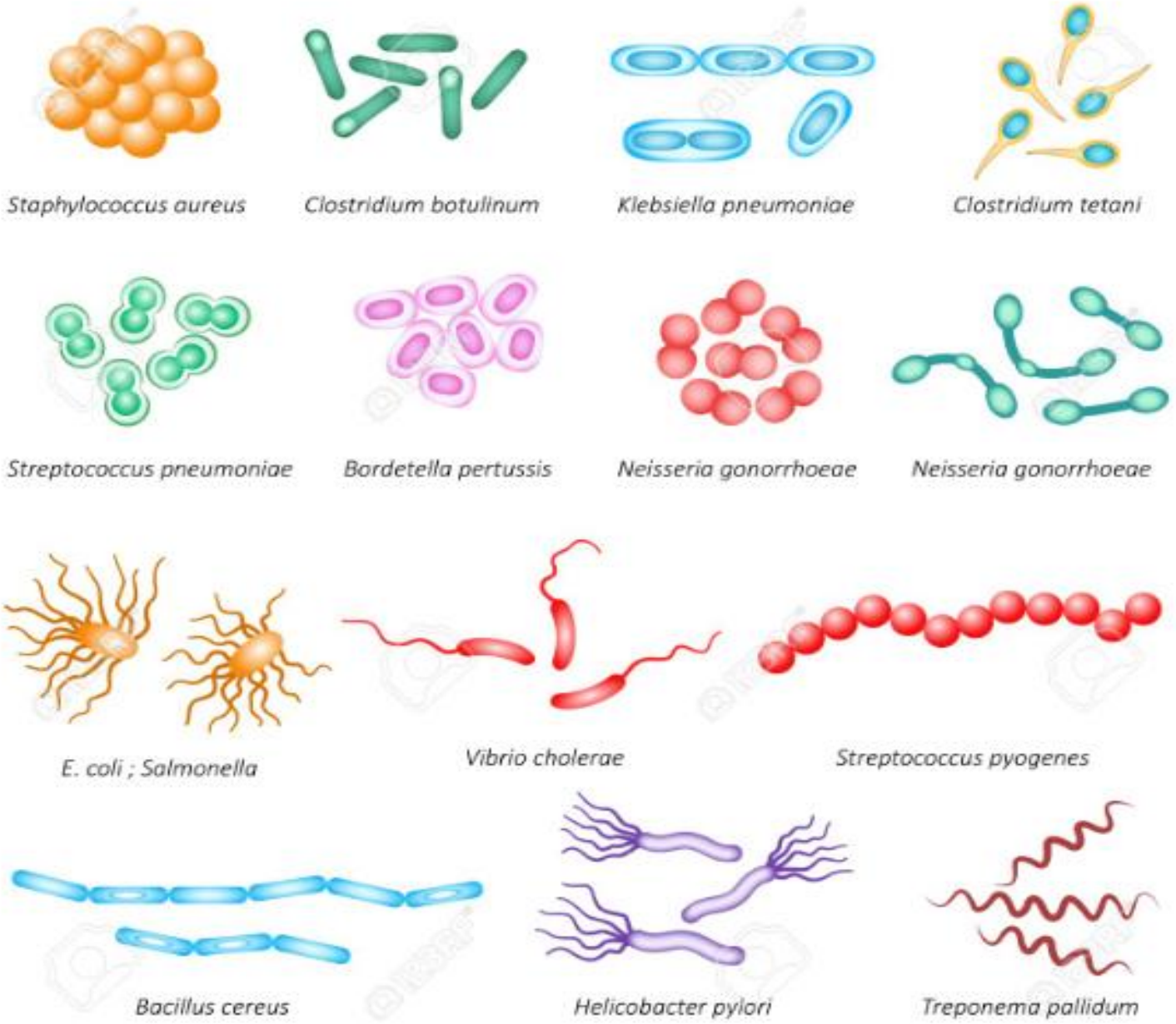
Gram +ve Bacteria

Gram -ve Bacteria

Common types ans shapes of bacteria



Common types and shapes of bacteria



CHARACTERISTICS	RESULTS
Gram staining	+
Morphology	Rod shaped
Aerobic test	+
Starch hydrolysis test	+
Voges-Proskauer test	+
Citrate test	+
6.5% Nacl test	+
Catalase test	+