SOIL BIOLOGY
AQSE006

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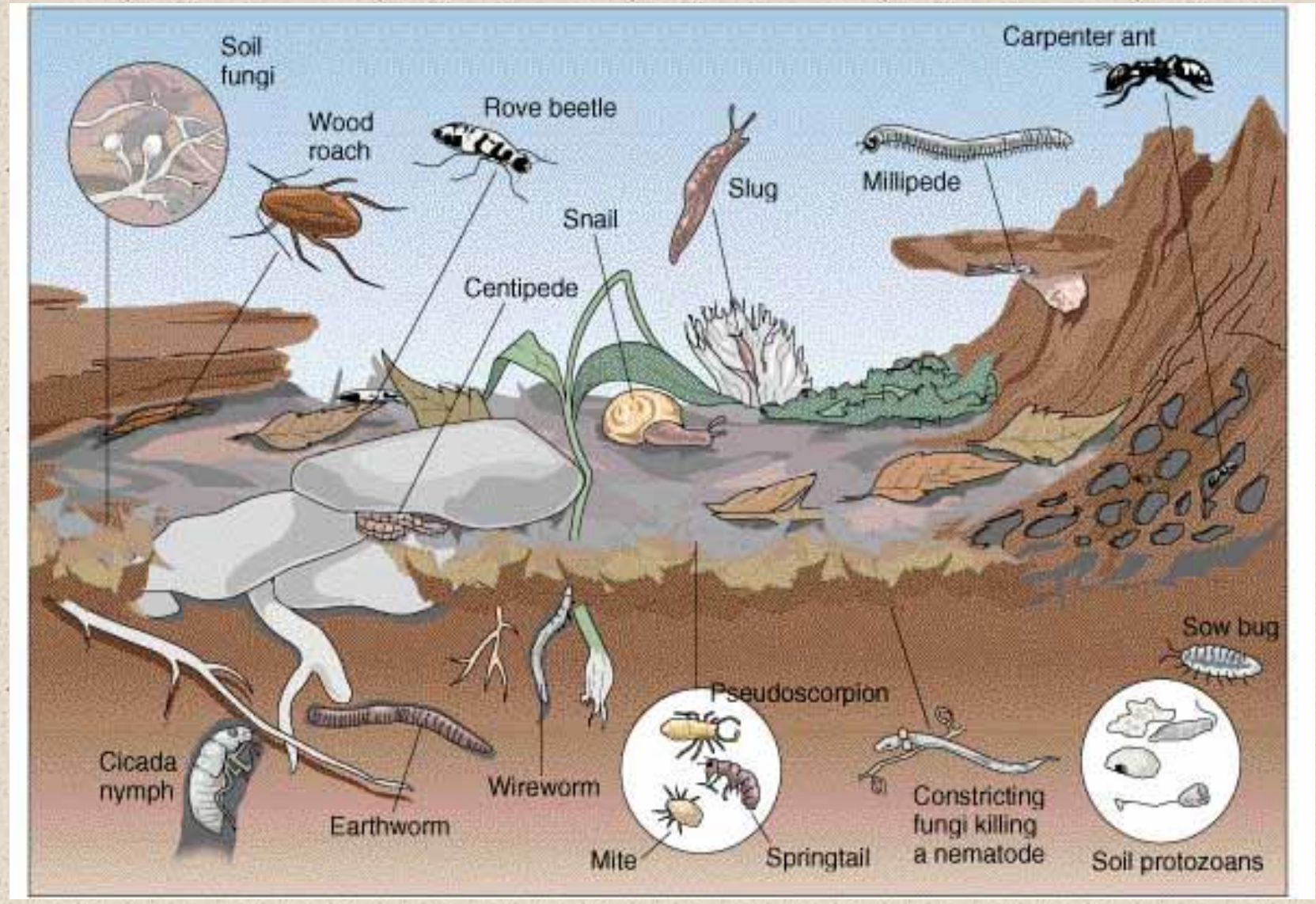
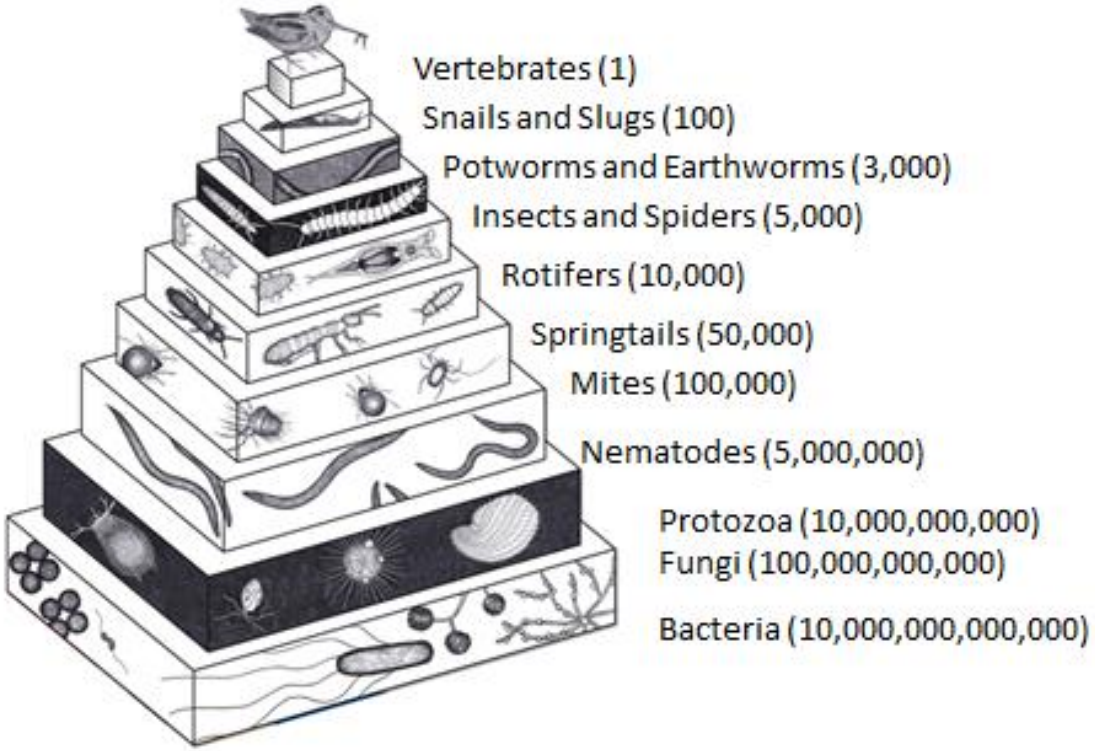
Smal but complicated



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 microorganisms in the terrestrial ecosystem lives in the soil and the microbiology of such ecosystems is widely regarded as **soil biology or microbiology**

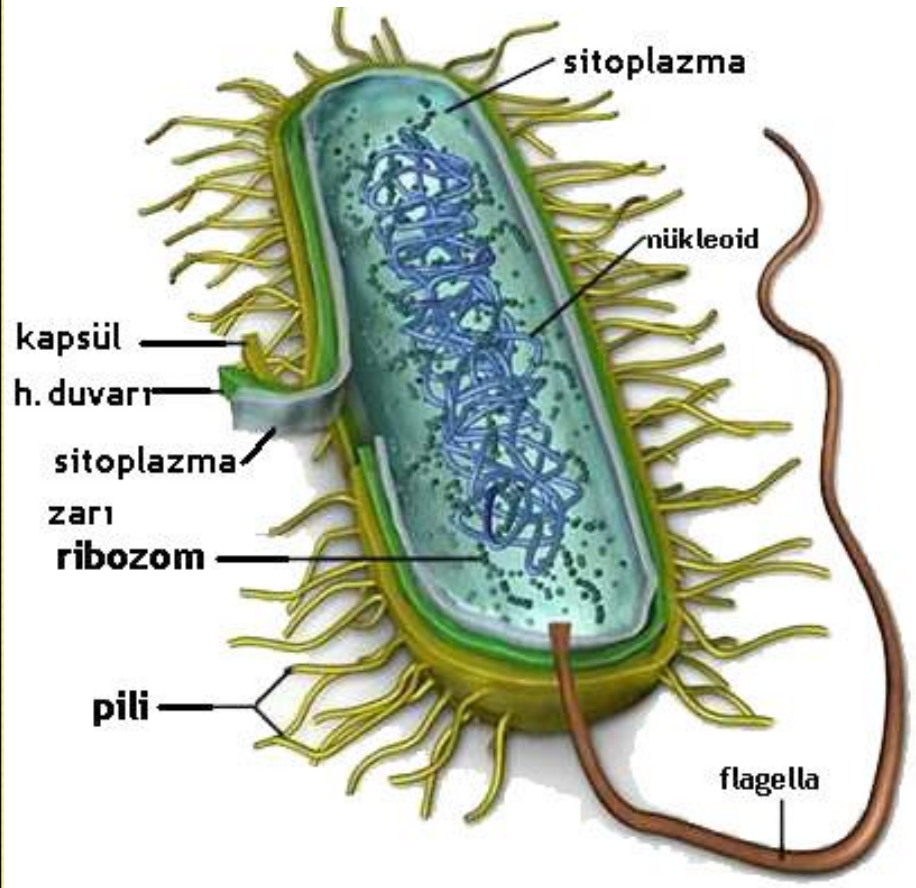
All living organisms can be classified into two major groups, mainly **eukaryotes** and **prokaryotes**, according to their cell structure differences

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

Prokaryote cell



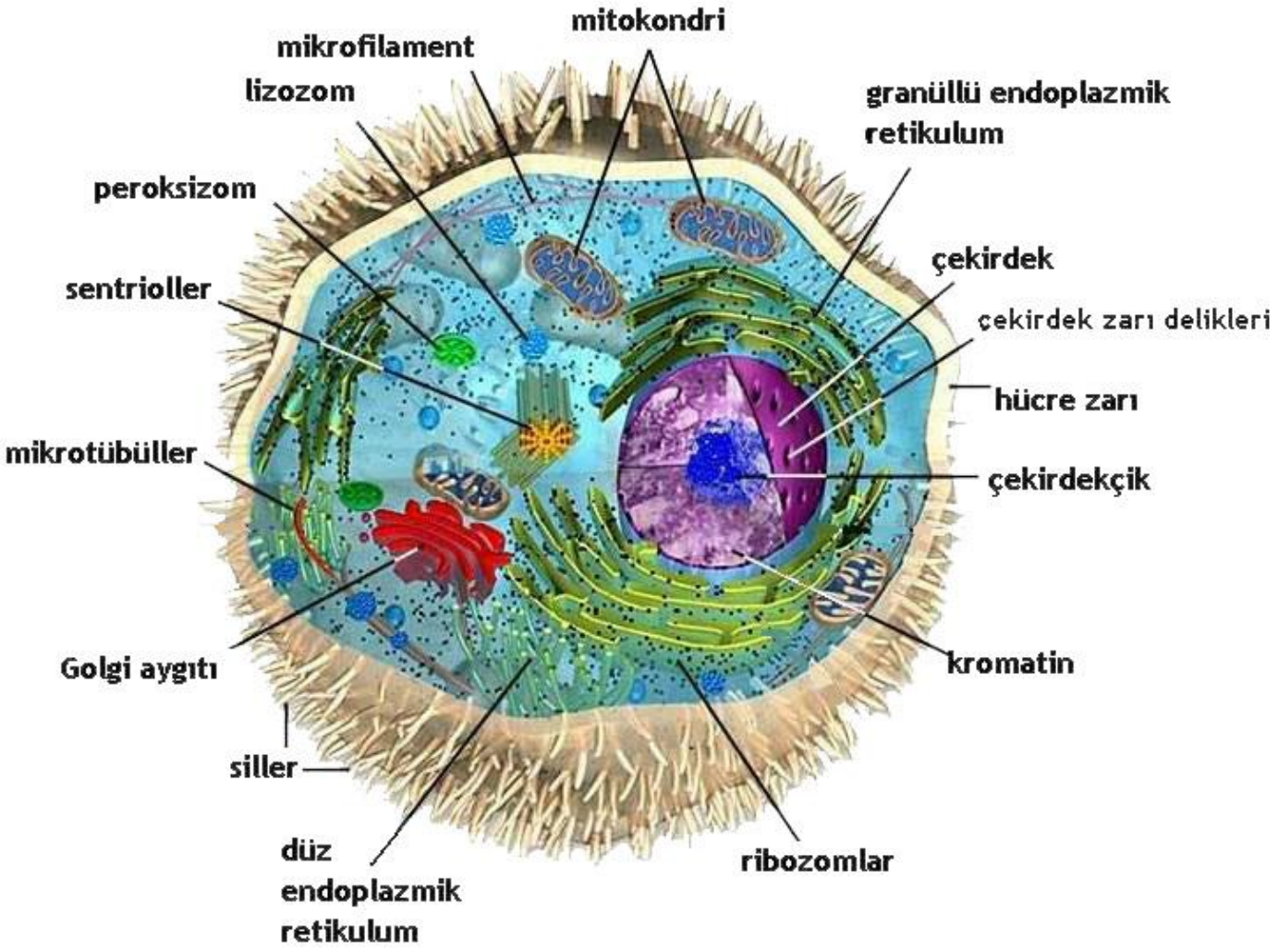
The prokaryote cell contains simple DNA molecules and a nuclear region surrounded by membranes

- 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

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

Euocaryote cell



Eukaryotes are divided into 2 main groups

I) multicellular organisms with cells having specific tasks

II) Unicellular organisms with cells having same properties

Multicellular organisms are classified in 2 general categories

Plants and animals (depending on energy and carbon sources, structure, growth type and movements).

Single cell organisms are divided into 3 general categories; protozoa, fungus, algae

Prokaryotes

Although bacteria are described as single cells, they may exist as cell chains or cellular clusters (colonies)

Actinomycetes are generally branched filaments and prokaryotes showing a highly complex internal structure

Algae are actually photosynthetic bacteria resembling true plants and plants with chlorophyll. With this feature, they convert light energy into cellular tissue and functional energy.

Eukaryotes

- Fungi and algae are defined as eukaryotes

- They contain one or more chromosomes, surrounded by a nuclear envelope. Similar to all higher organisms, their inner cell structures are more complex than multicellular plants and animals.
- **Algae are less important for bioremediation purposes as they survive with limited number of organic compounds.**
- **Most fungi and microalgae are filamentous or single cells. They show single-cell form or other form at different stages of life cycles.**

Classification of microorganisms (according to carbon resource)

- "Heterotrophic' microorganisms (using soil organic matter as of energy and carbon source)

- "Autotrophic" microorganisms (using solar energy and/or oxidizing inorganic compounds and carbon dioxide as of energy and carbon source.

Classification of microorganisms (according to their size)

- **Macrofauna** (earthworms, other arthropods, or small vertebrates)
- **Mesofauna** (mites and microarthropods)
-**Microfauna** (nematodes, bacteria, algae, fungi)

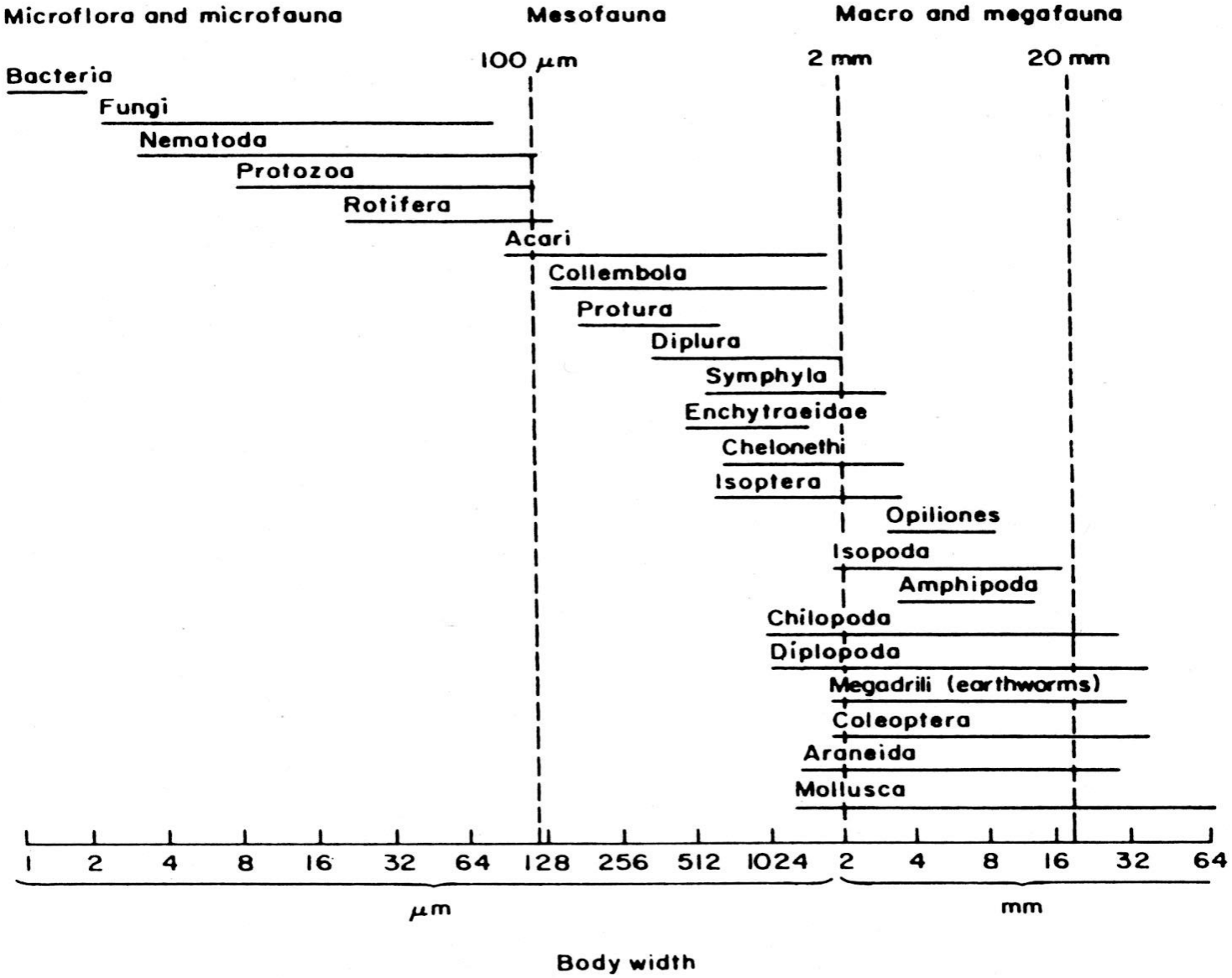
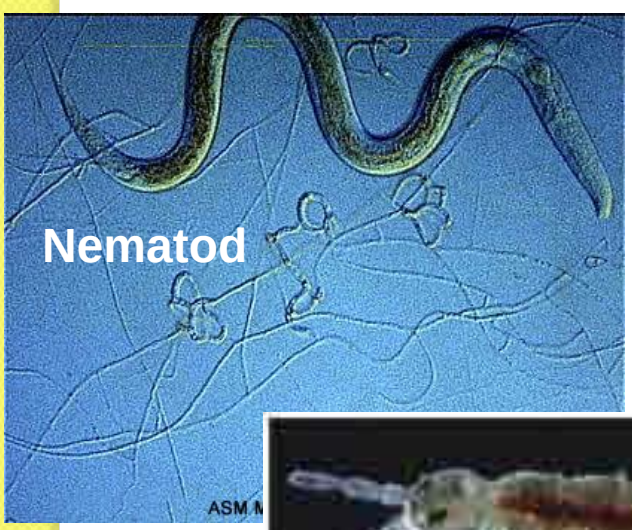


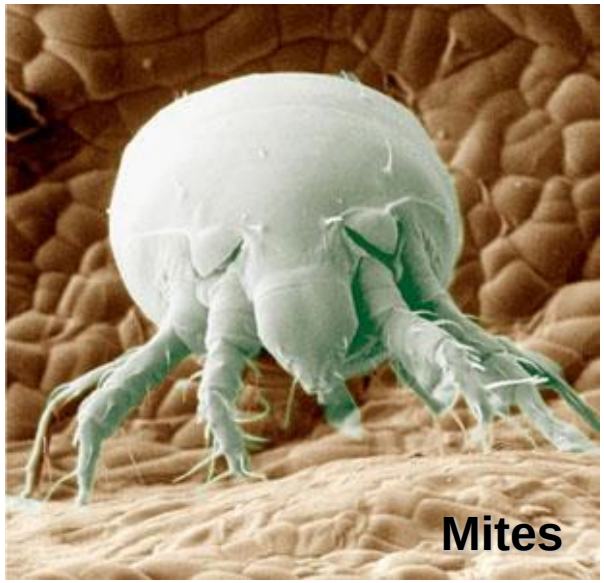
FIGURE 4.3 Size classification of organisms in decomposer food webs by body width (Swift *et al.*, 1979).

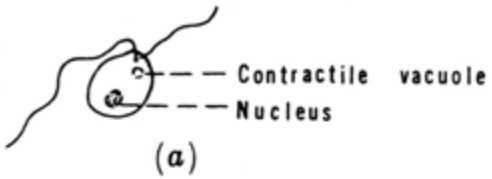
Soil Macrofauna

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

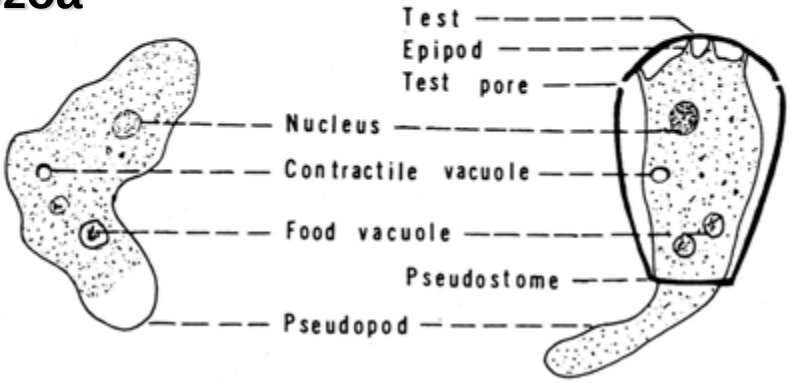
Soil Mesofauna





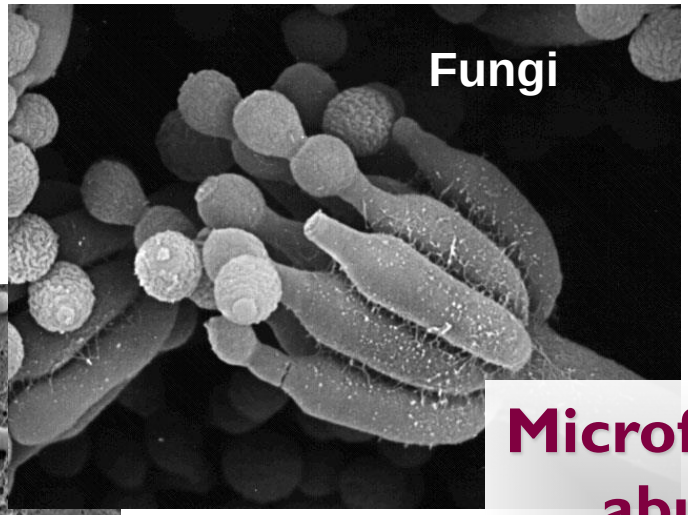


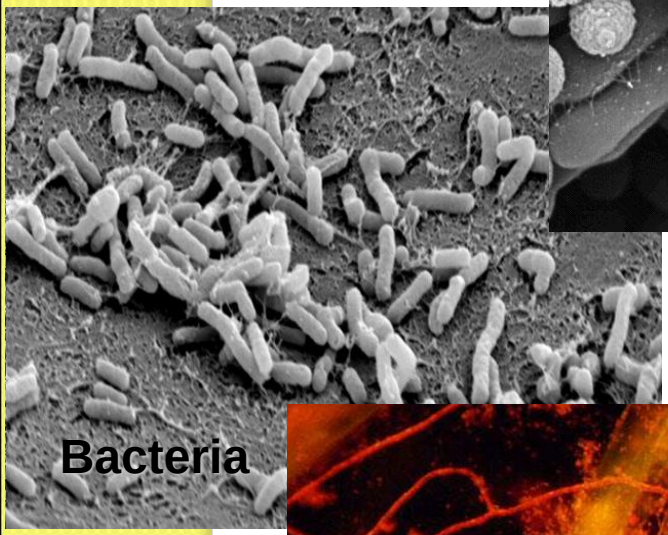
Protozoa

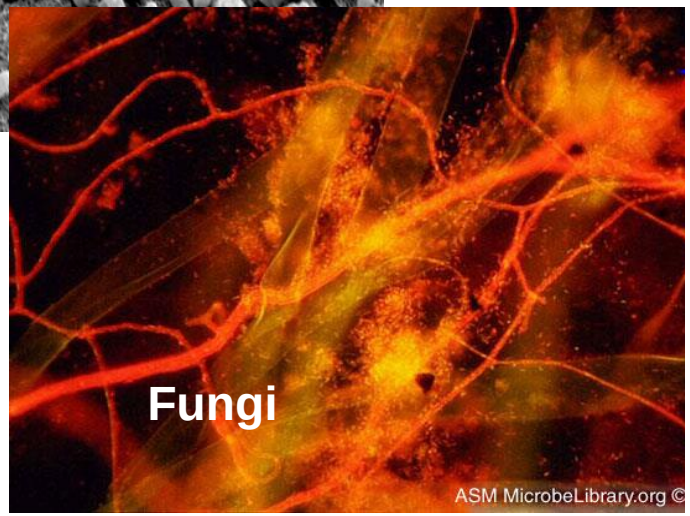


Mesofauna is important because responible for organic matter decomposition, predation and controlling pathogenes in soils

Soil microfauna

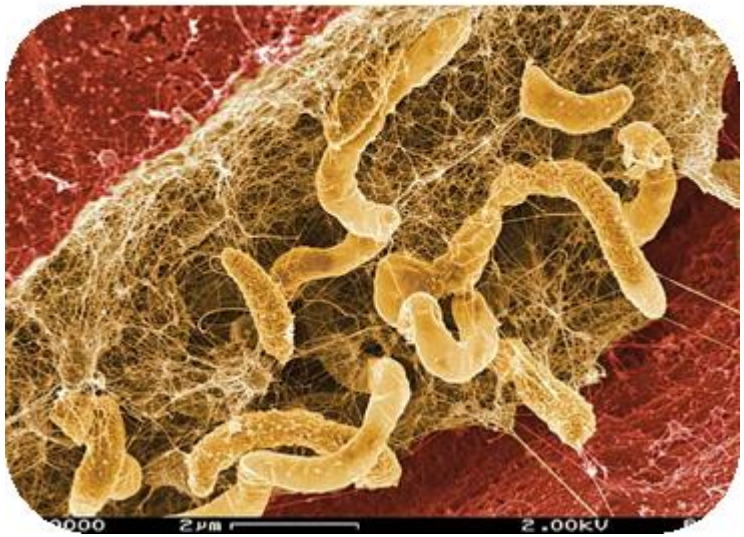






Microfauna is the most abundant in the soil and mainly responsible for the decay of organic matter, nutrient transformations and cycles, "carbon sequestration" and disease suppression as well .Therefore it is regarded as living part of soil organic matter.

Bacteria

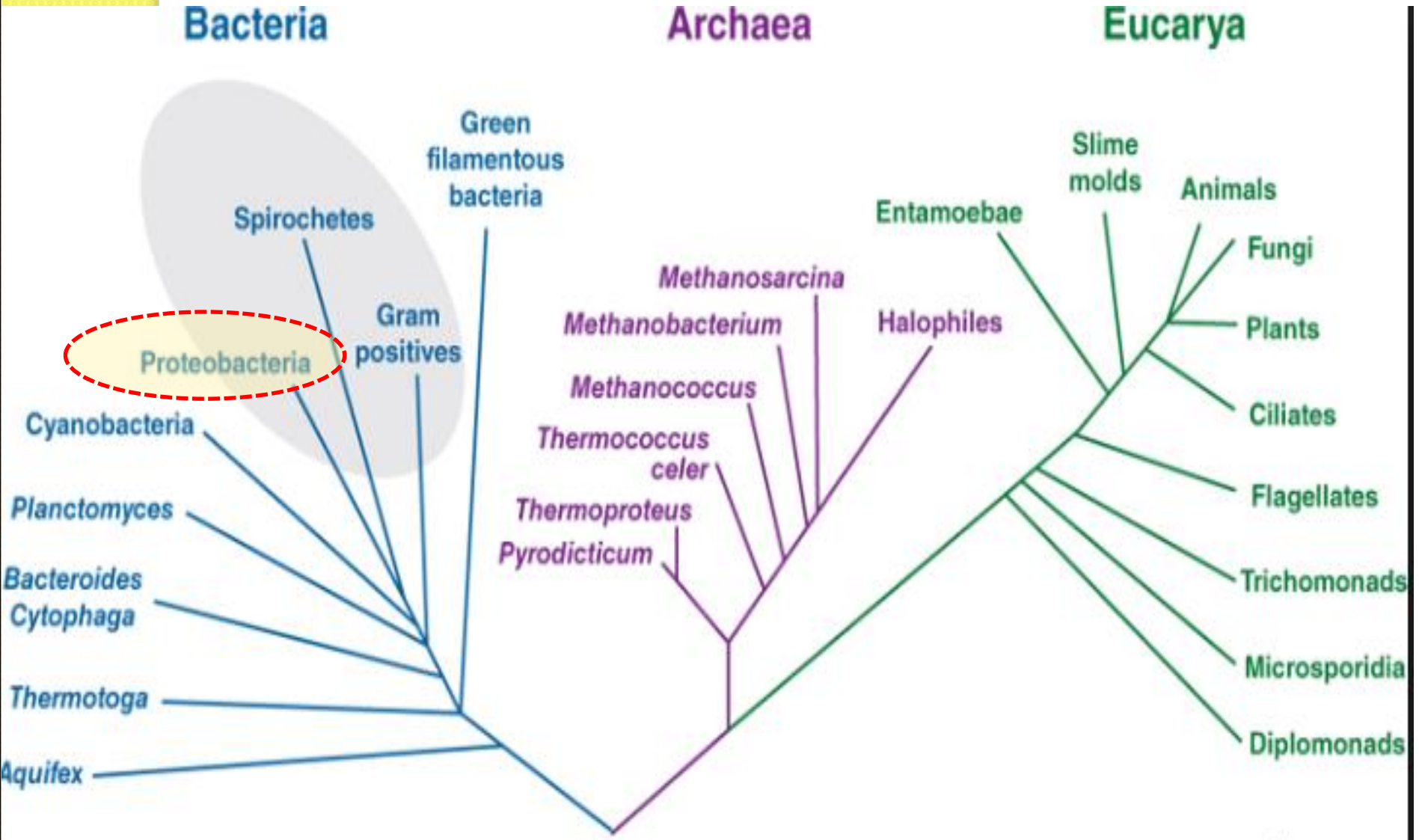


Bacteria are some of the smallest of life forms, normally just 1 to 3 micrometers in length. They are rather complex, however, because each cell contains everything needed for life. **Plants need bacteria to convert elements in the soil and air into nutrients that plants require for growth.**

Undestanding soil bacteria (Classification)

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

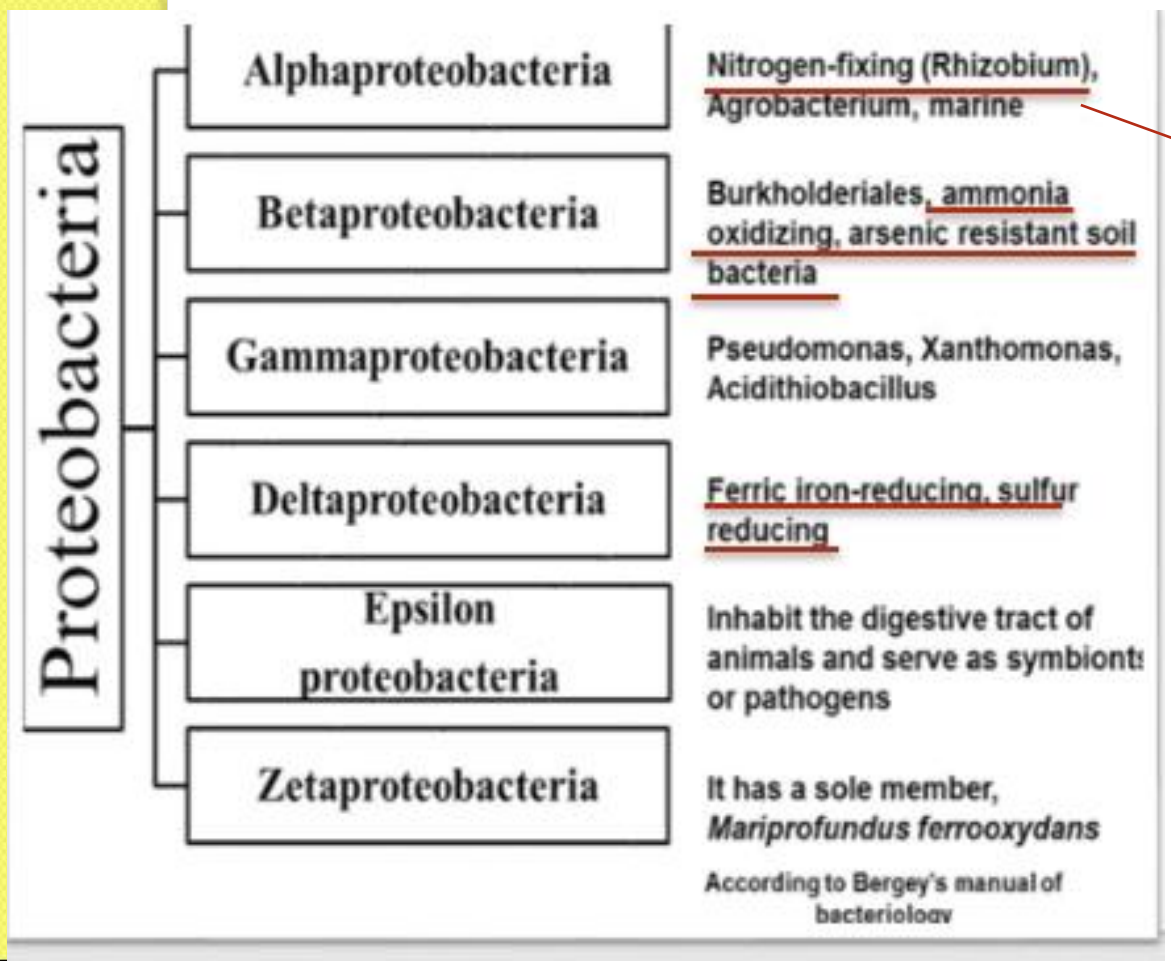
Phylogenetic Tree of Life!

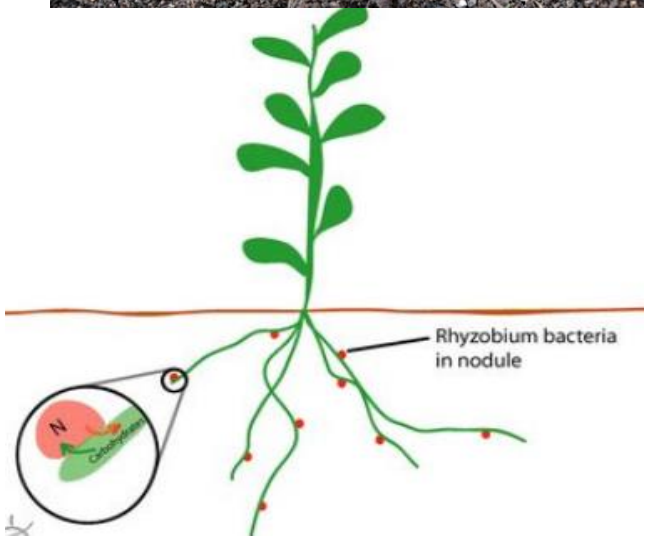


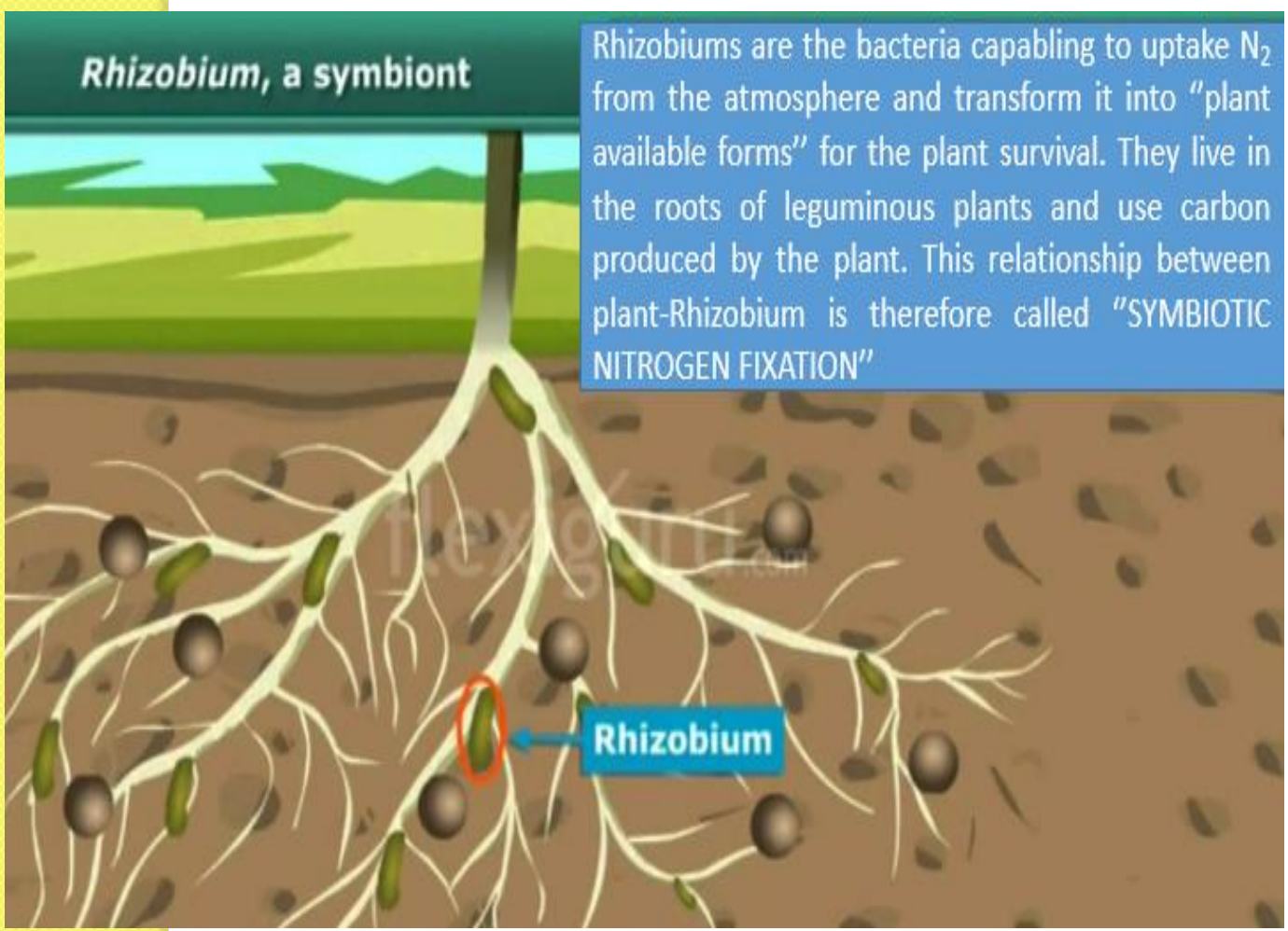
Source: Karen C. Carroll, Stephen A. Morse, Timothy Mietzner, Steve Miller: Jawetz, Melnick, & Adelberg's Medical Microbiology, 27th Edition.
www.accessmedicine.com

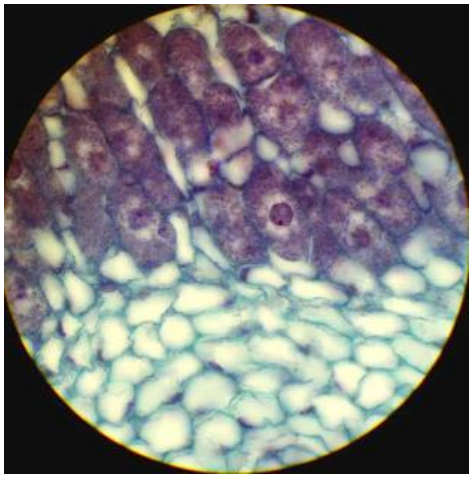
Phylogenetic Tree of Life

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

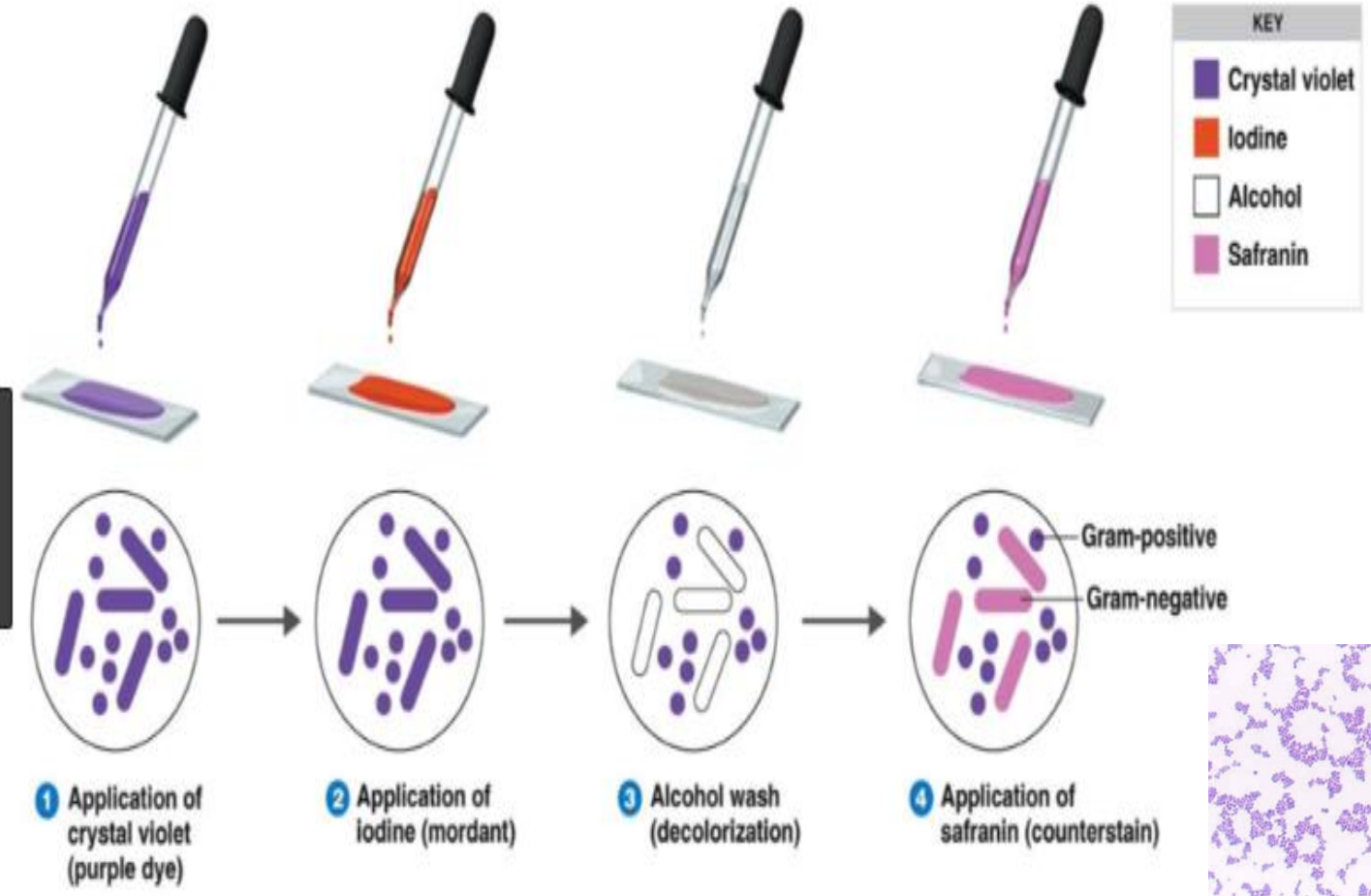
Order: Rhizobiales

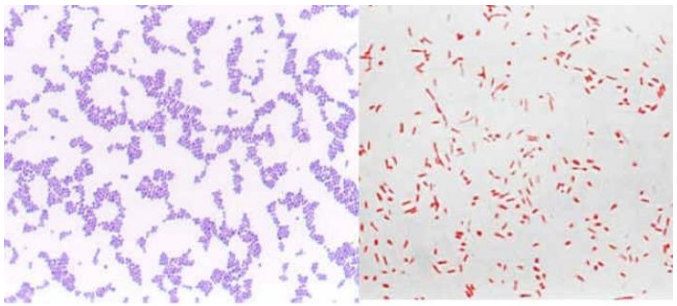
Family: Rhizobiaceae

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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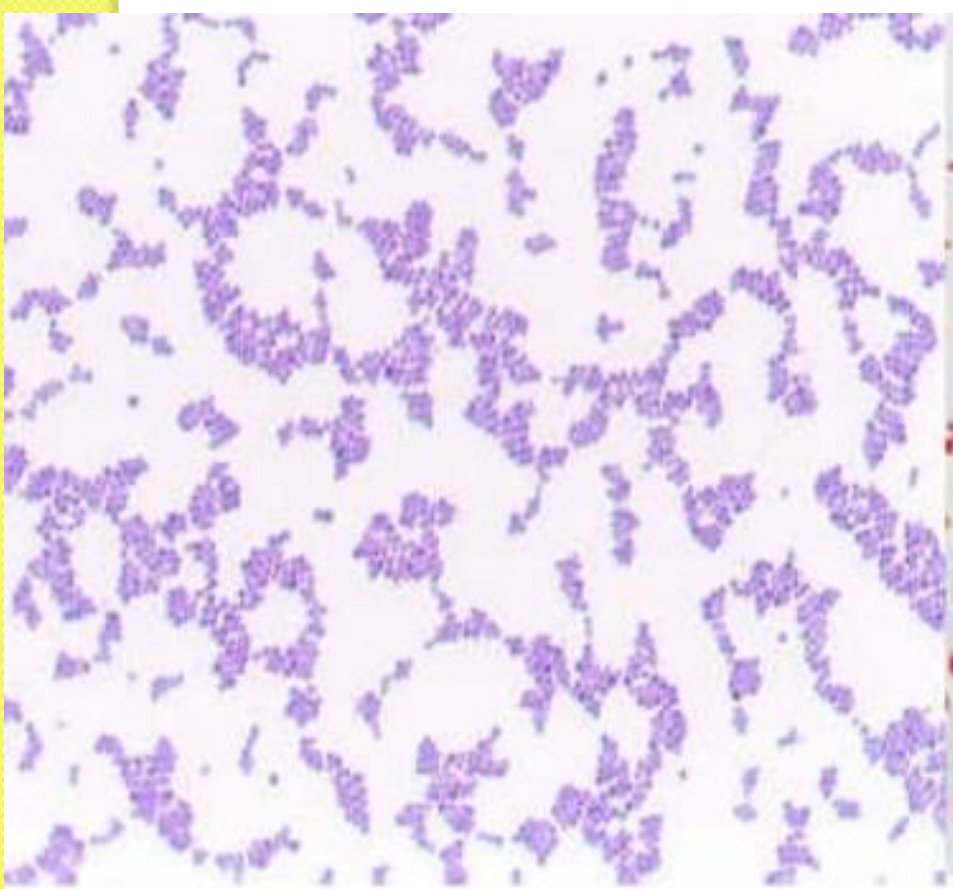
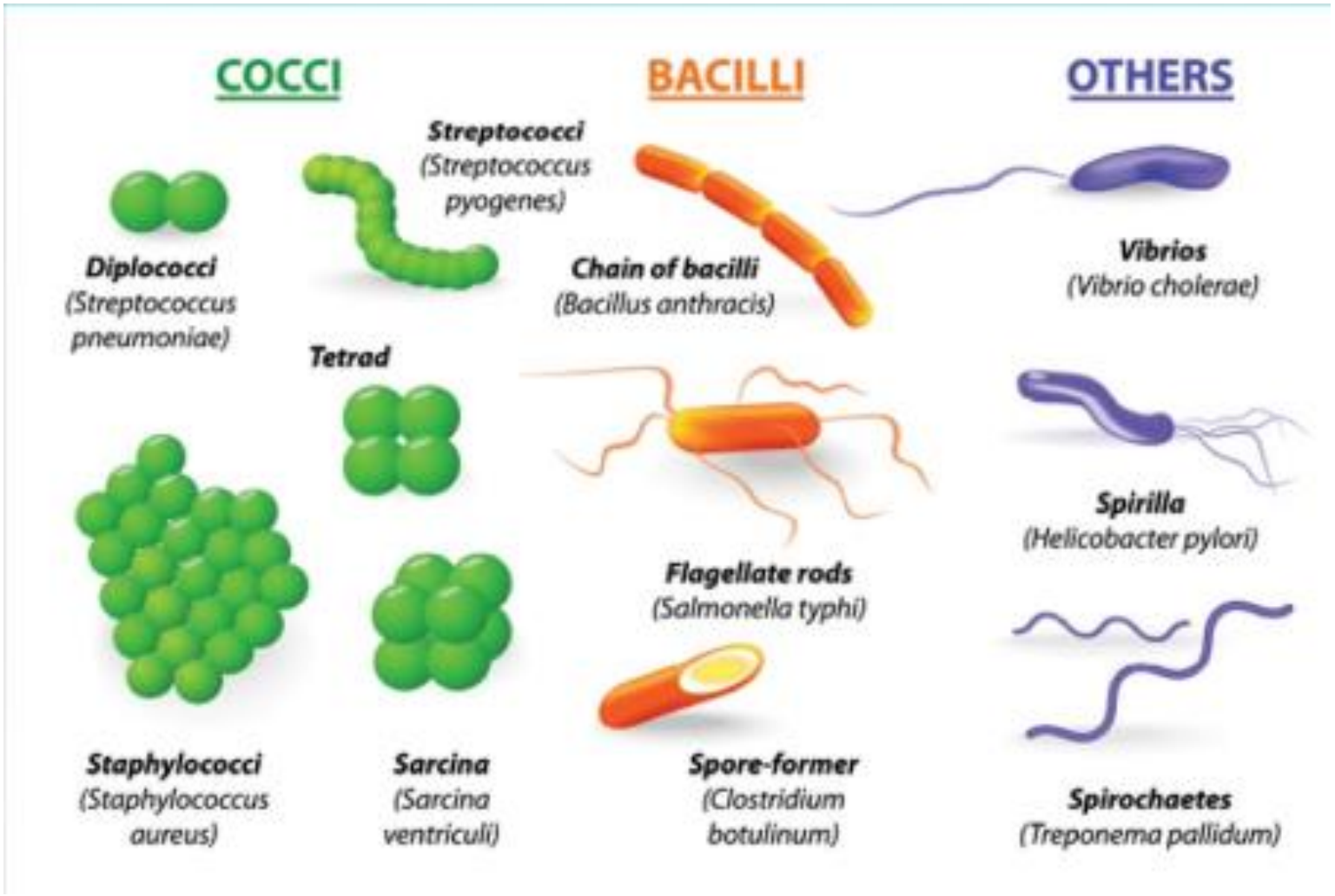


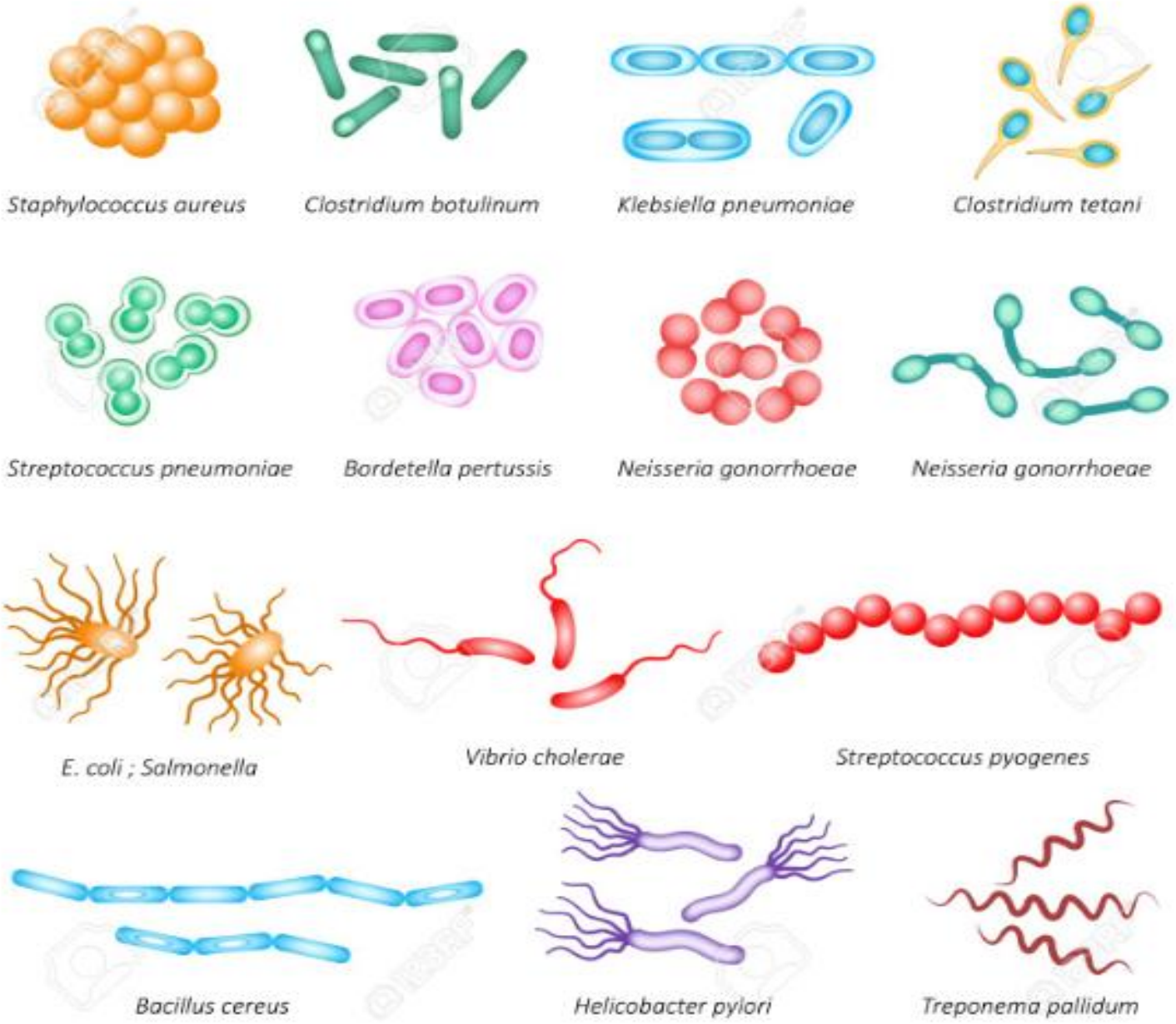
Gram +ve Bacteria

Gram -ve Bacteria

Common types ans shapes of bacteria

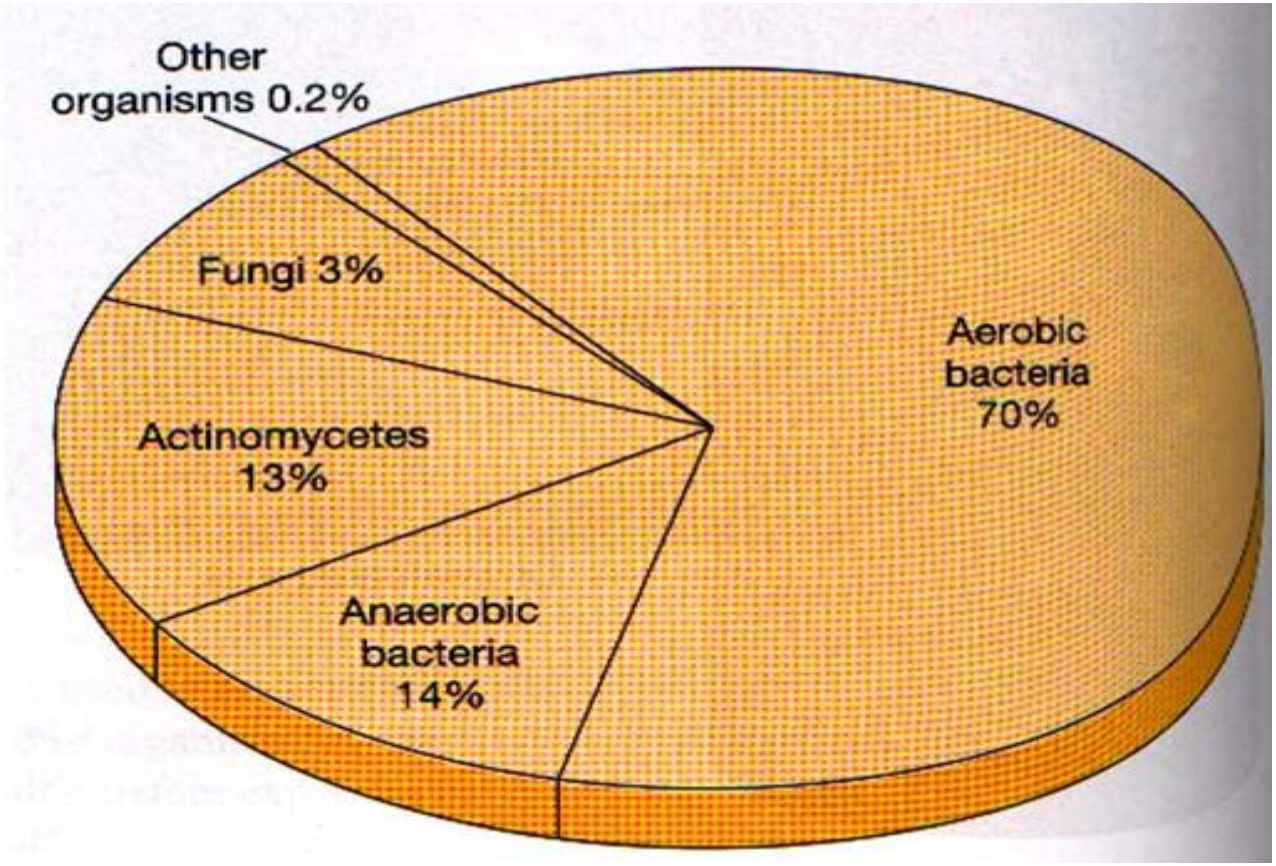


Common types and shapes of bacteria



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

Different soil microorganisms in numbers



Biomass distribution of agricultural soils (0-15cm depth)

M.O.	Number per g soil	Biomass (g / m^3)
Bacteria	10^8	160
Fungi	10^5	200
Actinomycetes	10^5 - 10^6	160
Algae	10^4 - 10^5	32
Protozoa	10^4	38

Classification of soil bacteria according to their energy and carbon needs

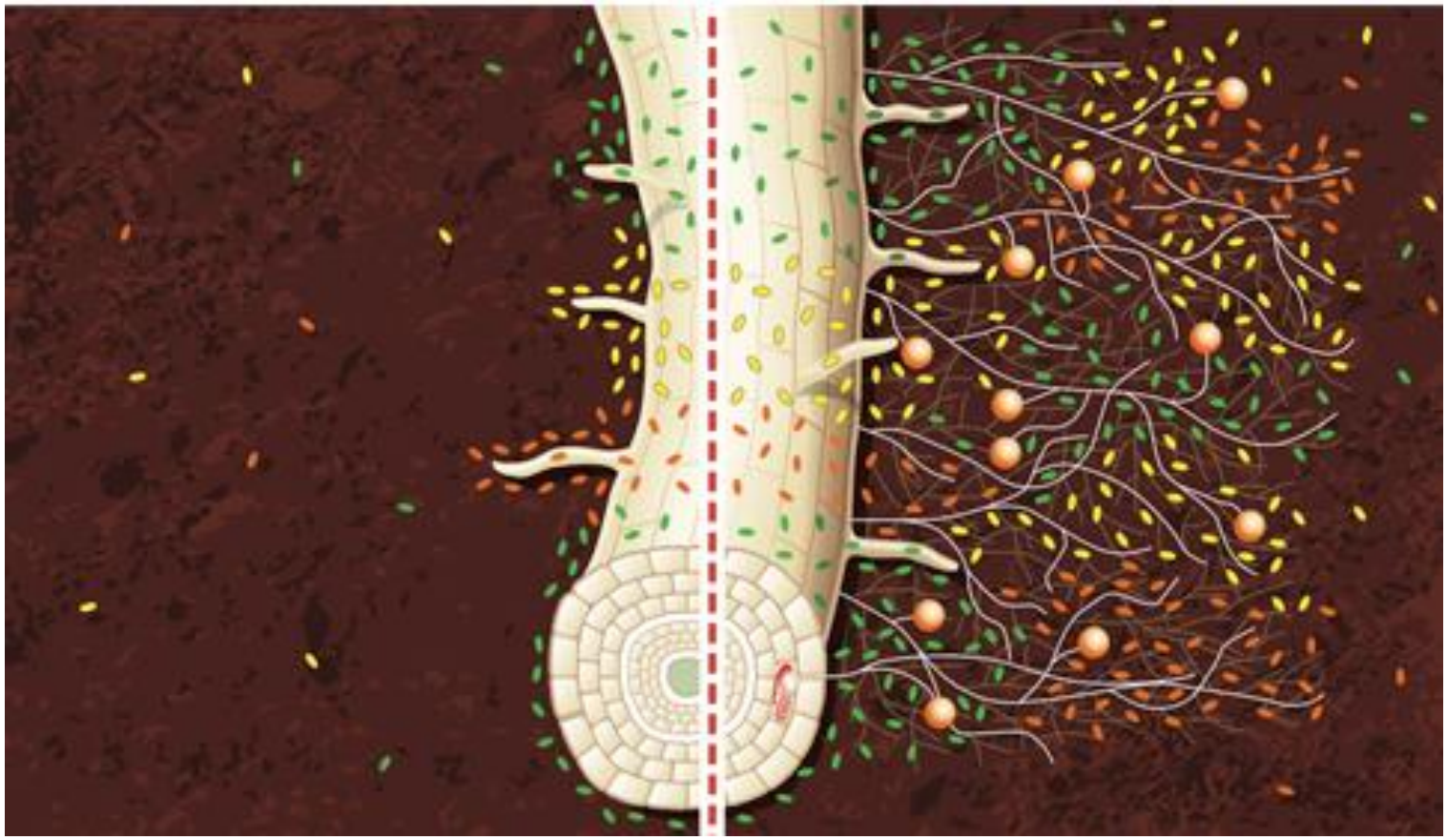
1) **Heterotrophic microorganisms** (using organic nutrients as energy and carbon sources (fungi, protozoa, **bacteria**, animals)

2) **Ototrophic microorganisms** (obtaining their energy from the oxidation of solar energy or inorganic compounds, and carbon from assimilation of CO2)

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

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

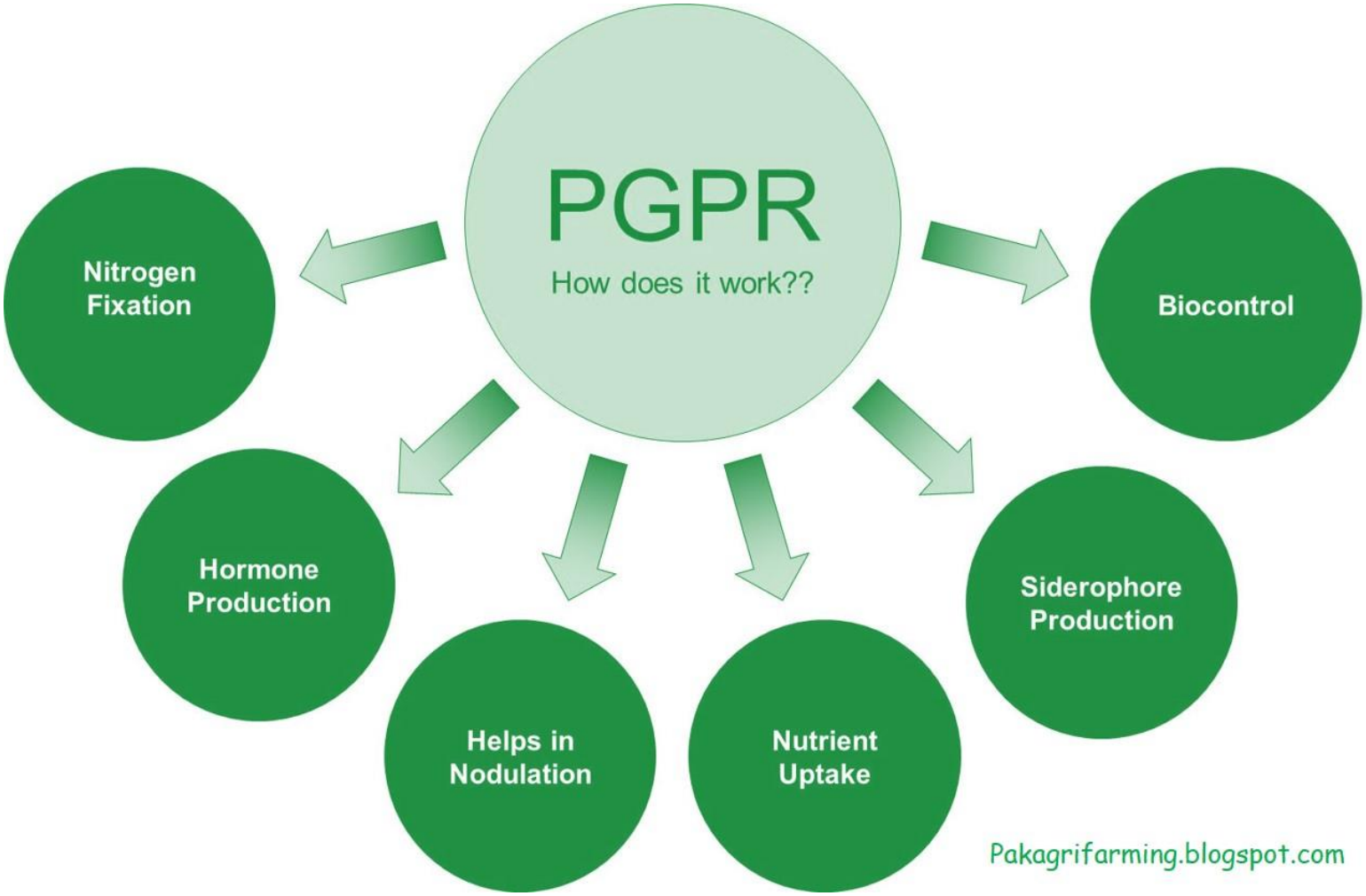
Functionality of soil microorganisms in soil



Non-rhizosphere

Rhizosphere zone + PGPR

Effective soil bacteria (Plant Growth Promoting Bacteria)

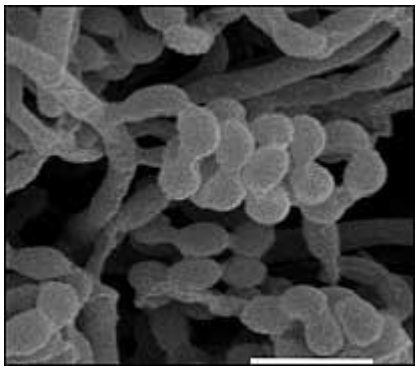


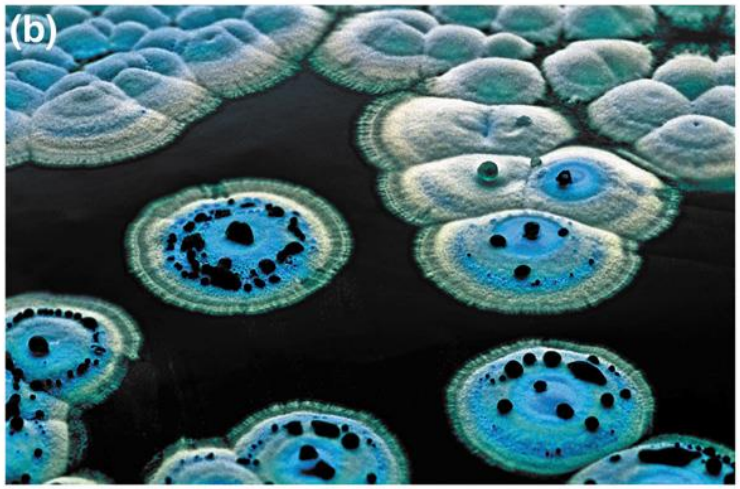
Nodulation of N_2 fixing bacteria

Streptomycetaceae

- Genus of filamentous bacteria of the family Streptomycetaceae (order Actinomycetales) including more than 500 species occurring in soil and water environments.
- Important in the decomposition of organic matter in soil
- Contributing in part to the earthy odour of soil and decaying leaves (SMELL OF RAIN)
- Characterized as gram-positive aerobic bacteria forming a threadlike net called a mycelium that bears chains of spores at maturity.

Streptomyces spp.





S. aureofaciens (chlortetracycline),
S. rimosis (tetracycline),
S. griseus (streptomycin),
S. erythraeus (erythromycin)
S. venezuelae (chloramphenicol).

Streptomycetes

5 different Streptomycetes. All of these bacteria normally live in the soil and produce antibiotics. Some, for example, Streptomyces azureus, give off colored pigments as seen on the plate.

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)

Most fungi, protozoa, all animals and bacteria are heterotrophic

All heterotrophic organisms assimilate small amounts of carbon dioxide and autotrophs whileautotrophs use carbon dioxide as carbon source

Algae, high plants and some bacterial strains are phototrophic

Chemoautotrophy is a type of diet used for some bacterial species that are economically and agriculturally important

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 .

Bakteriler, birçok kaynaktan enerji sağlayan mikroorganizmaların farklı bir grubunu içerirler.

Bazı bakteriler enerjilerinin birden fazla kaynak kullanılarak örneğin, ışık (fotootototrof ya da fotosentetik) yanında indirgenmiş organik (heterotrof) ya da indirgenmiş inorganik bileşiklerden (litotrof ya da kemootototrofik) sağlayabilirler.

Organik kirliliğin biyolojik ayrışımı için esas sorumlu grup heterotrof bakterilerdir. Litotrofik ya da fotosentetik bakteriler toksik metal ya da metalimsilerin dönüşümlerinde önemli olabilirler.

Tüm canlı organizmalar en sonunda, enerji ve elementlerin döngüsü için fotosentetik (ototrofik) ve litotrofik bakterilerle bağımlıdırlar.