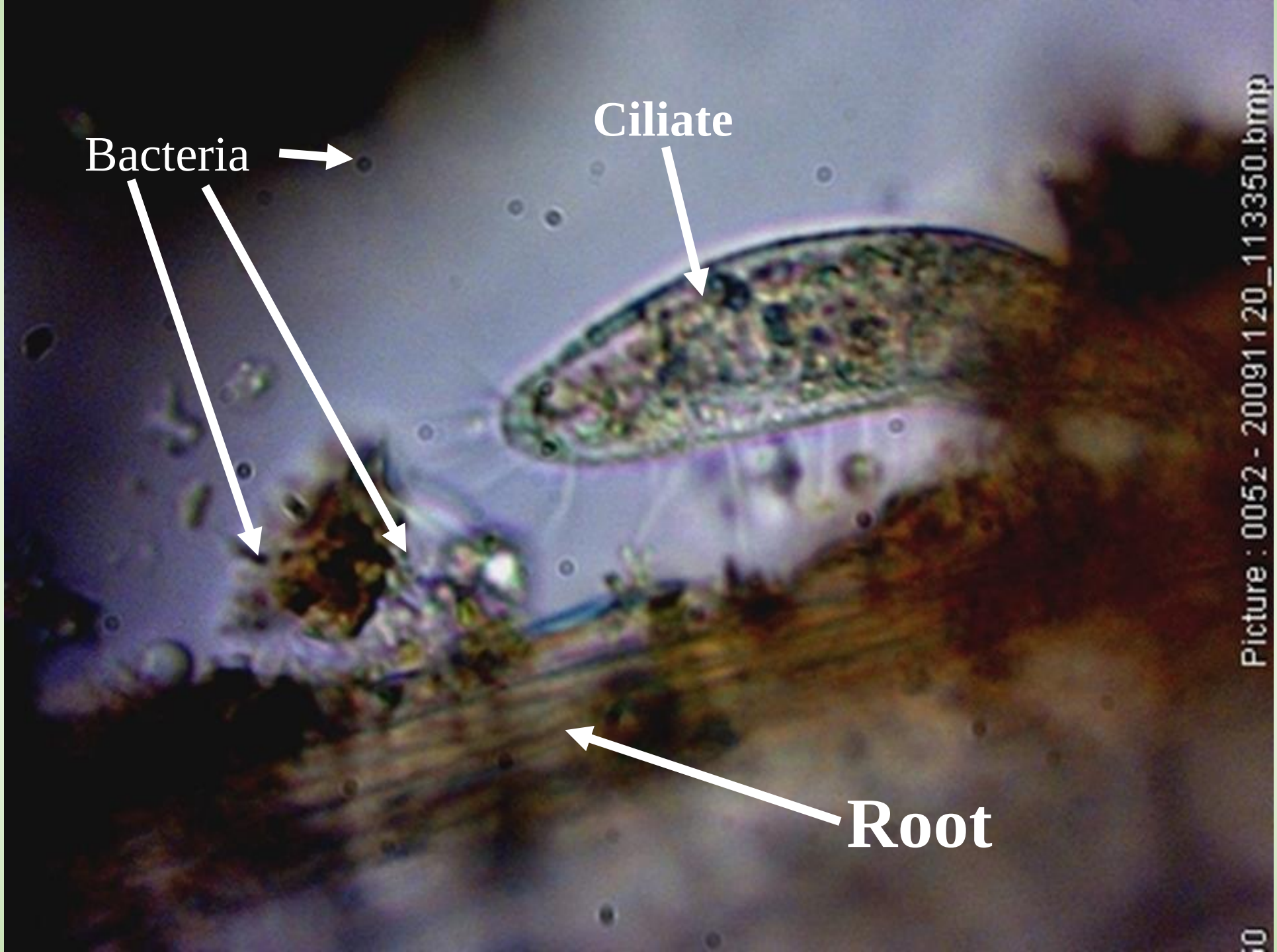
Chapter 4

Soil Food Web Microorganisms

Lecture 17 - Bacteria


Bacteria
Ciliate
Root
Picture : 0052 - 20091120_113350.bmp

Characteristics of Bacteria

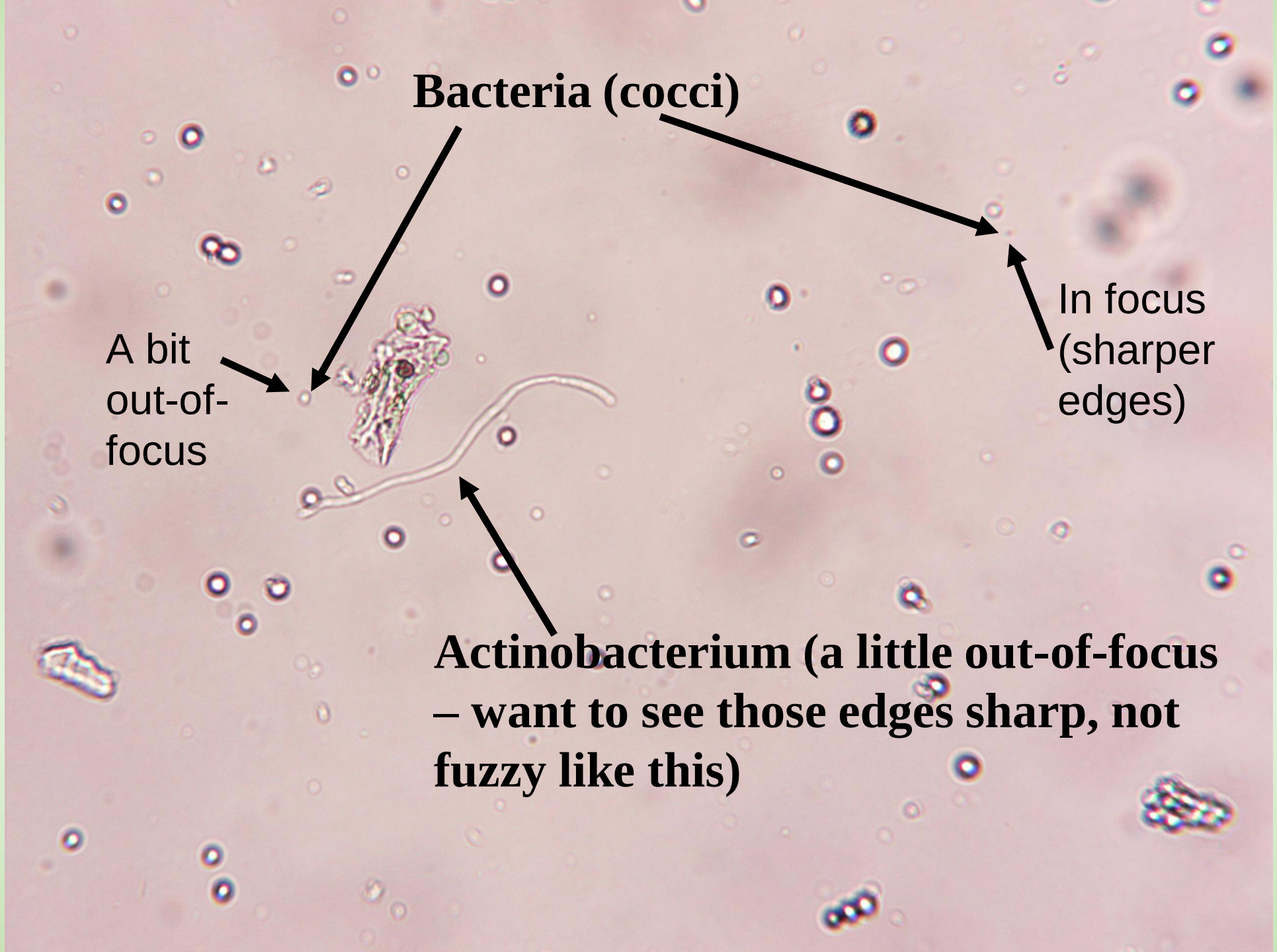
Beneficial Bacteria	Actinobacteria	Disease-causing Bacteria
Round (cocci); Longer than wide (rods);	Filamentous strands	Stiff corkscrews (spirilla); Snake-like (spirochetes), comma shape (vibrio)
Diameter typically 1.0 μm, but can be up to 5 μm	Diameter 1.0 – 1.5 μm	Diameter 1 μm; but length-wise can be 4 to 50 μm long
Can be motile or not motile. Motility usually require 1 to 20 flagella	Clear, colorless; may be able to see chain of rods or cocci inside the filaments	Clear, colorless. Motility occurs by flagella.
DNA, mRNA, tRNA, sequencing used to differentiate species, but not yet tied to function	Many species do better in reduced oxygen conditions, although aerobic species exist	Most are facultative anaerobes, requiring reduced oxygen between 4 to 6 ppm
Dormant Stages: Spores, protective glue layers	Dormant stages: Spores, reduced activity, protective layers	Dormant spores

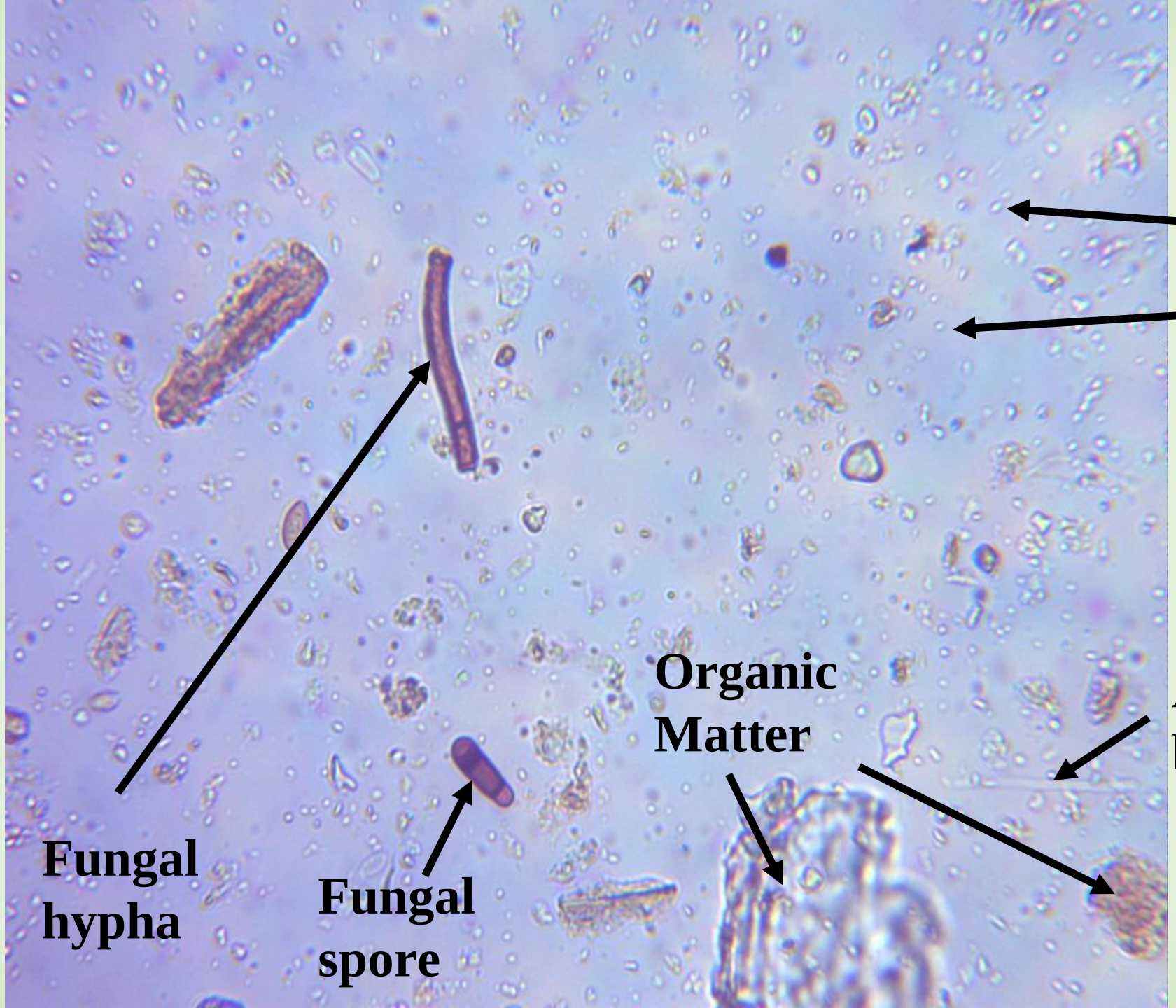
Define Aerobic, Facultative and Anaerobic

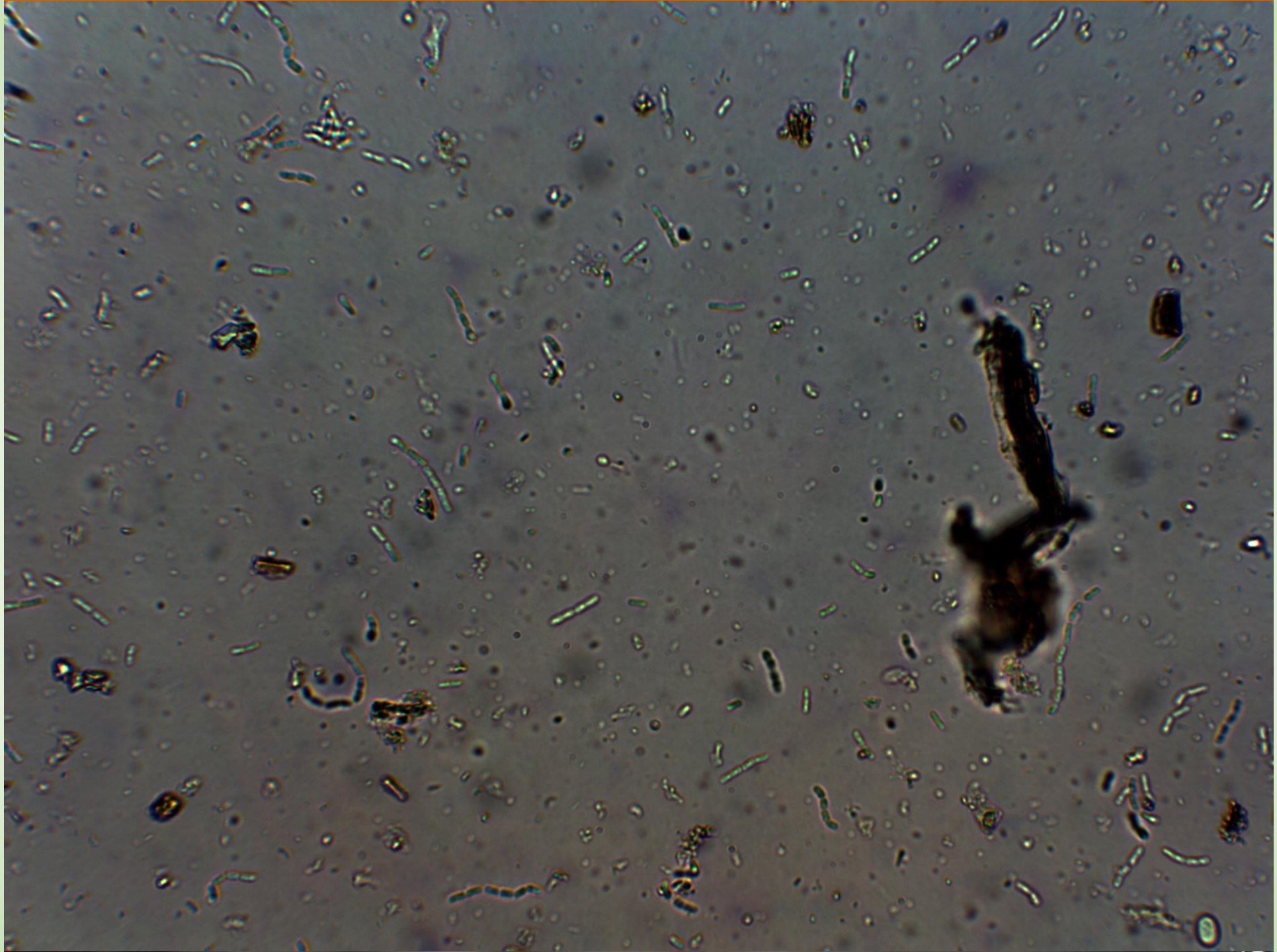
Aerobic: Energy-efficient decomposition enzymes. Enzymes require oxygen above 6 micrograms/gram

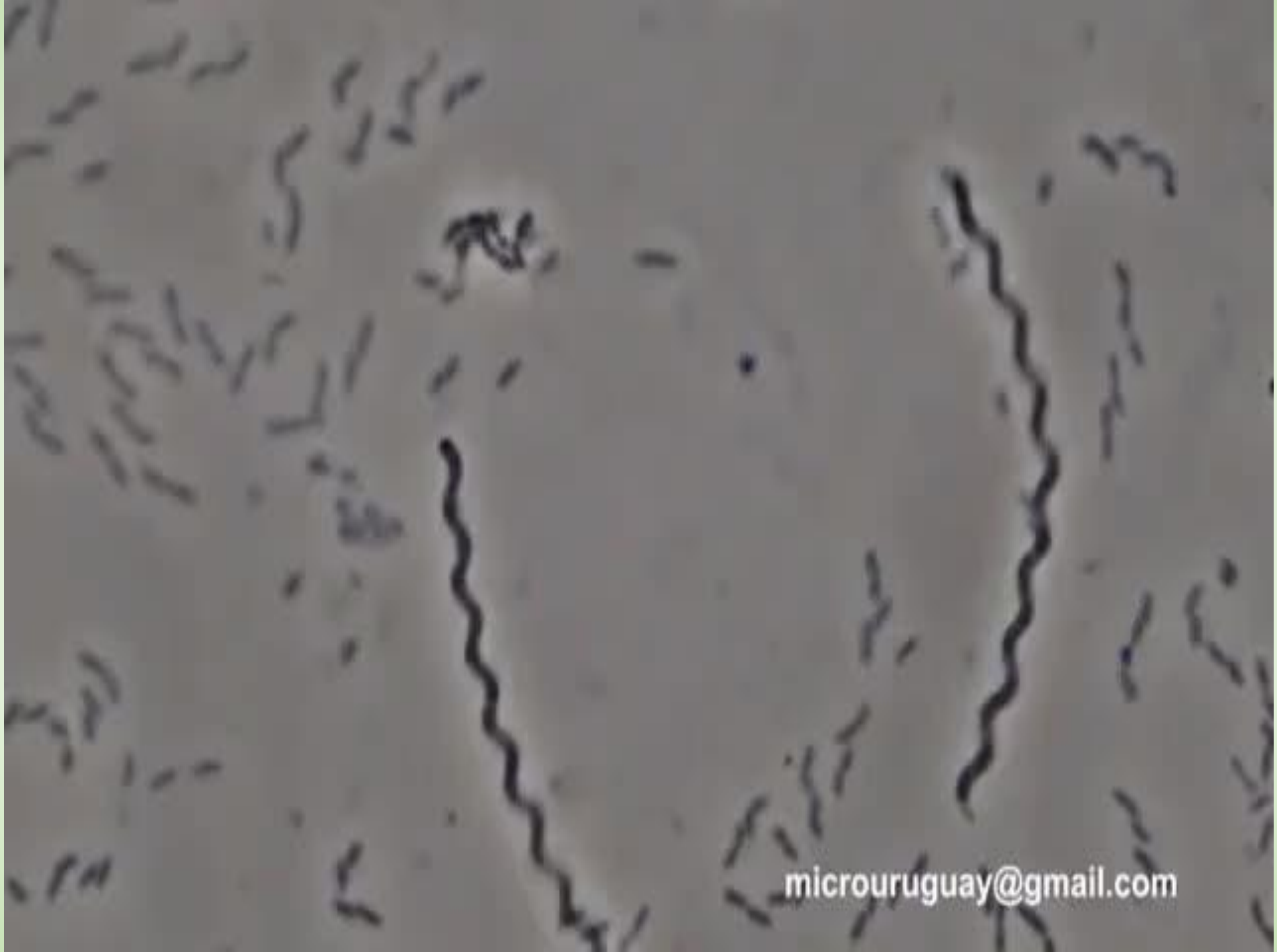
Facultative: Not energy-efficient, requires a set of anaerobic and another set of aerobic enzymes to be able to exploit shifting oxygen conditions

Anaerobic: Energy-efficient decomposition enzymes. Enzymes require oxygen below 4 micrograms/gram to function


Bacteria (cocci)
A bit out-of-focus
In focus (sharper edges)
Actinobacterium (a little out-of-focus – want to see those edges sharp, not fuzzy like this)


Bacteria
rod
coccus
Organic
Matter
Actino-
bacterium
Fungal
hypha
Fungal
spore

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Structure in soil; Holding nutrients; Decomposition; Bioremediation

Aerobic bacteria

- Make alkaline glues that hold sand, silt, clay and organic matter together.
- Build the smallest building block of soil, i.e., the “bricks” to build soil structure.
- Make enzymes to decompose organic matter or to pull mineral nutrients from sand, silt, clay and organic matter.
- Some enzymes can insert heavy metals into carbon structures and others can pull toxic chemicals apart.

Bacterial Function	Explanation
Reproduction	When bacteria accumulate enough nutrients and energy, the cell will undergo binary fission, i.e. splitting into two separate cells. In perfect conditions (temperature, moisture, food resources, etc) bacteria can reproduce every 20 minutes. If conditions aren't perfect, bacterial growth will slow. If conditions are not appropriate, bacteria can "hang out", go dormant or die.
Decomposition	Bacteria consume structurally simple foods (see Lecture 2) with C:N ratios from 5:1 to 60:1. Generally, bacteria produce only one set of enzymes at a time which attack the one type of bond, releasing simple foods that bacteria are best at grabbing. Typically bacterial enzymes are more efficient and competitive then enzymes made by other groups of organisms. Thus when simple food resources are present, then bacteria rule. However, when food is abundant, bacterial growth will be rapid, and oxygen consumed very rapidly, causing anaerobic conditions even when air is being bubbled into a brew. Aerobic organisms die or go dormant and anaerobic gases, acids and alcohol will harm plants.

Bacterial Function	Explanation
C:N	C:N of bacteria are in the range 5:1 – 10:1. Thus, when bacteria consume their typical foods (C:N 30:1), bacteria need to concentrate N by releasing 25 carbons. Most of that carbon is released as CO_2, with a few slightly complex organic materials released as waste products.
Predation	Bacteria are consumed mainly by protozoa, bacterial-feeding nematodes, earthworms and possibly micro-arthropods. The more difficult-to-decompose parts, i.e. cell walls and membranes, will be beyond the ability of these predators to decompose. Other bacteria and fungi may then use these materials as food, or condense them into structurally more complex organic forms.
Dormancy	Bacteria produce spores or dormant stages that can resist most environmental disturbances. Bacteria are quick to go into dormant stages, requiring one to several hours to recognize extreme conditions, shut down metabolic activity and form a spore. Spores can survive for several hundred years, although extreme fluctuations in conditions result in poorer survival rates.

Nitrogen-fixers: Mutualists and Free-living

Nitrogen-fixing bacteria come in two forms:

1.Rhizobium - (shape: coccobacilli or small rounded bacilli) who form nodules on roots of legumes.

2.Free-living Nitrogen-fixing bacteria - (typically look like actinobacteria but are no longer classified with that group)

Both require an anaerobic center to the colony of bacteria where the N-fixation gene is expressed. Thus, the bacteria has to get high concentrations of sugar to do the work.

Nitrifiers - Steps 6 & 7 (Nitrogen Cycle)

Nitrifying bacteria live in all sorts of conditions.

- **However**, alkaline conditions are required to make the enzymes that will remove the hydrogen ions from the nitrogen molecule (ammonium or NH_4) and replace them with two oxygens and make Nitrite (NO_2). That means aerobic bacterial-dominated soil with good structure.
- **The second step** in nitrification requires one more oxygen to be added to convert nitrite to nitrate (NO_3). Both steps remove oxygen from the environment, so these bacteria are often considered to be facultative organisms.