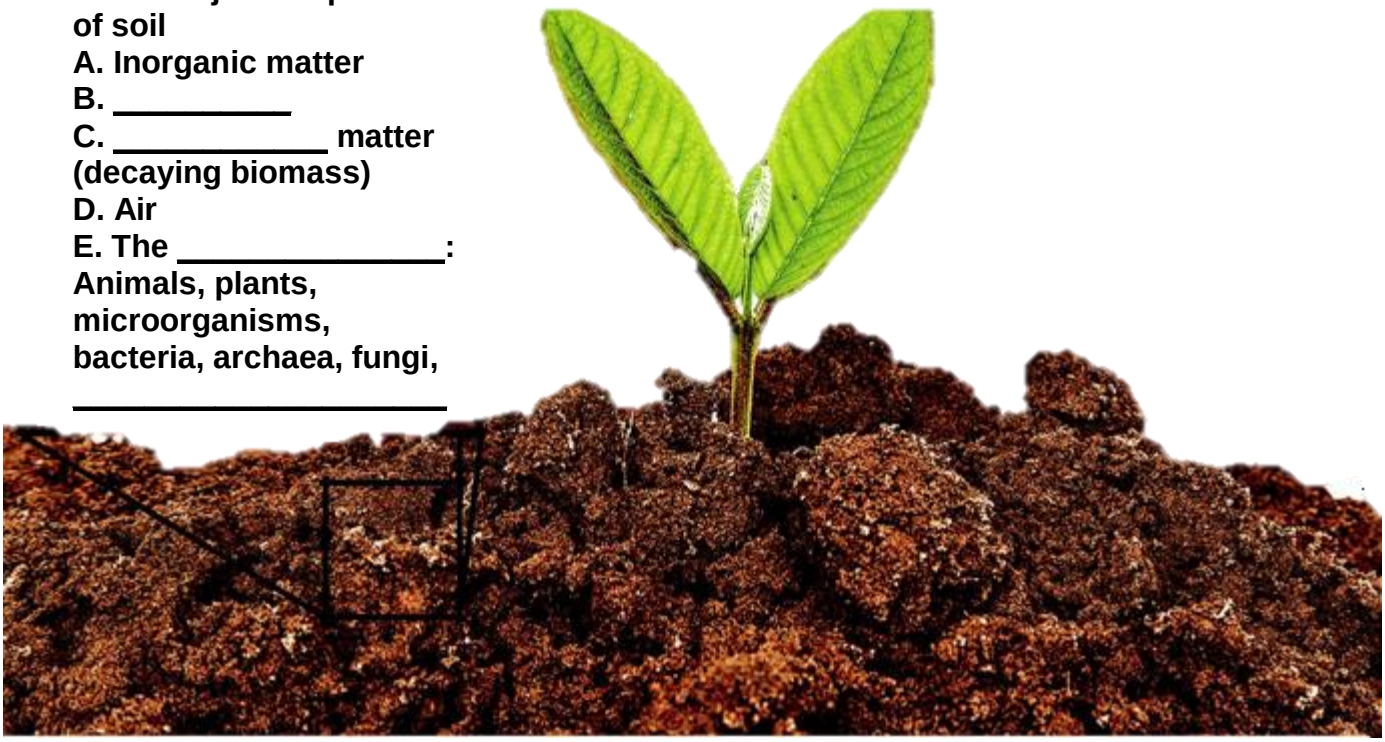
Lecture 23

The 5 major components of soil
A. Inorganic matter
B. _____
C. _____ matter (decaying biomass)
D. Air
E. The _____: Animals, plants, microorganisms, bacteria, archaea, fungi, _____

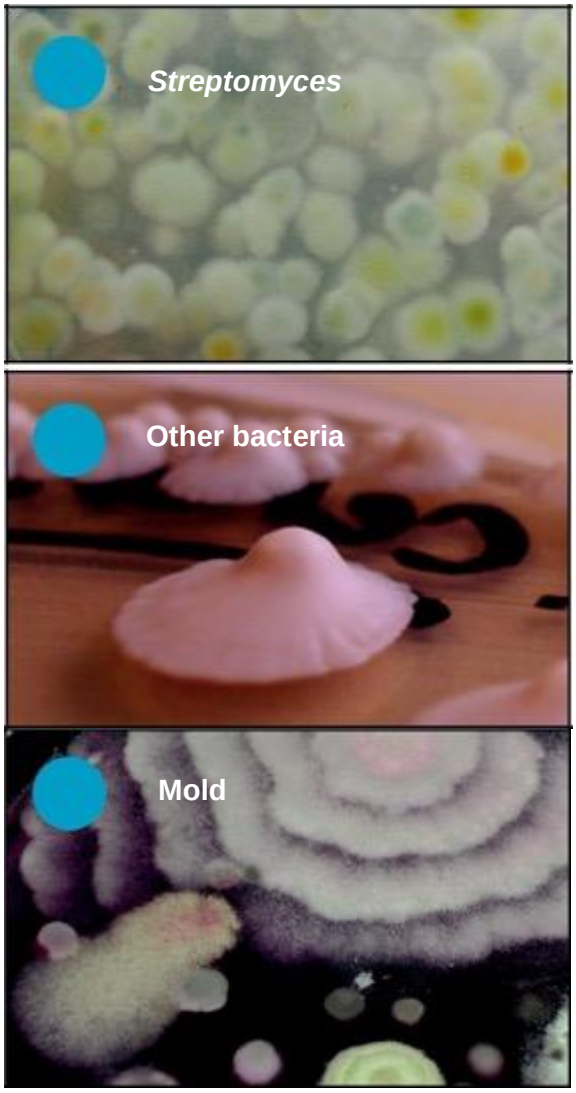


I. Soil microorganisms are important in:
- A. Biogeochemical cycles
  - 1. They _____, and _____, such as _____, and sulfur. Ecosystem would collapse without soil microorganisms _____.
- B. Biopesticides
  - 1. Proteins produced by some bacteria have been used to _____. A toxin produced by *Bacillus thurigiensis* is so useful that the gene that encodes for the toxin was isolated from the bacteria and _____. These genetically transformed _____ and _____ plants are now able to produce the _____ and protect themselves against damage by _____, such as moths and worms. *B. thuringiensis* has also been used to control _____ and _____.
- C. Sources of antibiotics
  - **Note:** You are already familiar with the use of soil microorganisms as sources of several antibiotics!

II. Enumeration
- A. The accurate enumeration of microorganisms in the soil is difficult because culture methods reveal only those few microorganisms that can grow in the _____. Direct microscopic examination of soil is also difficult and would not reveal virus particles or differentiate _____.

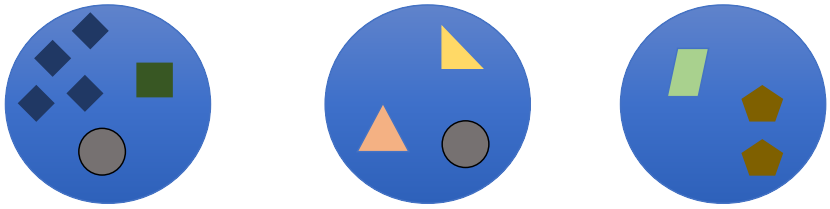
B. We will attempt to isolate three groups of soil microorganisms:

1. _____
   a. _____ in the group *Actinomycetes*.
   b. _____ with hyphae, conidia and spores
   c. Produce _____ which gives the soil an earthy odor
   d. Source of several _____ (e.g. *Streptomyces griseus* produces streptomycin)
   e. _____ medium is used for enrichment
2. _____
   a. _____ of soil microbes have been cultured and characterized.[1]
   b. Generally, there are more _____ bacteria (e.g. *Agrobacterium*, *Cellulomonas*, and *Pseudomonas*), but certainly Gram-positives, such as _____ _____ are present.
   c. Contamination may introduce _____ _____ but, generally, these are rapidly eliminated.
   d. _____ is used for enrichment
3. _____
   a. Abundant in _____ soils
   b. _____ that secrete enzymes to degrade polysaccharides, such as lignin and cellulose
   c. Free-living species are more easily cultured than are those _____ species.
   d. _____ is used for enrichment (a high carbohydrate content favors mold growth and streptomycin and rose bengal dye select against bacteria)

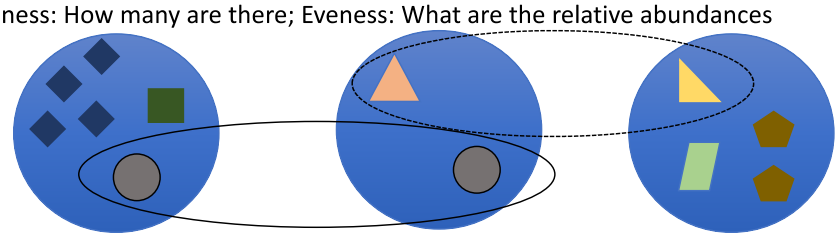


C. Microbial Diversity

1. Because so many organisms are _____ studies are shift from culture based methods to _____ to determine microbial community structures.
2. Sequencing methods often use the _____ to determine the all of the various bacterial organisms in a sample.
   i. Sequencing methods often do not refer to _____ but rather _____ that are unique genetic sequences.
3. Microbial Diversity studies uses terms common in _____.
   i. _____: A comparison of community structures. Often includes measures of _____ and _____.
   ii. _____: A comparison of species compositions between different environments.



Alpha Diversity:
Richness: How many are there; Eveness: What are the relative abundances

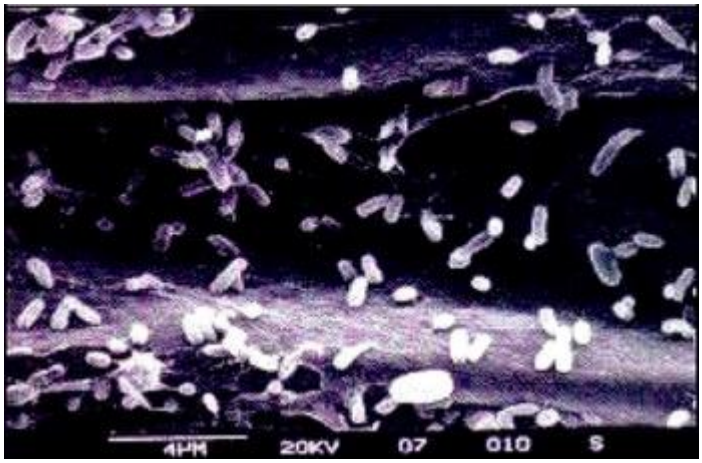


Beta diversity: How similar are the species in the two different environments

1. Statistic from Prescott, Harley, and Knein's Microbiology (2008)

D. _____

1. The plant cover in the soil is an important factor in determining the types and numbers of microorganisms in that soil. _____ is the zone of soil that adheres to plant roots and is enriched in nutrients. Plant root exudates and senescent parts of plant excrete organic molecules, including _____ _____, and _____, and can be an important source of nutrients for soil microorganisms. At the rhizosphere, there are _____ than in the surrounding soil. The rhizosphere also enhances _____.

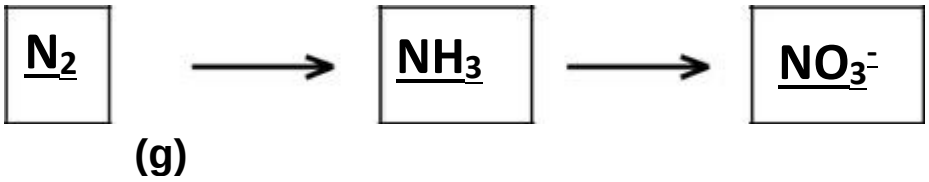


Scanning electron micrograph demonstrating the colonization of wheat roots by strains of *Azospirillium*. Photo courtesy of Dr. Wanjiru Mwatha

III. Nitrogen fixation

A. The _____ is one of the most important biogeochemical cycles with which microorganisms are involved.

1. Nitrogen is an essential building block for all amino acids and many other macromolecules. Unfortunately, most nitrogen exists as N_2 gas, which is not usable by most organisms. Thus, N_2 must be converted to more usable forms of nitrogen, such as _____ and _____. The conversion of $N_{2(g)}$ to NH_3 is called _____.



2. Nitrogen fixation by prokaryotes is responsible for transforming _____ of naturally occurring usable nitrogen forms. (See the diagram of the nitrogen cycle, next page.)

3. Common nitrogen-fixing bacteria found in soils include the _____ and the _____-fixing bacteria. The free-living, nitrogen-fixing bacteria include _____, and cyanobacteria.

a. _____

i. Azotobacter is the primary species that will be selected in/on nitrogen-free media. It is a _____ _____ nitrogen fixer.

ii. Only organisms that can fix $N_{2(g)}$ will grow on/in nitrogen-free media.

iii. Mannitol is the energy source.

iv. Molybdenum ions are included as cofactors to the nitrogenase enzyme.

b. Rhizobium

i. The symbiotic nitrogen-fixing bacteria in soils include the _____, which form a symbiotic relationship with _____ in what is commonly referred to as _____ _____.

ii. The rhizobia complex includes *Rhizobium*, *Sinorhizobium*, *Azorhizobium*, and *Bradyrhizobium*, which are common in soil and are able to fix N_2 _____of legumes. Nitrogen-fixing root nodule bacteria, such as *Bradyrhizobium*, present inside the nodule provide valuable _____ to the host plant, which promotes plant growth. The host plant provides _____ to the bacteria.

Note: Great thanks to Dr. Wanjiru Mwatha for providing expertise for this lecture.

How Does It Work?
The Nitrogen Cycle