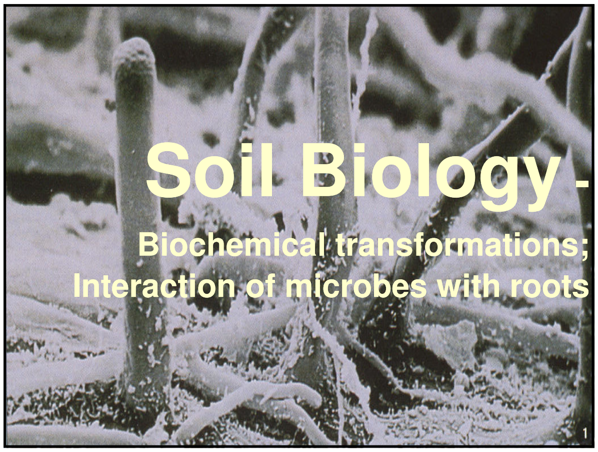
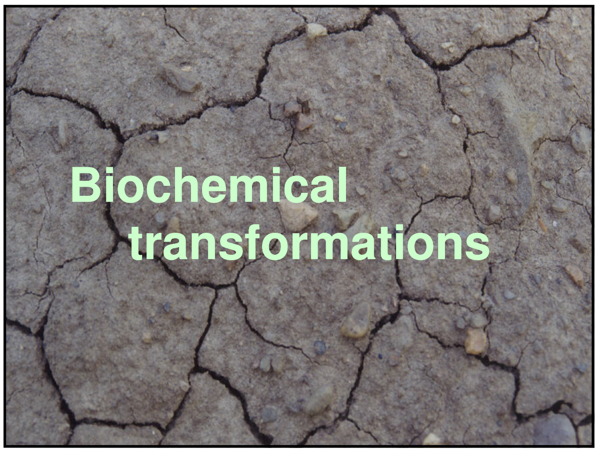
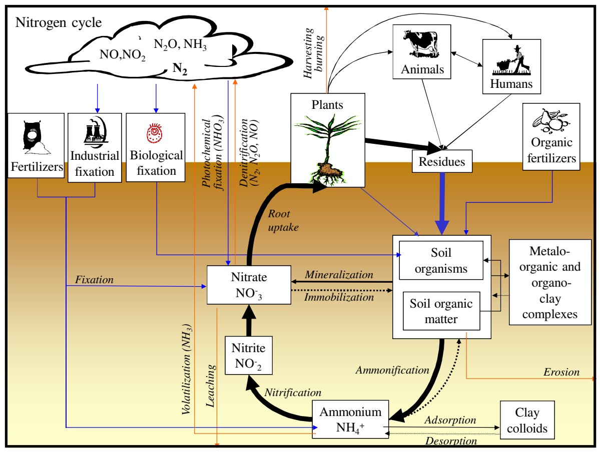


Lecture outline

- Biochemical transformations
  - Example #1: Biological N fixation
  - Example #2: Mineralization / Immobilization
  - Example #3: Denitrification
- Microbe interactions with plant roots
- Plant nutrients





The **sources** of soil N are:

- Biological fixation of N_2
- Deposition of N (NO_3^- and NH_4^+) compounds from the atmosphere by precipitation
- Fertilizers
- Plant residues
- Manure

Addition of organic matter

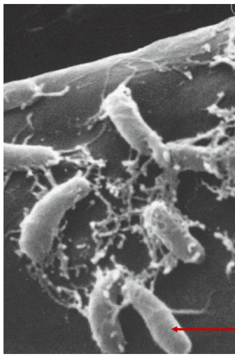
Processes that are mediated by soil organisms

The **losses** of soil N occur through:

- Plant removal
- Leaching
- Gaseous losses (denitrification and NH_3 volatilization)
- Erosion (wind and water)
- Ammonium fixation (clay complexes)

Processes that are mediated by soil organisms

Example #1 - Biological fixation of N



Biological conversion of N_2 to ammonia (NH_3) done by some bacteria, cyanobacteria, and actinomycetes

N fixing bacteria generate cellulose as they attach to the root hair

Example #1 – cont.

Biological N fixation

$$\overset{0}{N_2} + 8H^+ + 8e^- \xrightarrow[(Fe,Mo)]{Nitrogenase} 2\overset{3-}{N}H_3 + H_2$$

Estimated amount of N fixation in terrestrial ecosystems is ~139 million t N per year

Example #1 – cont.

Typical levels of biological N fixation

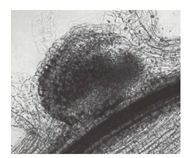
Crop or plant	Associated organism	Typical level of N fixation (kgN/ha/yr)
Symbiotic		
Legumes (nodulated)		
Alfalfa	Bacteria (*Rhizobium*)	150 – 250
Clover	Bacteria (*Rhizobium*)	100 – 150
Vetch	Bacteria (*Rhizobium*)	50 –150
Non-legumes (nodulated)		
Alders (*Alnus sp.*)	Actinomycetes (*Frankia*)	50 – 150
Non-legumes (non-nodulated)		
Bahia grass	Bacteria (*Azotobacter*)	5 – 30
Non-symbiotic		
Not involved with plants	Bacteria (*Azotobacter, Clostridium*)	5 - 20

Example #1 – cont.

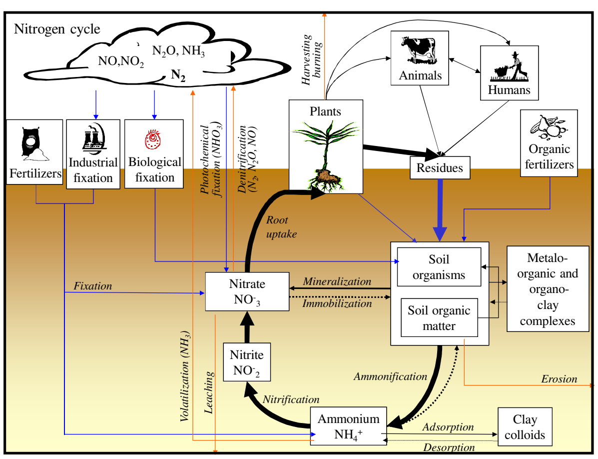
Symbiotic N fixers with legumes (nodulated)

Soybean nodules are spherical

Alfalfa nodules may grow multiple lobes



This newly emerged white clover root nodules will soon begin fixing N



Example #2

Mineralization / Immobilization

$$Organic\ N \underset{Immobilization}{\overset{Mineralization}{\rightleftarrows}} Inorganic\ N$$

Example #2

Mineralization:

- Aminization

$$Protein \longrightarrow R-NH_2 + CO_2 + E\uparrow + other\ products$$

- Ammonification

$$R-NH_2 + H_2O \longrightarrow NH_3 + R-OH + E\uparrow$$

$$NH_3 + H_2O \rightleftarrows NH_4^+ + OH^-$$

- Nitrification

$$2NH_4^+ + 3O_2 \longrightarrow 2NO_2^- + 2H_2O + 4H^+ + E\uparrow$$

Nitrosomonas sp.

$$2NO_2^- + O_2 \longrightarrow 2NO_3^- + E\uparrow$$

Nitrobacter sp.

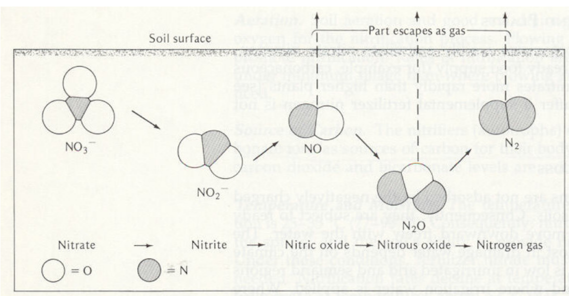
Example #2

Mineralization and microbes involved

- **Aminization** → heterotrophs (bacteria and fungi)
- **Ammonification** → heterotrophs (bacteria, actynomicetes, fungi)
- **Nitrification** → chemo-autotrophic bacteria

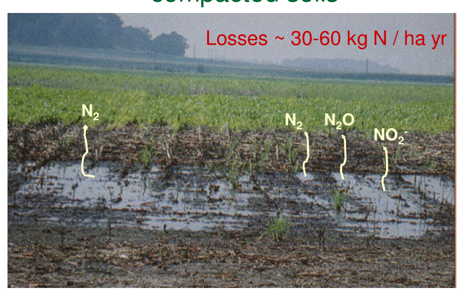
Example #3

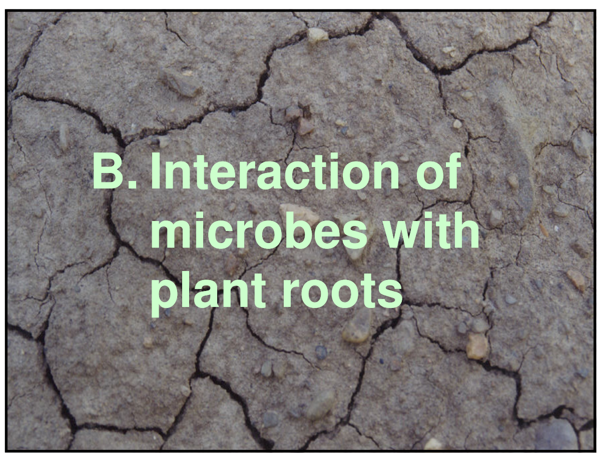
Denitrification – biological reduction of NO_3^- to gaseous compounds



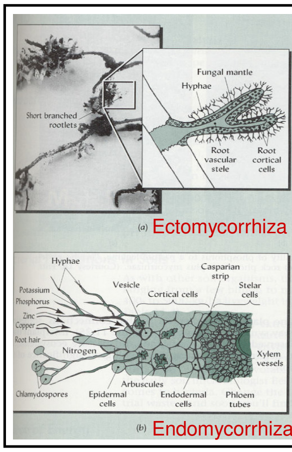
Example #3

Denitrification bacteria live under anaerobic conditions, such as those in saturated, compacted soils



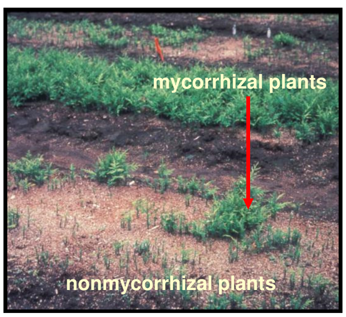


Mycorrhizae is a mutually beneficial, symbiotic association between plants and fungi, where fungus provides nutrients, while plant provides sugars from photosynthesis



Types of mycorrhizae:

- Ectomycorrhiza with tree sp. except our 'cedars'
- Ericoid mycorrhiza with Ericaceae (blueberry, salal)
- Arbuscular mycorrhiza with most other plants



Photos: Shannon Berch

Arbuscular mycorrhiza

arbuscules

Photos: Shannon Berch

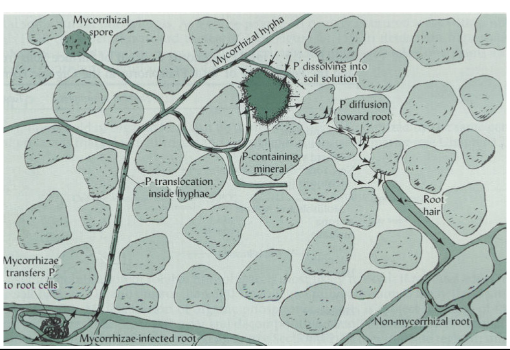
Ericoid mycorrhiza

colonized cells

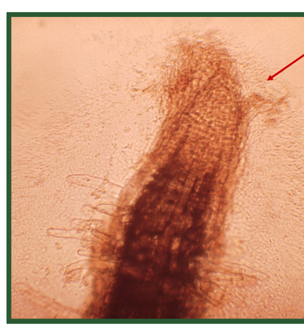
uncolonized cell

salal on cutblock

Role of mycorrhizal hyphae in the movement of phosphate ions to plant roots



Rhizosphere effects



Dead cells and exudates released from a corn root

Rhizosphere is the space near roots where microbes (e.g. bacteria) feed on dead root cells and exudates (sugars, proteins)

Jan/Feb 2011 issue of Canadian Geographic

How Avatar got it right: "Mother trees" use fungal systems to feed the forest – article featuring work of Dr. Suzanne Simard (Faculty of Forestry)

http://www.canadiangeographic.ca/magazine/jf11/fung al_systems.asp