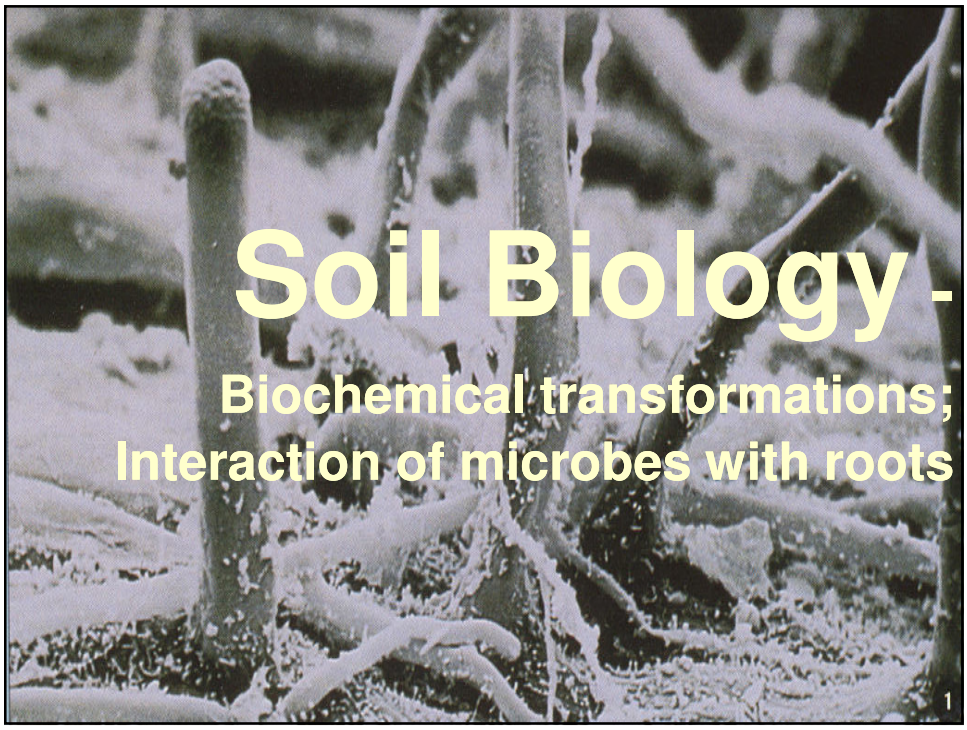

APBI200
SOIL BIOLOGY & NUTRIENTS


Soil Biology -
Biochemical transformations;
Interaction of microbes with roots
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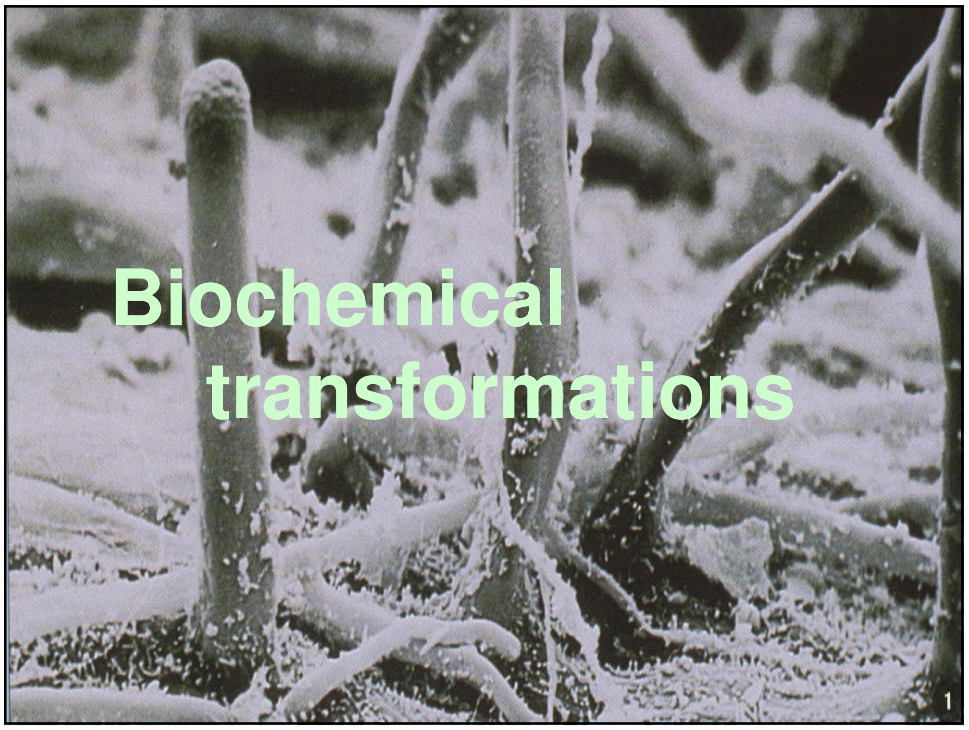
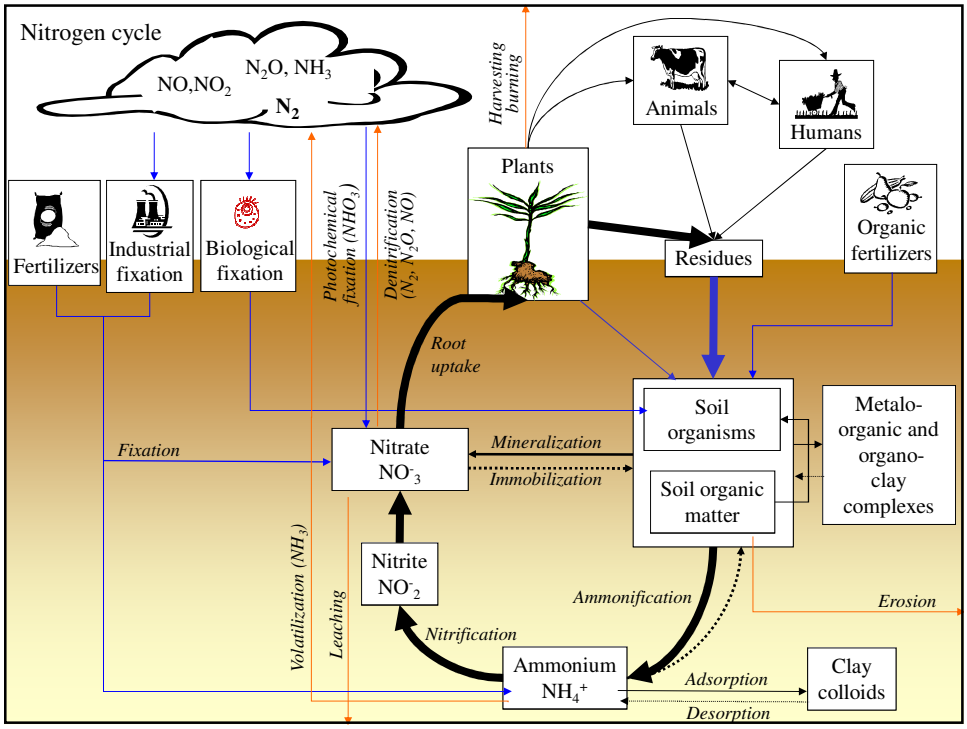
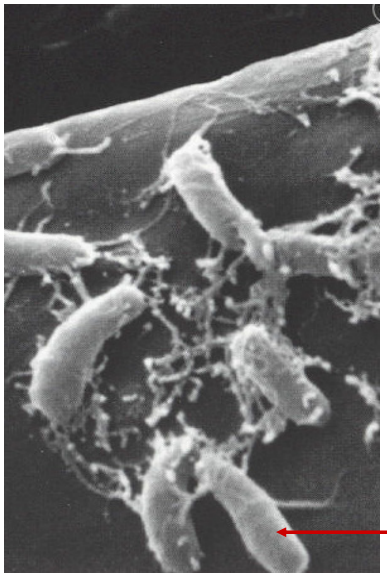
Lecture outline

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





Example #1 - Biological fixation of N



Biological conversion of N_2 gas to ammonia (NH_3) 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

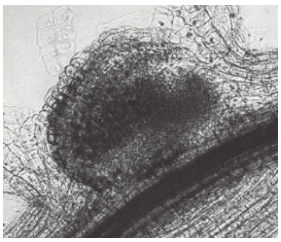
Crop or plant	Associated organism	Typical level of N fixation (kgN/ha/yr)
Symbiotic		
Legumes (nodulated)		
Alfalfa	Bacteria (*Rhizobium*)	150 – 250
Clover	Bacteria (*Rhizobium*)	100 – 150
Vetch	Bacteria (*Rhizobium*)	50 –150
Non-legumes (nodulated)		
Alders (*Alnus sp.*)	Actinomycetes (*Frankia*)	50 – 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

$$Organic\ N \underset{\text{Immobilization}}{\overset{Mineralization}{\rightleftharpoons}} Inorganic\ N$$

Example #2

Mineralization:

- Aminization

$$\mathrm{Pr}\,otein \longrightarrow R - NH_2 + CO_2 + E \uparrow + other\ products$$

- Ammonification

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

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

- Nitrification

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

Nitrosomonas sp. & Archaea

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

Nitrobacter sp.

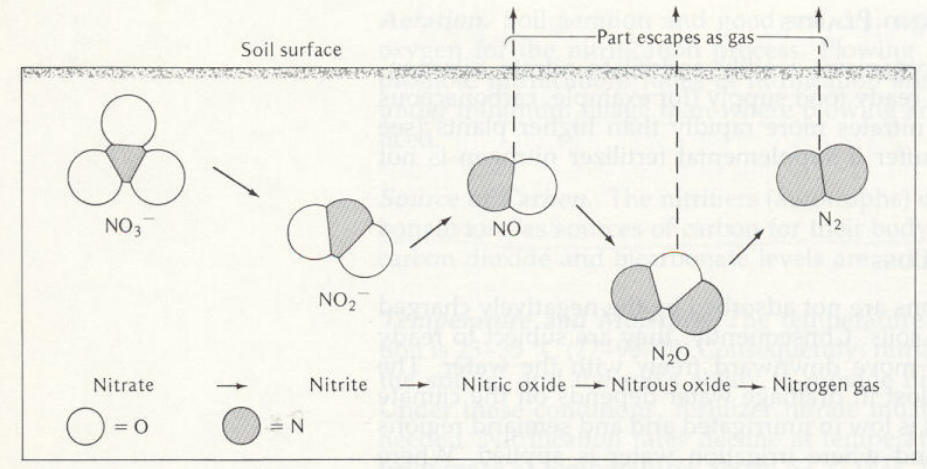
Example #2

Mineralization and microbes involved

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

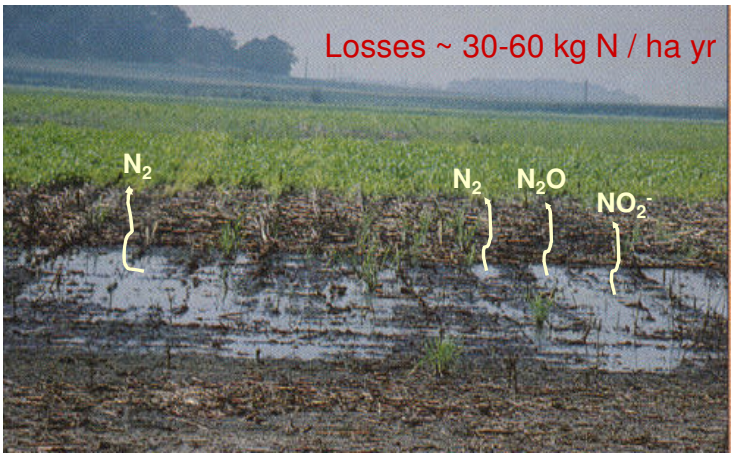
Example #3

Denitrification – biological reduction of NO_3^- to gaseous compounds

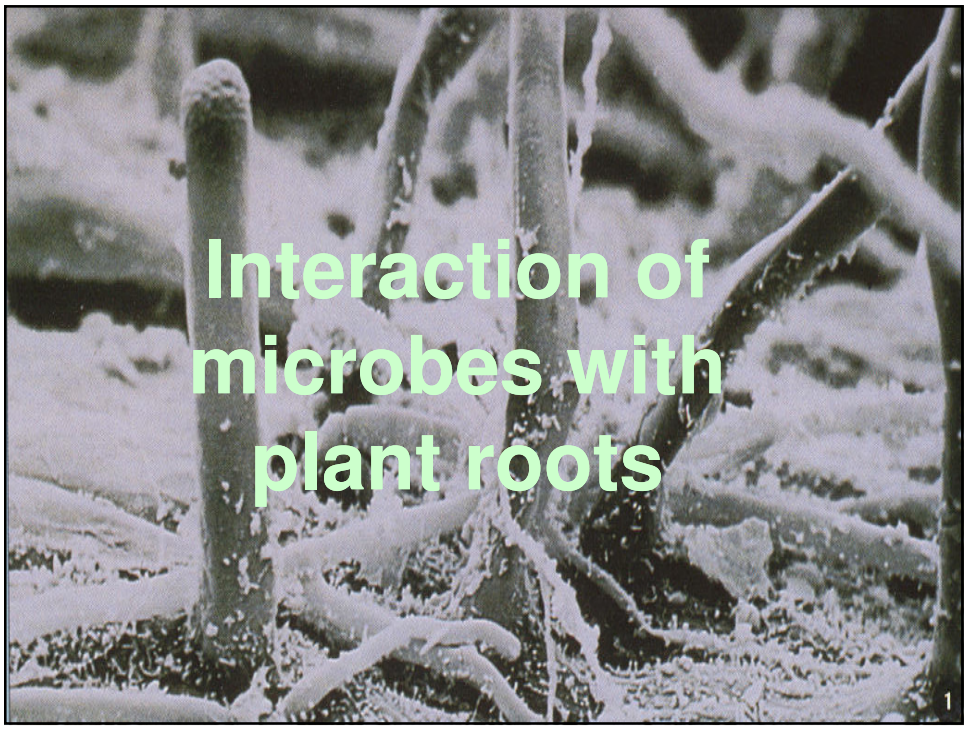


Example #3

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




Example #3
Riley Park, Vancouver
(photo: Maja Krzic)


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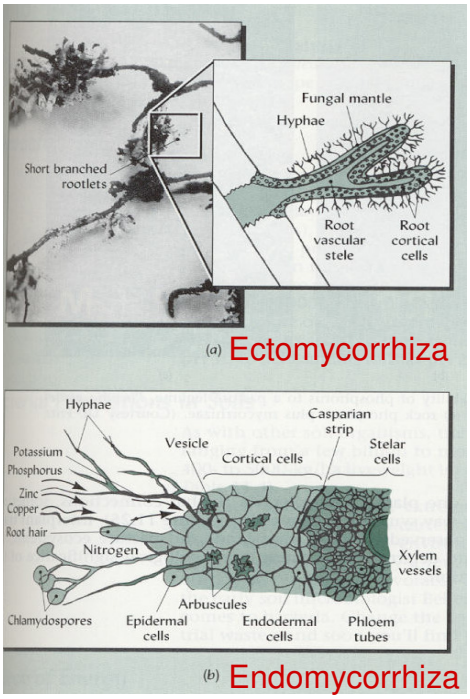
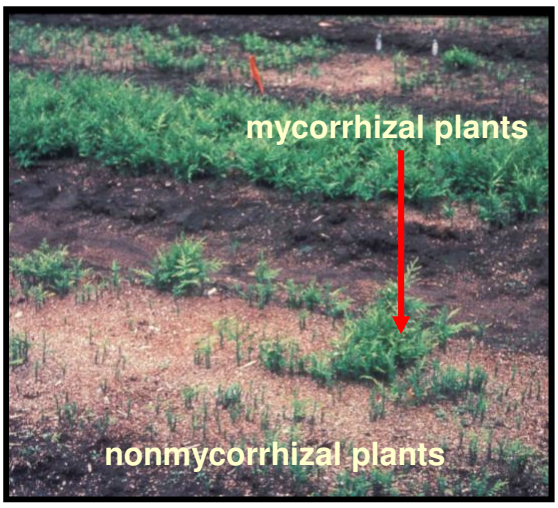
Mycorrhizae is a mutually beneficial, symbiotic association between plants and fungi, where fungus provides nutrients, while plant provides sugars from photosynthesis



Types of mycorrhizae:

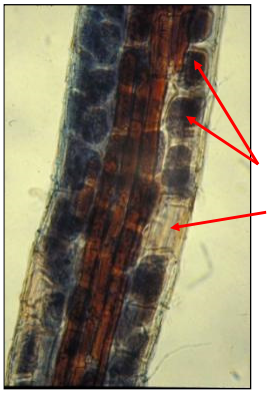
- Ectomycorrhiza with tree sp. except our 'cedars'
- Ericoid mycorrhiza with Ericaceae (blueberry, salal)
- Arbuscular mycorrhiza with most other plants



Photos: Shannon Berch

Arbuscular mycorrhiza

arbuscules



colonized cells

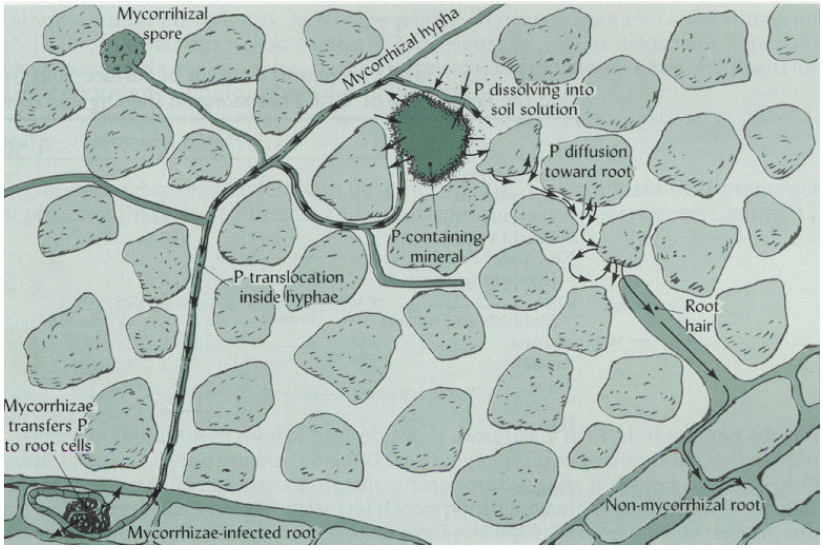
uncolonized cell

Photos: Shannon Berch

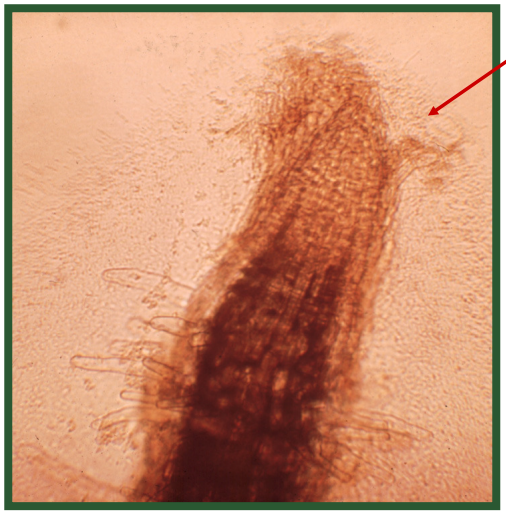
Ericoid mycorrhiza

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/fungal_systems.asp