

Lecture 10

The Nitrogen (N) Cycle

- Atmosphere is ca. 78 % N_2 but most is unavailable to living things because ...
- N is important because ...
- Microbial processes are important in the steps of the N cycle.

The nitrogen cycle has 5 basic steps

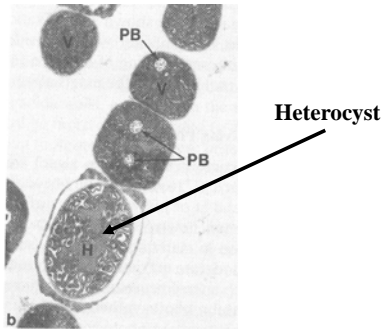
1) Nitrogen Fixation: $N_2 \Rightarrow NH_3$

Root Nodules on a Legume



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Heterocysts in *Anabaena*

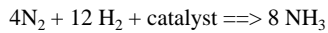


Humans Fix Nitrogen Too !



Fritz Haber

The Haber Process



at 500°C & several hundred atmospheres of pressure



2) Ammonification: organic N => NH₃

3) Nitrification: NH₃ => NO₂⁻ => NO₃⁻

2-step process - each step by different bacteria.

Step 1: oxidation of ammonia (NH₃) to nitrite (NO₂⁻) by _____

Step 2: oxidation of nitrite (NO₂⁻) to nitrate (NO₃⁻) by _____

Both steps couple E-releasing oxidations to fixation of carbon - chemoautotrophs.

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If plants are called photoautotrophs, what would you call *Nitrosomonas*?

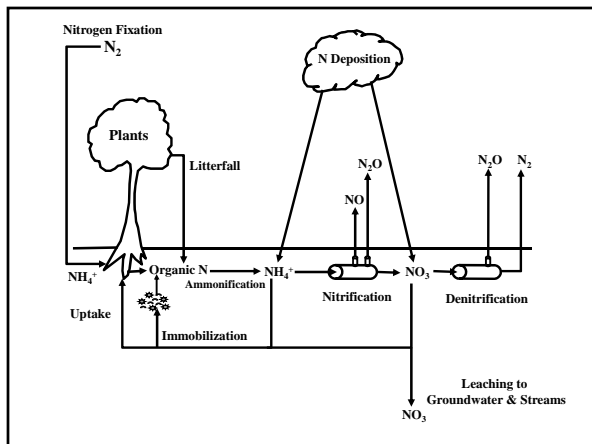
Would it help if you knew that

photo means they get E from light

auto means they get C from inorganic sources

4) Nitrogen Assimilation: $\text{NH}_3 \Rightarrow$ organic N
 $\text{NO}_3^- \Rightarrow$ organic N

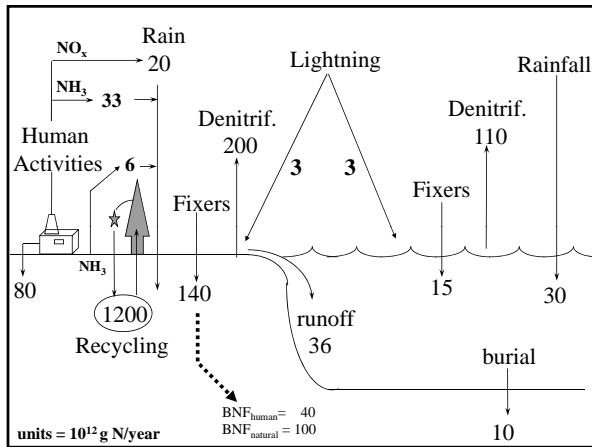
5) Denitrification: NO_3^- or $\text{NO}_2^- \Rightarrow \text{N}_2$ or N_2O

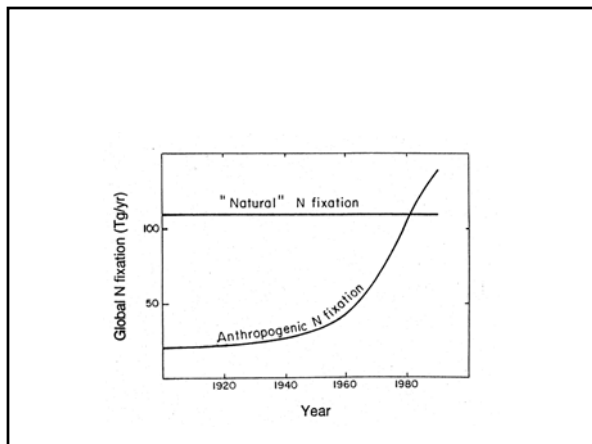


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Active N Pools

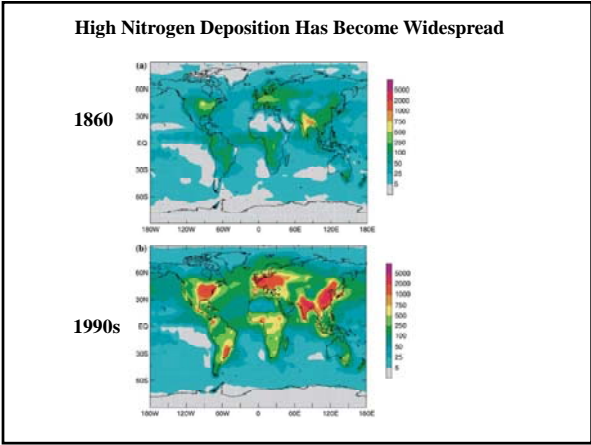
- Atmosphere $3,800,000 \times 10^{15}$ g N
- Ocean $21,000 \times 10^{15}$ g N
- Soil Organic Matter 95×10^{15} g N
- Terrestrial Biota 3.5×10^{15} g N





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Terrestrial Ecosystems Can be Overfertilized



Potential Consequences of N Saturation

- Increased surface-water NO_3^- concentrations.
- Enhanced losses of nutrient cations.
- Soil acidification & greater soluble Al .

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Nitrogen Cycle Mean Residence Times

- Atmosphere
ca. 9 million years
- Land biota
ca. 3 years

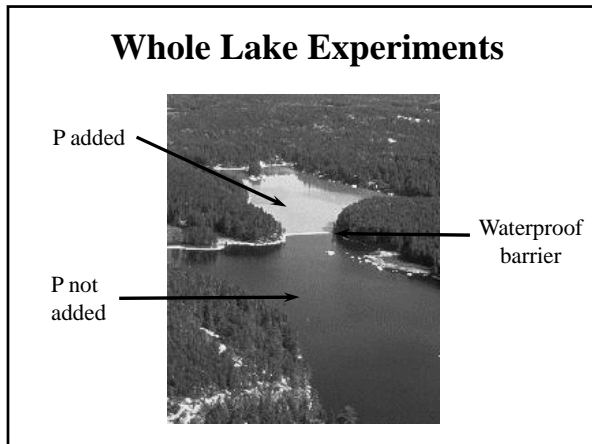
Summary of N Cycle

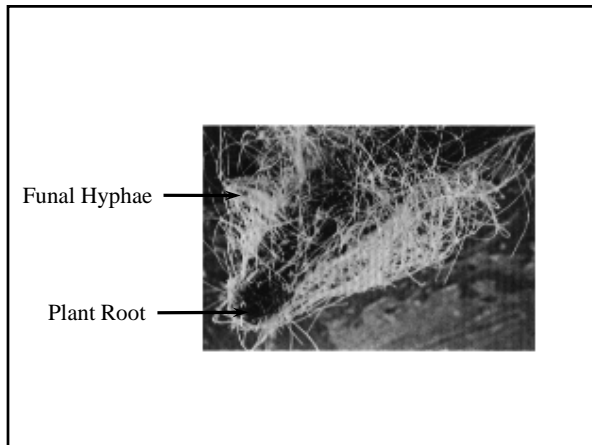
- Largest active pool = N_2 in atmosphere which is 181x > amount in ocean
- N in soil organic matter is 27x > amount in terrestrial biota
- Largest flux = uptake by plants of which almost all is from recycled organic N
- Human activities \approx 60 % of total inputs to land
- River flow \approx 40% total inputs to oceans

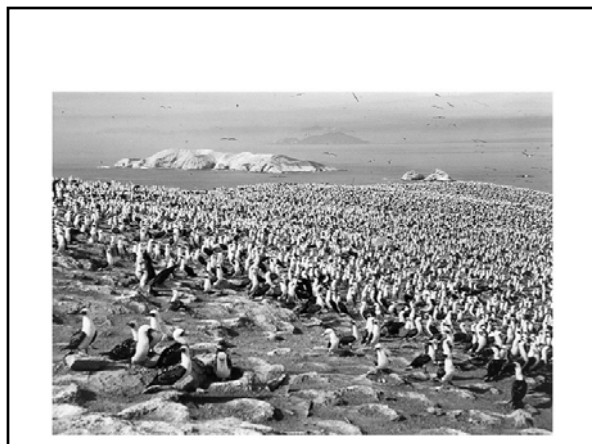
The Phosphorus (P) Cycle

- Example of a sedimentary cycle => no gaseous phase
- P is abundant in soil but in forms that are not readily available to biota
- PO_4^{-3} is an available form of P
- P is important because ...

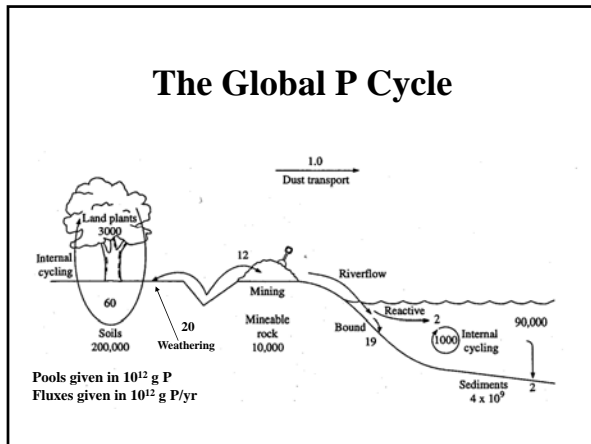
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- ### Summary of P Cycle
- Abundant but low availability.
 - Weathering of P-rich rock is original source.
 - Geologic processes are slow (millions of years) so biota rapidly recycle organic-P.
 - Residence time in biota is only a few days in the ocean.

- ### Summary of P Cycle
- Large loss to ocean relative to rate of return to land.
 - Losses in runoff are 93% particulate-P
 - Mycorrhizae ↑ absorption by plant roots
 - Mining P-rich rocks is a major source to land.
