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

Heterocysts in *Anabaena*

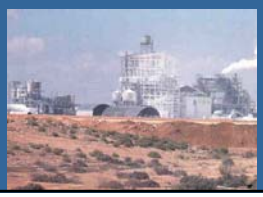
Humans Fix Nitrogen Too !

Fritz Haber

The Haber Process

$4N_2 + 12\ H_2 + \text{catalyst} \Longrightarrow 8\ NH_3$

at 500°C & several hundred atmospheres of pressure



2) Ammonification: organic N => NH_3

3) Nitrification: NH_3 => NO_2^- => NO_3^-

2-step process - each step by different bacteria.

Step 1: oxidation of ammonia (NH_3) to nitrite (NO_2^-) by _____

Step 2: oxidation of nitrite (NO_2^-) to nitrate (NO_3^-) by _____

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

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

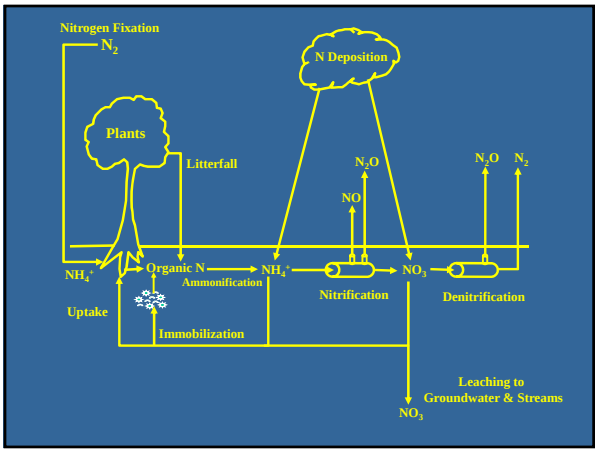
Would it help if you knew that ….

photo means they get E from light

auto means they get C from inorganic sources

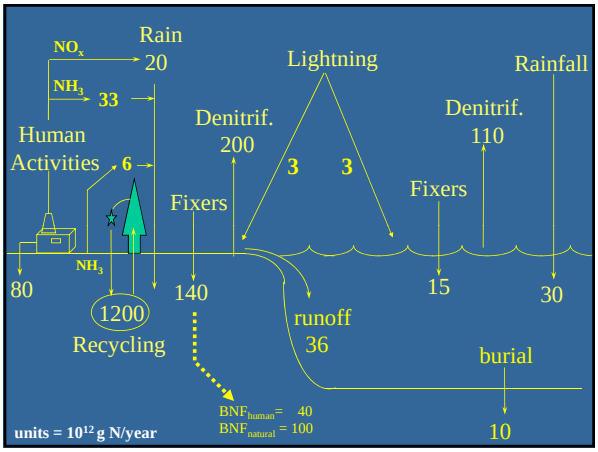
4) Nitrogen Assimilation: NH_3 => organic N
NO_3^- => organic N

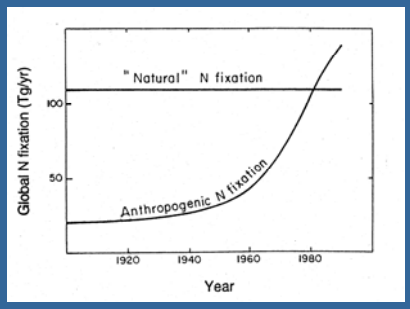
5) Denitrification: NO_3^- or NO_2^- => N_2 or N_2O



Active N Pools

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



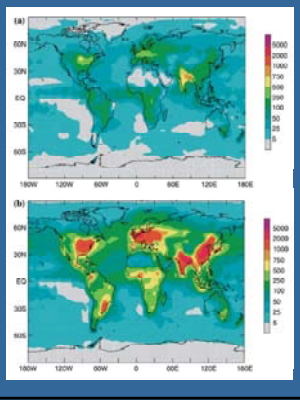


Terrestrial Ecosystems Can be Overfertilized

High Nitrogen Deposition Has Become Widespread

1860

1990s



Potential Consequences of N Saturation

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

Nitrogen Cycle
Mean Residence Times

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

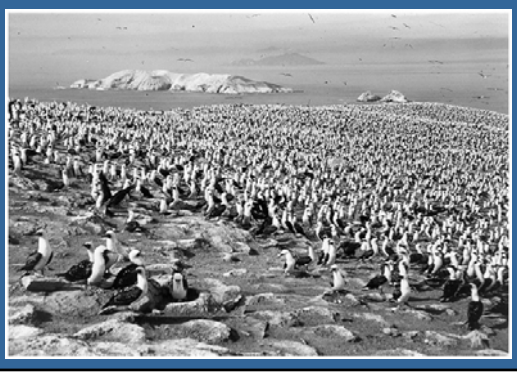
Summary of N Cycle

- 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 ≈ 60 % of total inputs to land
- River flow ≈ 40% total inputs to oceans

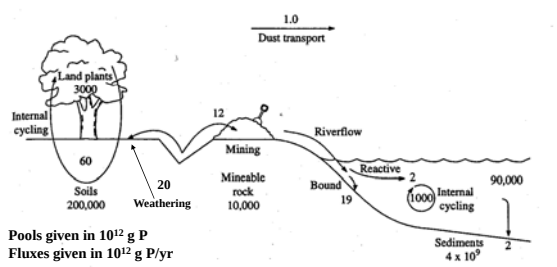
The Phosphorus (P) Cycle

- 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 …

Whole Lake Experiments



The Global P Cycle



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.