The Nitrogen (N) Cycle

• Atmosphere is ca. 78% N₂ 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: \( N₂ \rightarrow NH₃ \)

Root Nodules on a Legume
2) **Ammonification**: organic N $\Rightarrow$ NH$_3$

3) **Nitrification**: NH$_3$ $\Rightarrow$ NO$_2$ $\Rightarrow$ 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.
4) **Nitrogen Assimilation**: $\text{NH}_3 \rightarrow \text{organic N}$  
$\text{NO}_3^- \rightarrow \text{organic N}$  
Performed by both plants & microbes. Assimilation by microbes is also called **immobilization**.

5) **Denitrification**: $\text{NO}_3^-$ or $\text{NO}_2^- \rightarrow \text{N}_2$ or $\text{N}_2\text{O}$  
Performed by many bacteria. Returns N to the atmosphere. Anaerobic reaction which allows bacteria to grow and live w/out oxygen.

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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**: $95 \times 10^{15}$ g N  
- **Terrestrial Biota**: $3.5 \times 10^{15}$ g N
Terrestrial Ecosystems Can be Overfertilized
High Nitrogen Deposition Has Become Widespread

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 = N₂ 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
- PO₄³⁻ is an available form of P
- P is important because …

Whole Lake Experiments

- P added
- P not added
- Waterproof barrier
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.

Aquatic Ecosystems Can be Overfertilized

P added

P not added

Waterproof barrier
Temperate Lakes Can Thermally Stratify In The Summer

Eutrophication of stratified shallow lakes can change species composition

THIRD-LARGEST "DEAD ZONE" SINCE 1985 AREA SIZE OF NEW JERSEY

Mid-Summer 2007