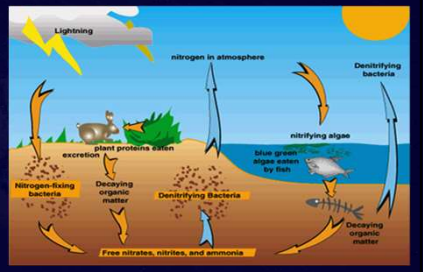
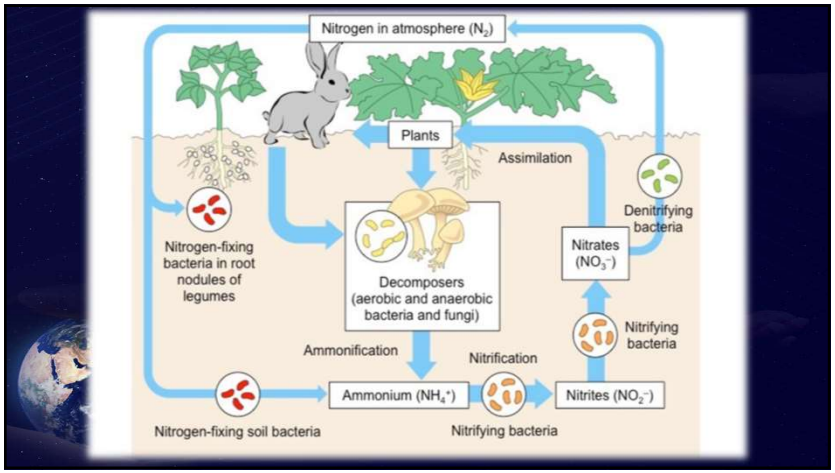
The Nitrogen Cycle

- The most complex cycle
- N_2 = 78% of the troposphere, chemically unreactive
- Essential part of Protein and DNA
- Cannot be easily absorbed from the air.



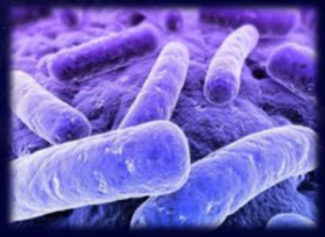
The Nitrogen Cycle

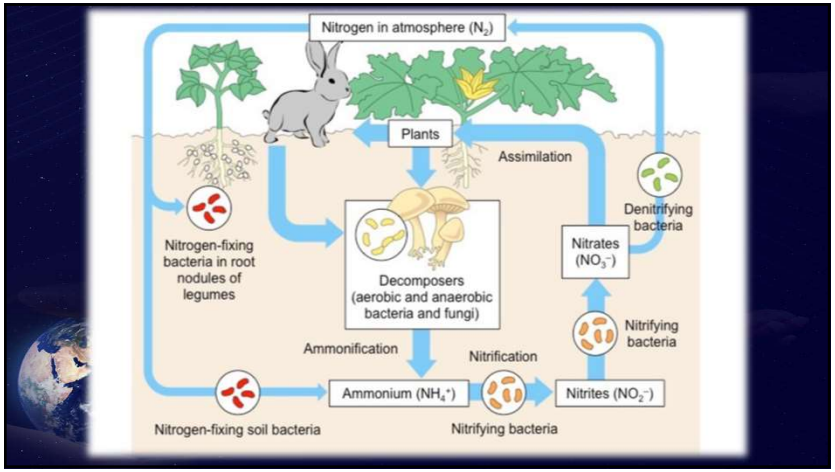
- **1. Nitrogen Fixation**: N_2 from the air is converted to ammonia (NH_3) in the soil
  - Can be done by bacteria in water & soil. On root nodules of legumes (peas, clover, beans, etc.)



The Nitrogen Cycle

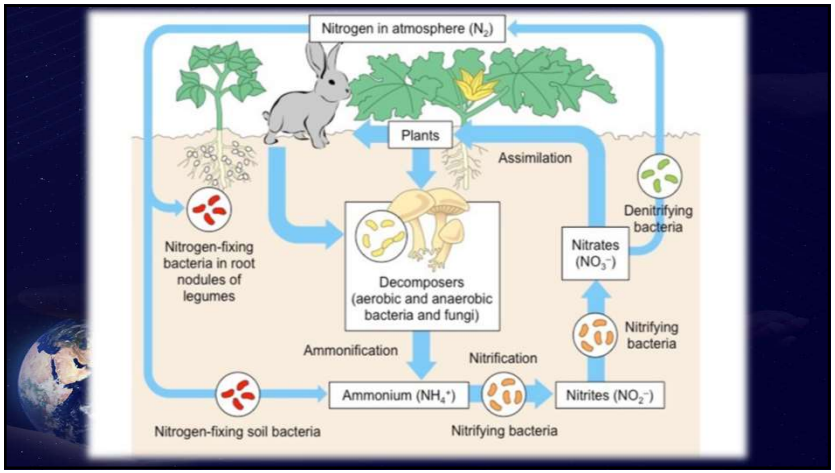
- **2. Nitrification**: Ammonia (NH_3) converted to nitrite (NO_2^-) and then nitrate (NO_3^-), the most usable forms of nitrogen
  - Both reactions carried out by bacteria in the soil





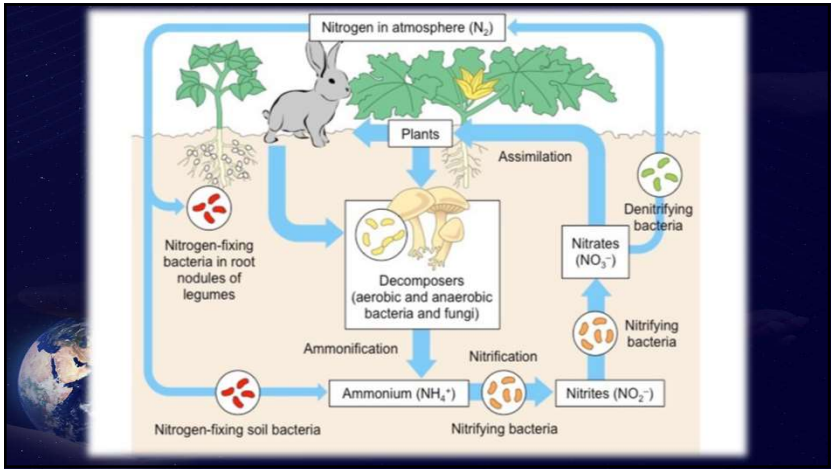
The Nitrogen Cycle

- **3. Assimilation**: Plants absorb nitrogen from the soil and incorporate it into their protein and DNA.
- Animals eat the plants and the nitrogen is passed through the ecosystem.



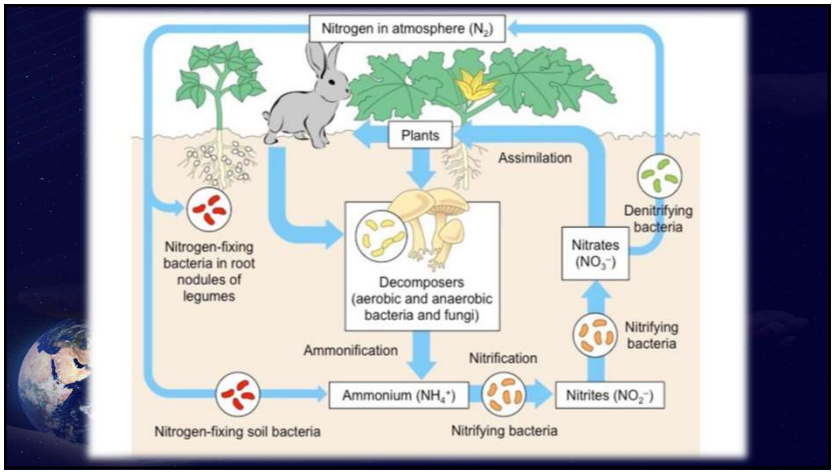
The Nitrogen Cycle

- **4. Ammonification**: Body waste, cast-offs, and dead organisms are converted back into ammonia (NH_3) in the soil.
  - By decomposer bacteria



The Nitrogen Cycle

- **5. Denitrification**: Ammonia (NH_3) is converted back to N_2
  - Mostly by anaerobic bacteria in waterlogged soil, bottom sediments of lakes, swamps, bogs and oceans



Significant Human Interventions (Part 1)

- **Farming, agriculture & cities**
- Nitrogen-rich fertilizers from farms and sewage from municipalities runs off into bodies of water
- This stimulates the growth of algae which dies. When decomposers eat the dead bacteria they use all the oxygen in the water and the aquatic animals suffocate.

Significant Human Interventions (Part 2)

- **Internal combustion engine exhaust (i.e., fossil fuel burning)**
- Results in NO_2 being added to the atmosphere
- Combining O_2 with atmospheric nitrogen results in nitric acid, a significant component of acid rain

Humans affect the nitrogen cycle

- **Haber-Bosch process** = production of fertilizers by combining nitrogen and hydrogen to synthesize ammonia
  - Humans overcame the limits on crop productivity
- Fixing atmospheric nitrogen with fertilizers
  - Increases emissions of greenhouse gases and smog
  - Washes calcium and potassium out of soil
  - Acidifies water and soils
  - Moves nitrogen into terrestrial systems and oceans which creates dead zones
  - Reduces diversity of plants adapted to low-nitrogen soils
  - Changed estuaries and coastal ecosystems and fisheries

More Human Interventions

- Nitrogen can be depleted from topsoil when we over-harvest or over-graze plants and then burn or clear grasslands and forests
- Cattle waste and inorganic nitrogen-containing fertilizers are broken down by bacteria into nitrous oxide, which is a heat-trapping gas and can contribute to the warming of the atmosphere.

Solutions to the dead zone

- The Harmful Algal Bloom and Hypoxia Research and Control Act (1998)
  - Called for an assessment of hypoxia in the dead zone
- Solutions outlined included:
  - Reduce nitrogen fertilizer use in Midwestern farms
  - Apply fertilizer at times which minimize runoff
  - Use alternative crops and manage manure better
  - Restore wetlands and create artificial ones
  - Improve sewage treatment technologies
  - Evaluate these approaches

Humans affect the carbon cycle

- Burning fossil fuels moves carbon from the ground to the air
- Cutting forests and burning fields moves carbon from vegetation to the air
- Today's atmospheric carbon dioxide reservoir is the largest in the past 800,000 years
  - It is the driving force behind climate change
- The missing carbon sink: 1-2 billion metric tons of carbon are unaccounted for
  - It may be taken up by plants or soils of northern temperate and boreal forests

Human impacts on the hydrologic cycle

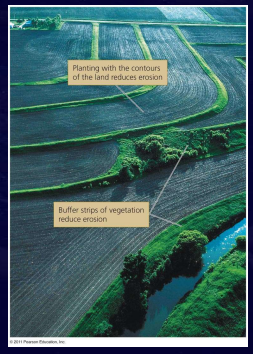
- Removing forests and vegetation increases runoff and erosion, reduces transpiration and lowers water tables
- Irrigating agricultural fields depletes rivers, lakes and streams and increases evaporation
- Damming rivers increases evaporation and infiltration
- Emitting pollutants changes the nature of precipitation
- The most threatening impact: overdrawing groundwater for drinking, irrigation, and industrial use
  - Water shortages create worldwide conflicts

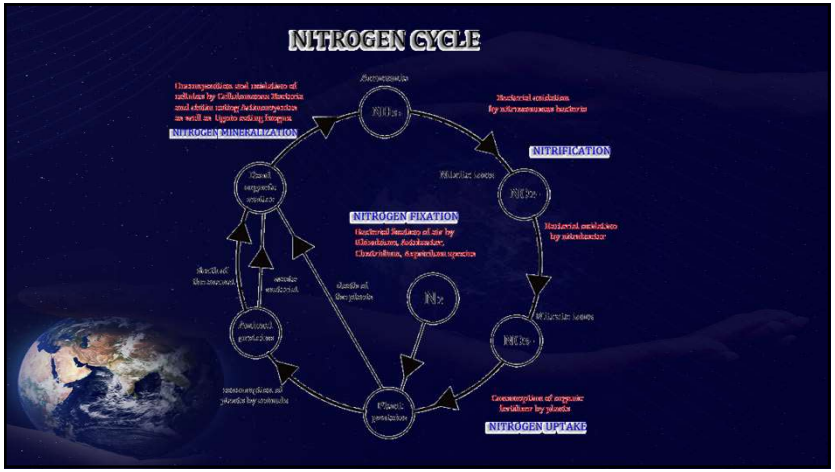
Humans affect the phosphorus cycle

- Mining rocks for fertilizer moves phosphorus from the soil to water systems
- Wastewater discharge also releases phosphorus
- Runoff containing phosphorus causes eutrophication of aquatic systems
  - Produces murkier waters
  - Alters the structure and function of aquatic systems
  - Do not buy detergents that contain phosphate

Decreasing pollution

- Scientists, farmers and policymakers are encouraged to
  - Decrease fertilizer use
  - While safeguarding agriculture
- Offering insurance and incentives
- Using new farming methods
- Planting cover crops
- Maintaining wetlands
- There have been some successes
  - Despite a lack of funding




NITROGEN CYCLE
Ammonia
NH3
Decomposition and oxidation of cellulose by Cellulomonas bacteria and chitin using Actinomycetes as well as lignin eating fungus
NITROGEN MINERALIZATION
Bacterial oxidation by nitrosomonas bacteria
NITRIFICATION
Nitrite ions
NO2-
Dead organic matter
NITROGEN FIXATION
Bacterial fixation of air by Rhizobium, Azotobacter, Clostridium, Aspergillus species
Bacterial oxidation by nitrobacter
death of the animal
excreta and urine
death of the plants
N2
Nitrate ions
NO3-
Animal products
Plant proteins
consumption of animals by animals
Consumption of organic fertilizers by plants
NITROGEN UPTAKE