# Nitrification and Denitrification

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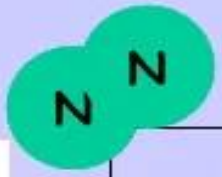
# SOURCES OF NITROGEN

- Atmospheric Nitrogen
  - 78% of atmosphere
  - Plants cannot utilize this form
  - Some Bacteria, Blue Green Algae, leguminous plants
- Nitrates, Nitrites and Ammonia
  - Nitrate is chief form
- Amino acids in the soil
  - Many soil organisms use this form
  - Higher plants can also taken by higher plants
- Organic Nitrogenous compounds in insects
  - Insectivorous plants

The largest single source of *nitrogen* is in the *atmosphere*.

*Atmospheric nitrogen* is converted to *ammonia* or *nitrates*.




***Atmospheric Nitrogen*** **($N_2$)**


***Ammonia*** **($NH_3$)**

***Nitrogen combines with Hydrogen to make Ammonia***

***Nitrates*** **($NO_3$)**

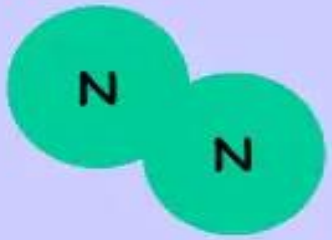
***Nitrogen combines with Oxygen to make Nitrates***

# It is one of nature's great ironies…

*Nitrogen* is an essential component of DNA and proteins—the building blocks of life.

Although the majority of the air we breathe is *nitrogen*, most living organisms are *unable to use nitrogen* as it exists in the *atmosphere*!

**How does *atmospheric nitrogen* get changed into a form that can be used by most living organisms?**




**By traveling through one of the four processes in the Nitrogen Cycle!**

***(1) Nitrogen Fixation***

***(4) Denitrification***


***(3) Nitrification***

***(2) Ammonification***

"*Nitrogen Fixation*" is the process that causes the strong two-atom nitrogen molecules found in the atmosphere to break apart so they can combine with other atoms.


Nitrogen gets "*fixed*" when it is combined with oxygen or hydrogen.

# There are three ways that *nitrogen* gets "fixed"!

*(a) Atmospheric Fixation*

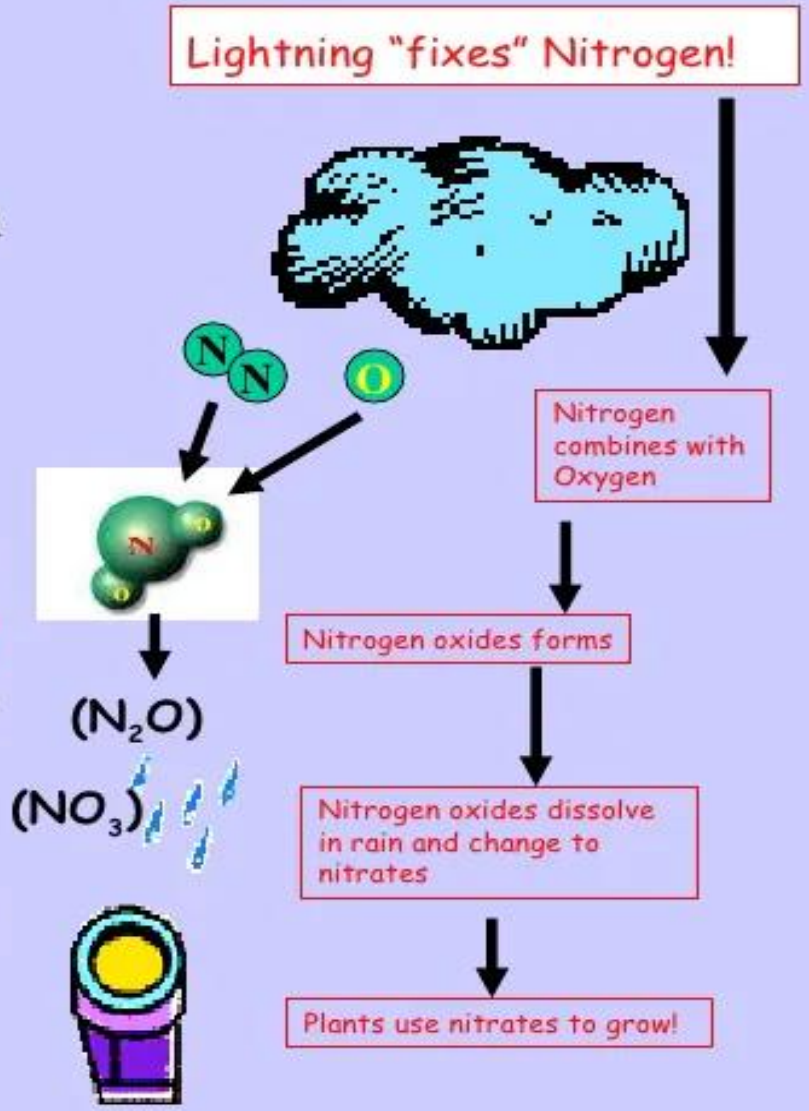
*(b) Industrial Fixation*

*(c) Biological Fixation*

*Bacteria*

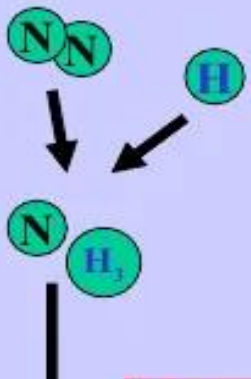
## Atmospheric Fixation (Only 5 to 8% of the Fixation Process)

The enormous energy of *lightning breaks nitrogen molecules apart* and enables the nitrogen atoms to combine with oxygen forming *nitrogen oxides* ($N_2O$). Nitrogen oxides dissolve in rain, forming nitrates. *Nitrates* ($NO_3$) are carried to the ground with the rain.



## Industrial Fixation

Under great pressure, at a temperature of 600 degrees Celcius, and with the use of a catalyst, *atmospheric nitrogen ($N_2$)* and *hydrogen* are combined to form *ammonia ($NH_3$)*. Ammonia can be used as a *fertilizer*.




*Industrial Plant combines nitrogen and hydrogen*

($NH_3$)

*Ammonia is formed*

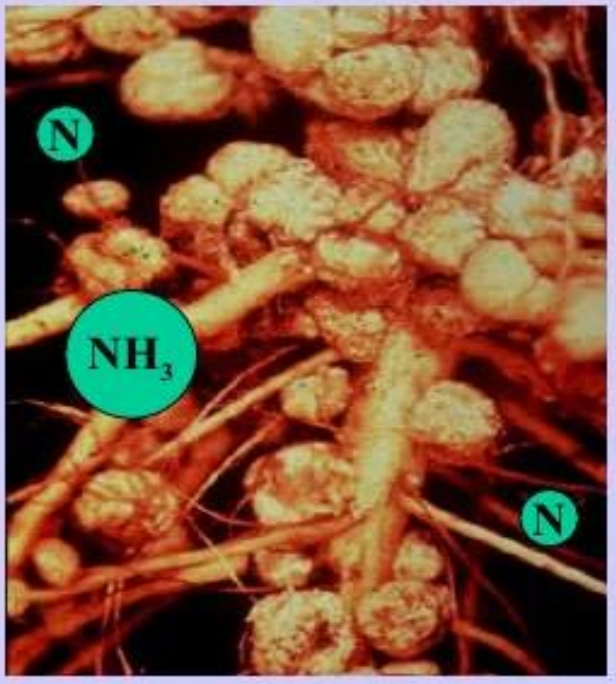
*Ammonia is used a fertilizer in soil*

## Symbiotic Relationship Bacteria

Bacteria live in the roots of legume family plants and provide the plants with *ammonia ($NH_3$)* in exchange for the plant's carbon and a protected home.

Some of the ammonia escapes into the surrounding soil enriching it with usable nitrogen for all plants.

Legume plants




*Roots with nodules where bacteria live*

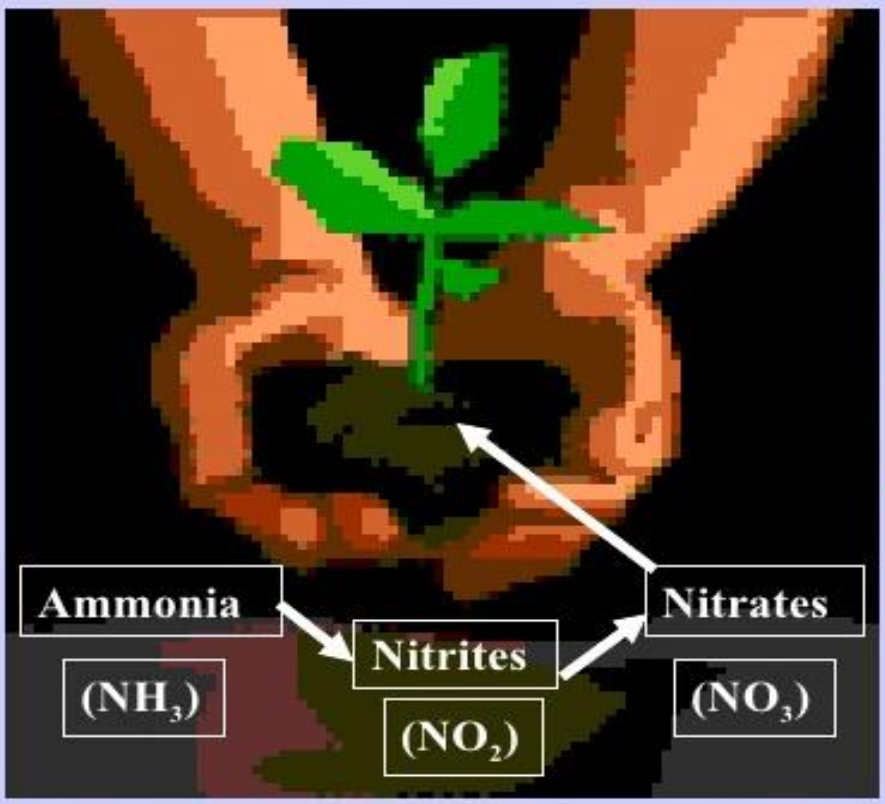
*Nitrogen changes into ammonia.*

*Ammonification*: Decomposition by bacteria and fungi breaks down amino acids from dead animals and wastes into *ammonia*.

**Bacteria decomposers break down amino acids into ammonia**

Because plants cannot use the *organic forms* of nitrogen that are in the soil as a result of:
(1) wastes (manure and sewage)
(2) compost and decomposing roots and leaves

Nitrifying bacteria in the ground first combine *ammonia* with *oxygen* to form *nitrites*. Then another group of nitrifying bacteria convert *nitrites* to *nitrates* which **green plants can absorb** and use!




Nitrifying bacteria in soil combine ammonia with oxygen

↓

Ammonia changes to nitrites

↓

Nitrifying bacteria in soil convert nitrites to nitrates

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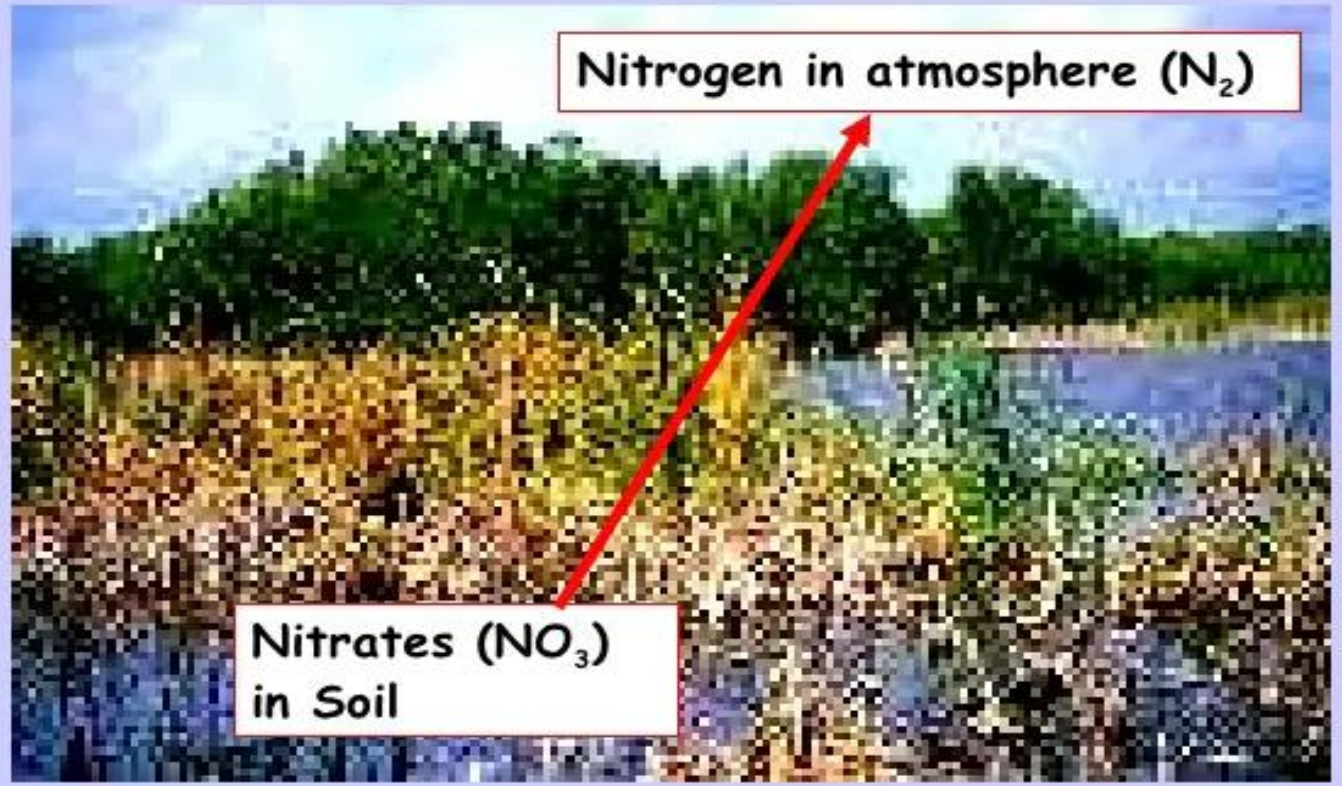
Plants absorb nitrates and grow!

*Denitrification* converts *nitrates ($NO_3$)* in the soil to *atmospheric nitrogen ($N_2$)* replenishing the atmosphere.



Denitrifying bacteria live deep in soil and in swampy sediments where conditions make it difficult for them to get oxygen. The denitrifying bacteria use *nitrates* as an alternative to oxygen, leaving free *nitrogen gas* as a byproduct. They close the nitrogen cycle!

Nitrogen in atmosphere closes the nitrogen cycle!

$(N_2)$

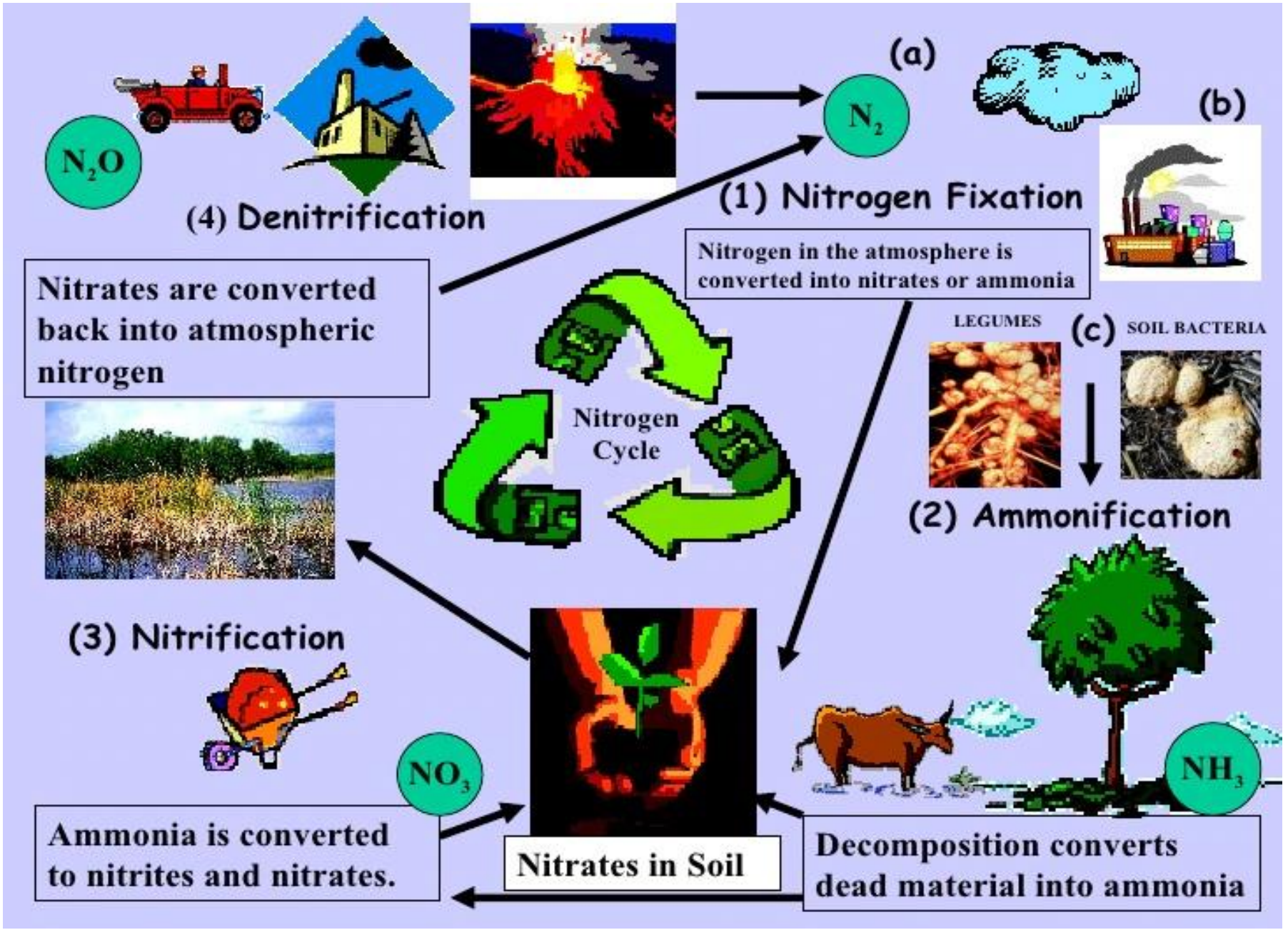
$(NO_3)$

Denitrifying bacteria live deep in soil and use nitrates as an alternative to oxygen making a byproduct of nitrogen gas.

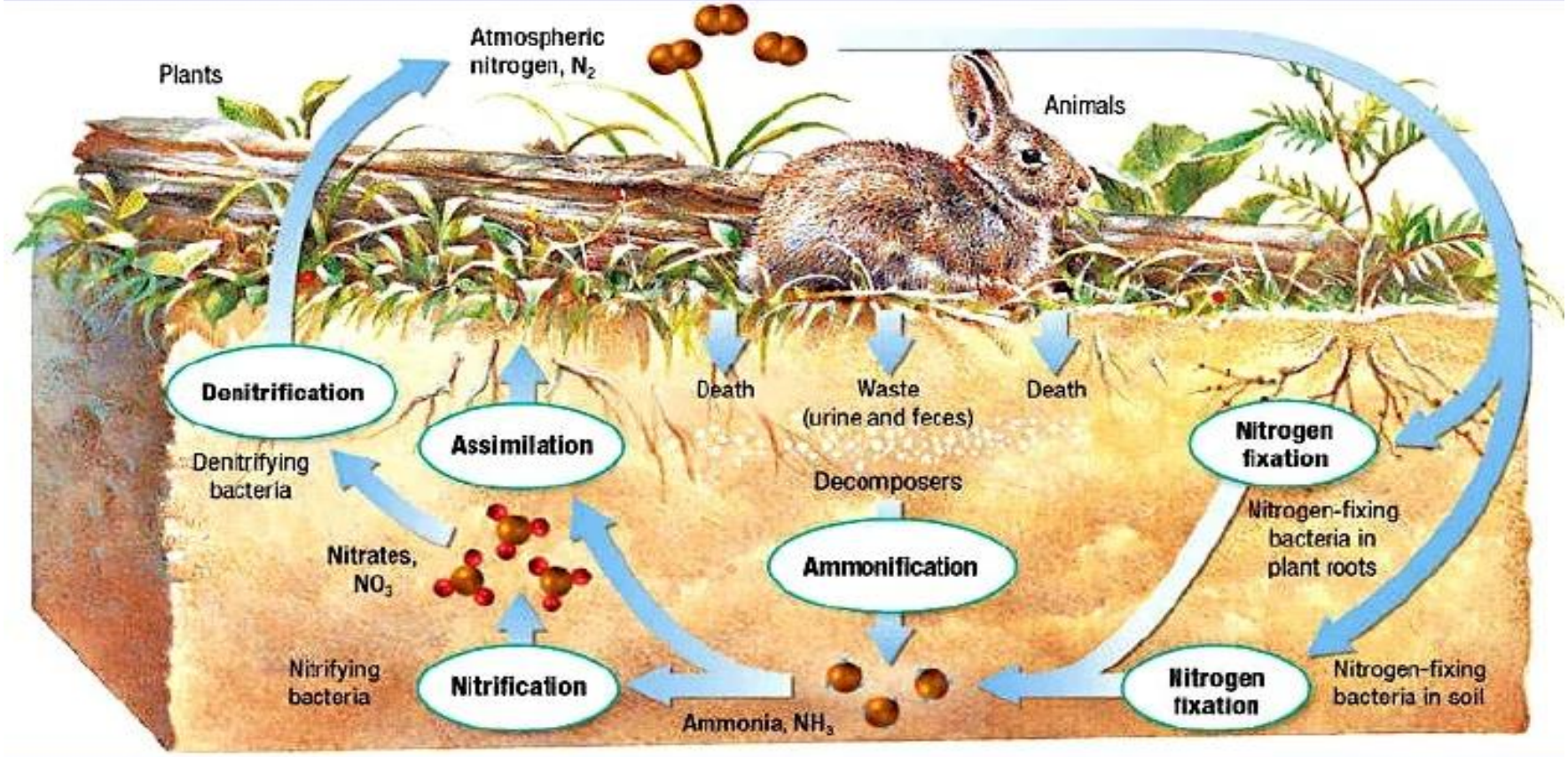
# Other ways that nitrogen returns to the atmosphere…

Emissions from industrial combustion and gasoline engines create nitrous oxides gas ($N_2O$).

Volcano eruptions emit nitrous oxides gas ($N_2O$).


(a)
(b)
$N_2$
$N_2O$
(1) Nitrogen Fixation
(4) Denitrification
Nitrogen in the atmosphere is converted into nitrates or ammonia
Nitrates are converted back into atmospheric nitrogen
Nitrogen Cycle
LEGUMES
(c)
SOIL BACTERIA
(2) Ammonification
(3) Nitrification
$NO_3$
$NH_3$
Ammonia is converted to nitrites and nitrates.
Nitrates in Soil
Decomposition converts dead material into ammonia

# THE NITROGEN CYCLE



| Process | Reaction |
| --- | --- |
| Fixation | $N_2(g) + 8H^+ + 8e^- \rightarrow 2NH_3(g) + H_2(g)$ |
| Ammonification | $NH_2\text{-}CO\text{-}NH_2 + H_2O(l) \rightarrow 2NH_3(g) + CO_2(g)$ |
| Nitrification (Two Steps) | (1) $NH_4^+ + 1.5O_2(g) \rightarrow NO_2^- + 2H^+ + H_2O(l)$<br>(2) $NO_2^- + 0.5O_2(g) \rightarrow NO_3^-$ |
| Denitrification | $NO_3^- \rightarrow NO_2^- \rightarrow NO \rightarrow N_2O \rightarrow N_2$ |