

Nitrogen cycle

Organic nitrogen compounds

Nitrogen-containing compounds are important in plants. Examples are proteins (including enzymes), nucleotides (e.g. ATP) and nucleic acids (e.g. DNA and RNA).

The process of decay of dead remains is also known as putrefaction. Decay, or putrefying, bacteria and fungi break down organic nitrogen compounds in dead remains, faeces and urine to give ammonia. In the soil the ammonia forms ammonium ions.

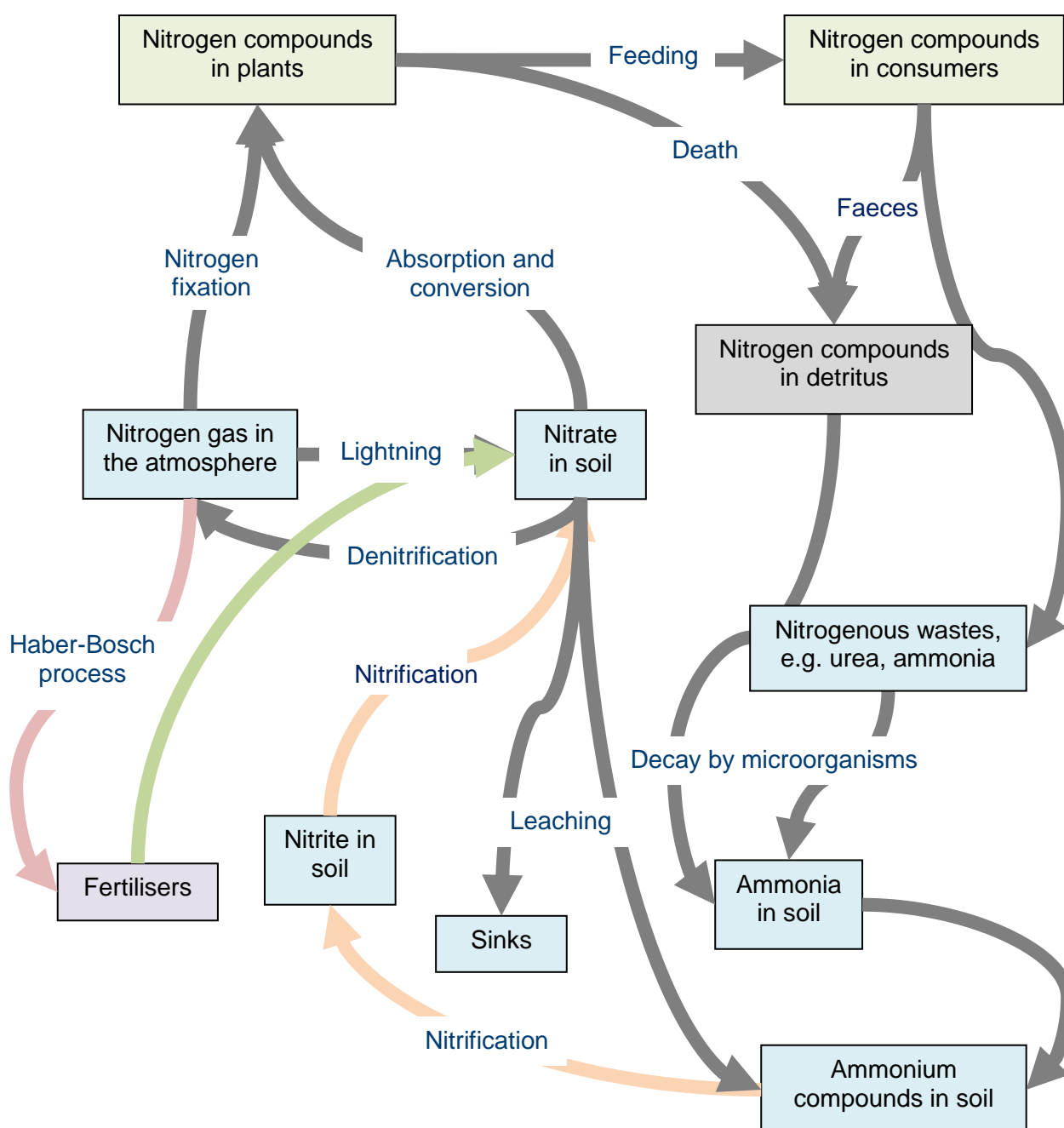
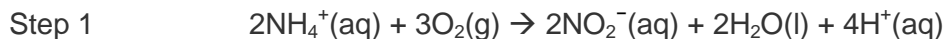


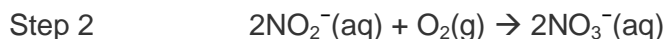
Figure The nitrogen cycle.

Nitrification

- Plants are able to use ammonium ions or nitrate ions to form proteins from carbohydrates. If the soil is not too cold and oxygen is available for aerobic respiration, ammonium ions may be oxidised to nitrate ions by nitrifying bacteria. This two step process is called nitrification.



The reaction is catalysed by *Nitrosomonas* bacteria.



The reaction is catalysed by *Nitrobacter* bacteria.

- Energy released in these oxidation reactions is used to synthesise organic compounds in the same way that green plants use light in photosynthesis. This is called chemosynthesis.
- 90% of the fixation of nitrogen in the soil is, however, carried out by free-living species of bacteria and cyanobacteria, such as *Azotobacter* and *Nostoc*.

Water-logging and denitrification

- In anaerobic conditions, for example when the soil is waterlogged excluding air, another group of denitrifying bacteria convert the nitrate back to gaseous nitrogen. These bacteria use nitrate ions as electron acceptors for respiration instead of oxygen. Denitrifying bacteria include *Pseudomonas denitrificans*.
- Waterlogged soils therefore become nitrate depleted and plant growth is significantly reduced.

Nitrogen fixation

- Bacteria that possess the enzyme nitrogenase can convert gaseous nitrogen into ammonia. The bacterium *Rhizobium* forms a symbiotic relationship with leguminous plants. The bacterium stimulates the growth of root nodules. Here colonies of the bacterium obtain carbohydrate from the host plant. They use this in respiration to release energy and make ATP and reduced NAD to make ammonium ions from nitrogen gas in the soil.
- Nitrogenase activity is inhibited by high oxygen concentrations. A pigment, leghaemoglobin, reduces the oxygen concentration in the root nodules, but makes it readily available for respiration. This maintains the high rate of aerobic respiration needed to supply the ATP needed for nitrogen fixation.
- The ammonia is available for the plant to synthesise protein and other nitrogen containing organic compounds. Legumes are therefore able to grow successfully on soils deficient in inorganic nitrogen.
- Atmospheric nitrogen is also fixed on a large scale in chemical factories worldwide using the Haber Bosch process. Nitrogen and hydrogen are reacted to make ammonia.

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More information about the industrial fixation of nitrogen can be found in
Manufacturing ammonia

Finding out

Why is nitrogen gas so unreactive?

How do plants 'fix' nitrogen?