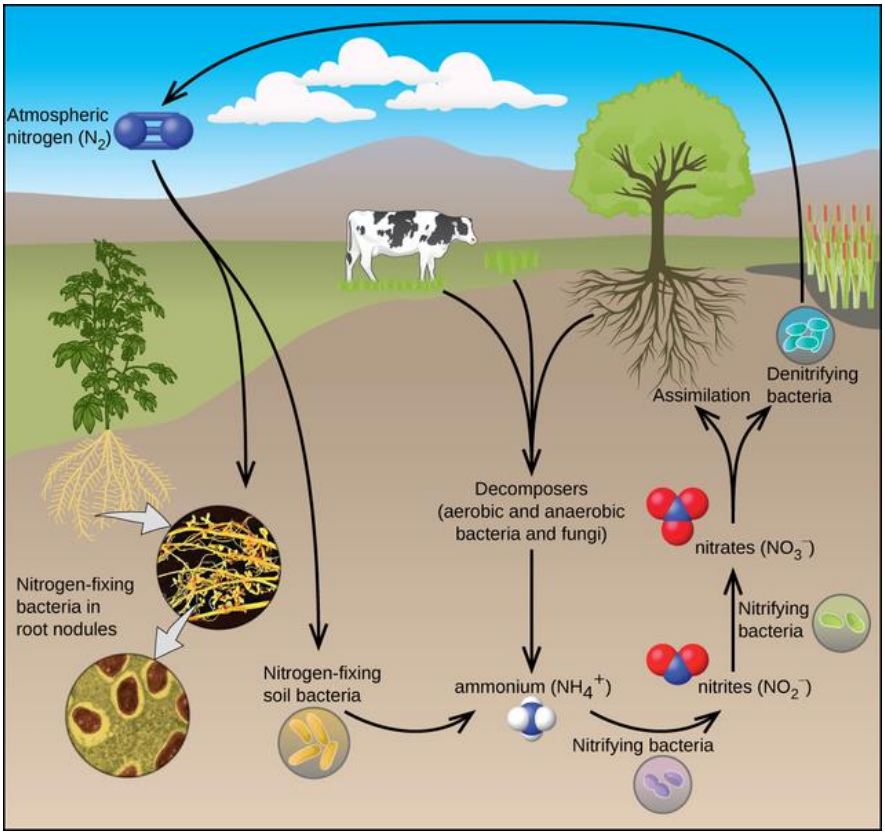
‘Tagging’ nitrogen atoms – to explore the nitrogen cycle

A thought experiment to investigate nitrogen cycle processes

Pretend to ‘tag’ a nitrogen atom by going near an open window with a blue pen and stabbing the air to make a nitrogen atom appear bright blue - ●.

Then use this diagram and a plant in a pot (or the view through the window – see ‘context’ section) to help to ask and answer the following questions.



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- If this nitrogen atom becomes part of the nitrogen cycle through this potted plant, where would it go next? *A. It could go into the soil and be ‘fixed’ by bacteria in the roots of the plant to make an ammonium ion (NH_4^+).* Take the plant out of the pot and pretend you can see the blue nitrogen atom in one of the roots.
- What could happen to the ammonium ion when it met nitrifying bacteria? *A. The bacteria could remove the hydrogen atoms and add two oxygen atoms to each nitrogen atom to form a nitrite ion (NO_2^-).* Pretend that you can see this happening in the soil.
- What could happen to the nitrite ion when it met more nitrifying bacteria? *A. These bacteria could add another oxygen atom to each nitrite ion to make a nitrate ion (NO_3^-).* Pretend you can see this happening too.
- What could happen to the nitrate ion when it reached an area of the soil with no oxygen (anaerobic, often waterlogged soil) containing denitrifying bacteria? *A. The bacteria could remove the oxygen from the nitrate ion, and then join each nitrogen into a pair to make a nitrogen molecule (N_2) and release it into the air again.* Pretend this happens in the plant pot soil, and the blue ‘tagged’ atom rises back into the air.
- How could the nitrogen in the air become part of the nitrogen cycle without the help of nitrogen-fixing soil bacteria? *A. Bacteria and fungi can turn decomposing excrement, plants and animals into ammonium ions directly.*
- What could happen to the nitrate ion if it was absorbed (assimilated) by the roots of the plant? *A. It could become part of the plant as the plant grows.* Pretend to show this happening in your potted plant.
- How are animals involved in the nitrogen cycle? *A. Plant-eating animals absorb nitrogen from the plants they eat and meat-eaters absorb nitrogen from the meat; both lose nitrogen in their excrement.* ‘Spot’ a blue nitrogen atom in one of the class-members.

Explain that all plants and animals need to assimilate nitrogen in order to grow. Nitrogen forms a key part of amino acids, and therefore proteins, and is also required for DNA.

Explain that some plants are much better than others at fixing nitrogen, and that without nitrogen fixation by microbes (some of which are closely associated with plants), most plant and animal growth would be impossible.

The back up

Title: ‘Tagging’ nitrogen atoms – to explore the nitrogen cycle

Subtitle: A thought experiment to investigate nitrogen cycle processes

Topic: Using the pretend ‘tagging’ of a nitrogen atom to trace its journey around the nitrogen cycle through a potted plant (or view from the window).

Age range of pupils: 11 years upwards

Time needed to complete activity: 10 minutes

Pupil learning outcomes: Pupils can:
- describe how nitrogen moves around the nitrogen cycle;
- explain each of the steps.

Context:
Drawings showing the cycling of matter are abstract concepts and so difficult for pupils to understand. Using the pretend ‘tagging’ method helps them to gain a more concrete idea of the different steps involved and so can be used to teach or consolidate understanding of the nitrogen and other cycles.

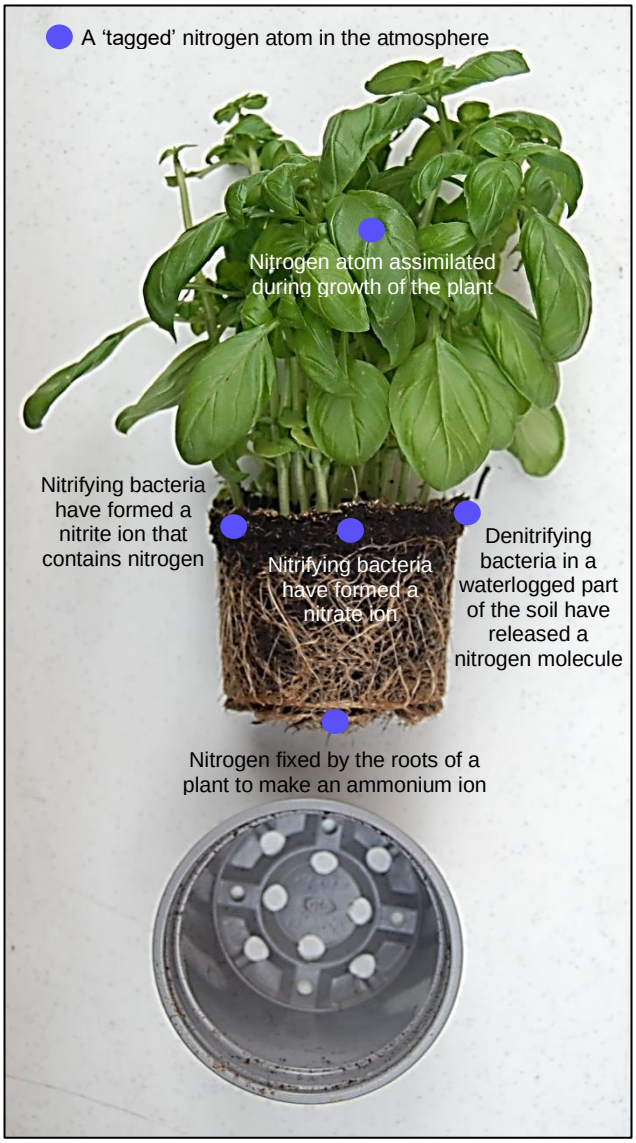
You can run a similar exercise through the window by ‘spotting’ a ‘tagged’ nitrogen atom entering the soil and then following its progress to an ammonium ion, a nitrite ion, a nitrate ion and then assimilation into the plants you can see, followed by release back into the atmosphere.

Note that humans get around the nitrogen-fixing problem by adding nitrogen-rich fertilisers to soils.

Also note that lightning can break up nitrogen molecules in the air which then combine with oxygen to form nitrates. These are brought down in rain and then join the nitrogen cycle.

Following up the activity:
Follow a ‘tagged’ nitrogen atom through different routes such as being assimilated by grass, being eaten by a cow, being excreted and then decomposed to form an ammonium ion, etc.

Underlying principles:
- Through the nitrogen cycle, a nitrogen atom goes through a series of biochemical processes that can include:
  - nitrogen fixing to produce ammonium ions,
  - formation of nitrites and nitrates by nitrifying bacteria,
  - denitrifying of nitrates back to molecular nitrogen or
  - assimilation during growth of plants.
- Other routes through the cycle involve decomposition and decay to ammonium ions.



A ‘potted’ nitrogen cycle. *(plant images, Chris King).*

Thinking skill development:
Understanding the abstract concept of a cycle of matter through a series of steps involves construction. Applying the nitrogen cycle concept to a real plant, or a view of soil and vegetation through the window, requires bridging.

Resource list:
- either a potted plant or a view through a window

Useful links:
You can find animations and presentations about the nitrogen cycle on the internet by using a search engine and clicking ‘videos’. Some are better than others!

Source: Chris King of the Earthlearningidea Team. Many thanks to Susie Lydon for her very helpful comments on an earlier draft of this ELI.