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**Chapter 3.5: The Nitrogen Cycle**

*By Sally Morgan and Mike Allaby*

     Nitrogen is an essential element that all organisms need to function properly. Plants grown on nitrogen-deficient soils suffer stunted growth and early death. In animals, nitrogen is a component of crucial organic molecules such as DNA and proteins. Although 78 percent of the atmosphere is nitrogen gas, it is relatively inert and therefore cannot be used directly by most living organisms until it has been converted into nitrates or other nitrogen compounds. Certain bacteria in the soil, and in the oceans, are among the few organisms that are able to carry out this conversion.

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| [Roots of Peas and Beans Have Swellings on Them](http://sks.sirs.com/cgi-bin/hst-graphic-single?id=SCO0649H-0-9862&keyno=0000127750&key=&type=ART&artno=0000282027) **Roots of Peas and Beans Have Swellings on Them**  The roots of peas and beans have small swellings along their length. These contain millions of symbiotic bacteria, which have the ability to take nitrogen gas from the atmosphere and convert it to nitrates that can be used by the plant. |

     Nitrogen is fixed by special nitrogen-fixing bacteria found in soil and water. These bacteria have the ability to take nitrogen gas from the air and convert it to nitrate. This is called nitrogen fixation. Some of these bacteria occur as free-living organisms in the soil. Others live in a symbiotic relationship with plants. Legumes such as clover, peas and beans have nitrogen-fixing bacteria on their roots which enable them to grow in nitrogen-deficient soil.

     Nitrates taken in by plant roots are incorporated into large organic molecules, which are transferred to animals when they eat the plants. The wastes and remains of both plants and animals contain organic nitrogen compounds which are broken down by decomposers and converted into inorganic compounds such as ammonium ions. Nitrifying bacteria convert these compounds back into nitrates in the soil, which can be taken in again by plants and cycled through the ecosystem once more.

     In denitrification, nitrates are converted back to nitrogen gas. Denitrifying bacteria are found in waterlogged soils where they release nitrogen gas, causing the soil to lose its nitrogen. Farmers normally try to prevent their fields from becoming waterlogged.

     Crop plants can use more nitrate than is present in most soils. This shortage limited crop yields for most of history. Nitrogen in artificially-produced compounds--the basic ingredient of fertilizers--is now more abundant than nitrogen from natural sources, and agricultural yields have improved dramatically. But the nitrogen cycle is easily unbalanced; even a small change can cause problems.

     Modern crops, such as wheat and rice, require high levels of nitrogen to sustain their fast growth rates. The plants are harvested at the end of the growing season. The nitrogen within the crop is not returned to the soil, whose nitrogen level quickly becomes depleted. Farmers then have to add artificial sources of nitrogen--fertilizers--to the soil. The most common fertilizers are inorganic substances such as ammonium nitrate. Organic fertilizers, such as sewage sludge and manure, are a good source of nitrate, but they are bulky and may contain disease organisms and heavy metals.

     Too much nitrogen can cause plants to become too lush and tall, so that they are more susceptible to damage from wind and disease. If a farmer applies too much nitrate fertilizer, particularly during wet weather, the water-soluble nitrate can leach out of the soil. It passes into water courses or soaks down to the water table--the supply below the Earth's surface. Eventually, the fertilizer ends up in a river or pond where it stimulates the growth of freshwater algae, which grow rapidly to form a green blanket over the surface of the water, called algal bloom. It can block the light to plants in the water, inhibiting their growth.

**Keywords**

**Algal Bloom**

     A sudden increase in the amount of **[left arrow](http://sks.sirs.com/cgi-bin/hst-article-display?id=SCO0649H-0-9862&artno=0000282027&type=ART&shfilter=U&key=fertilizer%20algae%20eutrophication&title=Chapter%203.5:%20The%20Nitrogen%20Cycle&res=Y&ren=N&gov=N&lnk=N&ic=N#A2)****algae[right arrow](http://sks.sirs.com/cgi-bin/hst-article-display?id=SCO0649H-0-9862&artno=0000282027&type=ART&shfilter=U&key=fertilizer%20algae%20eutrophication&title=Chapter%203.5:%20The%20Nitrogen%20Cycle&res=Y&ren=N&gov=N&lnk=N&ic=N#A4)** in a river or lake, stimulated by the input of nutrients such as phosphates and nitrates. The **[left arrow](http://sks.sirs.com/cgi-bin/hst-article-display?id=SCO0649H-0-9862&artno=0000282027&type=ART&shfilter=U&key=fertilizer%20algae%20eutrophication&title=Chapter%203.5:%20The%20Nitrogen%20Cycle&res=Y&ren=N&gov=N&lnk=N&ic=N#A3)****algae[right arrow](http://sks.sirs.com/cgi-bin/hst-article-display?id=SCO0649H-0-9862&artno=0000282027&type=ART&shfilter=U&key=fertilizer%20algae%20eutrophication&title=Chapter%203.5:%20The%20Nitrogen%20Cycle&res=Y&ren=N&gov=N&lnk=N&ic=N#A5)** multiply and cover the surface, smothering plants and reducing the light intensity in the upper water layer. The **[left arrow](http://sks.sirs.com/cgi-bin/hst-article-display?id=SCO0649H-0-9862&artno=0000282027&type=ART&shfilter=U&key=fertilizer%20algae%20eutrophication&title=Chapter%203.5:%20The%20Nitrogen%20Cycle&res=Y&ren=N&gov=N&lnk=N&ic=N#A4)****algae[right arrow](http://sks.sirs.com/cgi-bin/hst-article-display?id=SCO0649H-0-9862&artno=0000282027&type=ART&shfilter=U&key=fertilizer%20algae%20eutrophication&title=Chapter%203.5:%20The%20Nitrogen%20Cycle&res=Y&ren=N&gov=N&lnk=N&ic=N#A6)** eventually die; as their remains are decomposed by bacteria and other microorganisms, oxygen in the water is used up, and fish and other large animals in the water may suffocate. Decaying **[left arrow](http://sks.sirs.com/cgi-bin/hst-article-display?id=SCO0649H-0-9862&artno=0000282027&type=ART&shfilter=U&key=fertilizer%20algae%20eutrophication&title=Chapter%203.5:%20The%20Nitrogen%20Cycle&res=Y&ren=N&gov=N&lnk=N&ic=N#A5)****algae[right arrow](http://sks.sirs.com/cgi-bin/hst-article-display?id=SCO0649H-0-9862&artno=0000282027&type=ART&shfilter=U&key=fertilizer%20algae%20eutrophication&title=Chapter%203.5:%20The%20Nitrogen%20Cycle&res=Y&ren=N&gov=N&lnk=N&ic=N#A7)** may also give off toxins that kill fish and other wildlife. The toxins can be harmful to domestic animals and people.

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| [Nitrates Stimulate Algae Growing in Water](http://sks.sirs.com/cgi-bin/hst-graphic-single?id=SCO0649H-0-9862&keyno=0000127752&key=&type=ART&artno=0000282027) **Nitrates Stimulate Algae Growing in Water**  Nitrates stimulate algae growing in water as well as plants growing in soil. If runoff from fertilizer gets into a body of water, algae grow so profusely that they form a blanket over the surface. This usually happens in summer, when the light levels and warm temperatures favor growth. (Sally Morgan/Ecoscene) |

**Bacteria**

     A group of microscopic unicellular organisms. They usually reproduce by binary fission (dividing into two), and because this may occur approximately every 20 minutes, a single bacterium is potentially capable of producing 16 million copies of itself in a day.

     Bacteria can be classified into two broad classes (Gram positive and Gram negative) by their reactions to certain stains, or dyes, used in microscopy. The staining technique, called the Gram test after Danish bacteriologist Hans Gram, allows microbiologists to classify bacteria quickly.

     Many bacteria are parasites that cause animal diseases, such as bubonic plague, tuberculosis, cholera and tetanus, and plant diseases, such as soft rot. However, certain types of bacteria are vital in many food and industrial processes, while others play essential roles in the decomposition of organic matter (see carbon cycle and nitrogen cycle). Bacteria cannot normally survive temperatures above 100ºC, such as those produced in cooking or pasteurization; but some live around hot vents in the ocean floor of the eastern Pacific and are believed to withstand temperatures of 350ºC.

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     The excessive enrichment of a body of water, primarily by nitrate fertilizers washed from the soil by rain and phosphates from fertilizers and sewage. **[left arrow](http://sks.sirs.com/cgi-bin/hst-article-display?id=SCO0649H-0-9862&artno=0000282027&type=ART&shfilter=U&key=fertilizer%20algae%20eutrophication&title=Chapter%203.5:%20The%20Nitrogen%20Cycle&res=Y&ren=N&gov=N&lnk=N&ic=N#A7)****Eutrophication[right arrow](http://sks.sirs.com/cgi-bin/hst-article-display?id=SCO0649H-0-9862&artno=0000282027&type=ART&shfilter=U&key=fertilizer%20algae%20eutrophication&title=Chapter%203.5:%20The%20Nitrogen%20Cycle&res=Y&ren=N&gov=N&lnk=N&ic=N#A9)** stimulates an increase in the growth of aquatic plants, especially **[left arrow](http://sks.sirs.com/cgi-bin/hst-article-display?id=SCO0649H-0-9862&artno=0000282027&type=ART&shfilter=U&key=fertilizer%20algae%20eutrophication&title=Chapter%203.5:%20The%20Nitrogen%20Cycle&res=Y&ren=N&gov=N&lnk=N&ic=N#A8)****algae[right arrow](http://sks.sirs.com/cgi-bin/hst-article-display?id=SCO0649H-0-9862&artno=0000282027&type=ART&shfilter=U&key=fertilizer%20algae%20eutrophication&title=Chapter%203.5:%20The%20Nitrogen%20Cycle&res=Y&ren=N&gov=N&lnk=N&ic=N#A10)** (see algal bloom). As the **[left arrow](http://sks.sirs.com/cgi-bin/hst-article-display?id=SCO0649H-0-9862&artno=0000282027&type=ART&shfilter=U&key=fertilizer%20algae%20eutrophication&title=Chapter%203.5:%20The%20Nitrogen%20Cycle&res=Y&ren=N&gov=N&lnk=N&ic=N#A9)****algae** die, the population of bacteria that decompose their cells increases rapidly. The decomposers use dissolved oxygen for respiration; this depletes the amount in the water and can lead to the death of aquatic animals (fish and crustaceans) by asphyxiation.

**Legume**

     Any plant of the family Fabaceae, which has a pod containing dry seeds that are released by lengthwise splitting of the pod down both sides. The family includes peas, beans, lentils, clover and alfalfa (lucerne). Legumes are important because of their specialized roots, which have nodules that contain bacteria which fix nitrogen from the air and increase the fertility of the soil. See also nitrogen cycle and nitrogen fixation.

**Nitrate**

     A salt of nitric acid. Nitrates are widely used in the agrochemical and pharmaceutical industries. They are the most water-soluble salts known and play a major part in the nitrogen cycle. Nitrates in the soil, whether naturally occurring or from inorganic or organic fertilizers, are absorbed by the roots of plants and are their chief source of nitrogen. See nitrogen cycle and nitrogen fixation.

**Nitrogen Fixation**

     The process by which atmospheric nitrogen is converted into nitrogen compounds by microorganisms, such as blue-green bacteria (cyanobacteria). There are two kinds of nitrogen-fixing bacteria in soil: one is free-living and the other lives symbiotically in the root nodules of legumes. The process indirectly makes nitrogen available to plants. Nitrogen fixation also occurs in the ocean, where free-living bacteria and blue-green bacteria are the fixing agents. Several chemical processes duplicate nitrogen fixation to produce fertilizers.