Nature's process for nitrogen fixation caught in action

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Nitrogen gas is converted to ammonia fertilizer by a chemical process that involves high temperature and high pressure. Nature does the same thing at ambient temperature and pressure. The process, called nitrogen fixation, is essential to life as it provides nutrients to plant life.

A research team from Utah State University, Virginia Tech, and Northwestern University asked whether the biological process, carried out by microbes that contain the enzyme nitrogenase, follows the same pathway as recently reported chemical methods. Their research method resulted in the ability to witness steps in the biological process that enables some microorganisms to convert atmospheric nitrogen to nutrients.

The research is reported in the *Proceedings of the National Academy of Science* (PNAS) Special Feature Issue on Nitrogen Fixation, in the invited article, "A methyldiazene ($HN=N-CH_3$) derived species bound to the nitrogenase active-site FeMo cofactor: Implications for mechanism," by Brett M. Barney of Utah State, Dmitriy Lukoyanov and Tran-Chin Yang of Northwestern, Dennis Dean at Virginia Tech, Brian M. Hoffman of Northwestern, and Lance C. Seefeldt of Utah State.

Dean, director of the Fralin Biotechnology Center at Virginia Tech, performed the genetics and molecular biology. The Utah Department of Chemistry and Biochemistry performed the biochemistry and the biophysics research was carried out in the Northwestern Department of Chemistry.

An enzyme is a protein that induces chemical changes in another substance. "Such reactions involve several stages in the reduction pathway," Dean said. "Nitrogenase activity is particularly complex because there are many intermediate stages between nitrogen gas (N_2) and ammonia (NH_3) that require adding electrons and protons."

In order to trap the process at a specific stage, the researchers synthesized a mimic of an intermediate compound in the pathway, and then followed its progress. The PNAS article talks about the challenge of identifying, trapping, synthesizing, and inserting the mimic and methods for observing the reduction of N_2.

Hoffman, Dean and Seefeldt have been working for years to figure out how to trap and characterize nitrogenase intermediates. Their success was reported in the Journal of the American Chemical Society and in Chemical and Engineering News in 2005. So, does the biological process follow the same pathway as the chemical process? "Our research suggests it does not," said Dean. "Nature appears to do it differently."

The article appears in PNAS online early edition before publication at www.pnas.org/cgi/content/abstract/0602130103v1 .

Source: Virginia Tech